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Indonesian Sign Language (BISINDO) Alphabet Detection System Using YOLO (You Only Look Once) Algorithm

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Abstract: This research aims to develop an Indonesian Sign Language (BISINDO) alphabet detection system using the YOLOv5 algorithm, an efficient and fast deep learning-based object detection model. The dataset used consists of BISINDO alphabet images enriched through data augmentation techniques such as rotation, flipping, and brightness adjustment. The evaluation results show that the YOLOv5s model achieved very good performance, with an average precision of 85.2%, recall of 89.3%, F1-score of 87.2%, and mean average precision (mAP) of 87.1%. The confusion matrix also indicates the model's ability to differentiate each BISINDO alphabet with high accuracy. The training data testing showed the model successfully achieved consistent decreases in all loss components, such as a decrease in train box loss from 0.06 to 0.015, and validation loss converging towards 0.002 for object loss and class loss. The real time testing also shows that the YOLOv5-based BISINDO alphabet detection system can perform well and consistently, indicating the practical application potential of this system to facilitate communication between people with hearing/speech disabilities and the general public. Overall, this research has resulted in an accurate and real-time implementable BISINDO alphabet recognition system.

Keywords: Sign Language, YOLO, Object Detection , BISINDO

1. Introduction

reaching 212,240 individuals as of March 2022 [1]. One group of individuals with disabilities comprises those who are deaf and speech-impaired. These individuals often face communication barriers due to their limited ability to hear and speak [2]. Therefore, they rely on Sign Language as their primary means of communication. Sign language itself utilizes hand gestures, facial expressions, and body language as substitutes for verbal communication [3].

One of the most commonly used sign languages in Indonesia is BISINDO (Indonesian Sign Language), which was developed within the deaf community to facilitate everyday communication [4]. However, despite its practicality, sign language remains underutilized in social life due to various constraints, particularly in terms of understanding among the general public and the lack of knowledge and awareness about sign language [5]. This often results in difficulties for deaf and speech-impaired individuals when interacting with the general public, hindering their participation in various aspects of social, economic, and educational life [6]. An example in the educational aspect can be seen in a survey conducted by the University of Indonesia's Disability Service Center (2022), which revealed that 78% of deaf students experience

difficulties interacting in the learning process due to minimal understanding of sign language among lecturers and students.

On the other hand, the advancing technology in pattern recognition and object detection has opened new opportunities to address communication barriers for people with disabilities, including the deaf and speech-impaired [7]. One technology currently widely used is the You Only Look Once (YOLO) algorithm, known for its ability to detect objects quickly and accurately in real-time. This algorithm is designed to recognize various objects in images or videos with high efficiency, making it highly potential for application in sign language recognition [8]. Based on these considerations, this research proposes the development of a BISINDO alphabet recognition system using YOLOv5, which is expected to serve as an innovative solution in facilitating communication between people with disabilities and the general public. The main focus of this research is the recognition of the BISINDO alphabet, which forms the foundation for word and sentence formation in sign language. This system aims to provide a strong foundation for further development of vocabulary and sentence detection, as well as assist in the process of understanding BISINDO for both people with disabilities and those who wish to learn sign language.

2. Materials and Methods

2.1. Indonesian Sign Language

Indonesian Sign Language (BISINDO) is a sign language developed by the Indonesian deaf community through GERKATIN [9]. Unlike SIBI, which adapts ASL, BISINDO has evolved naturally in accordance with Indonesian culture, utilizing simpler hand gestures, facial expressions, and body language, making it more effective for daily communication [10].

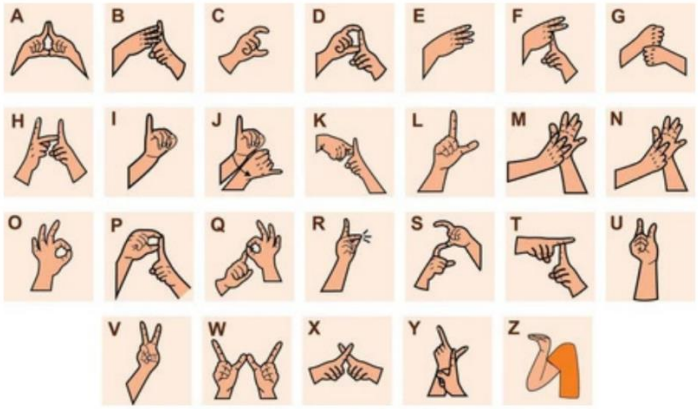


Figure 1. Alphabets in BISINDO

2.2. YOLO

You Only Look Once (YOLO) is an object detection algorithm that employs a single-stage detection approach to process images in a single pass [11]. YOLOv5, as the latest version, introduces improvements through Cross Stage Partial Network (CSP) and Path Aggregation Network (PAN), which enhance detection accuracy [12].

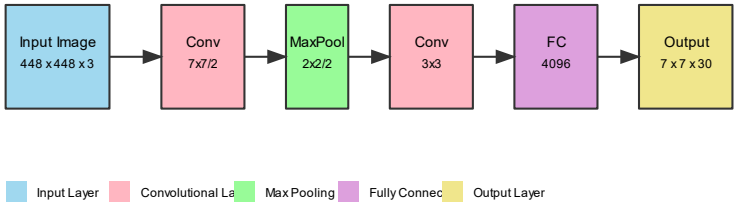


Figure 2. YOLO Architecture

2.3. *Previous Research*

Previous research has explored sign language recognition using computer vision and deep learning, such as a SIBI recognition system with YOLOv5 achieving 77% accuracy, and a hand detection system for Indonesian sign language using CNN and YOLO with 89% accuracy [13].

This current research aims to build upon these prior efforts by developing a real-time recognition system focused on BISINDO (Indonesian Sign Language) using the efficient and accurate YOLO algorithm. The goal is to address limitations of previous work, including the lack of high accuracy real-time systems and the need for expanded BISINDO datasets.

2.3. *Data Collection*

The dataset used in this research consists of a collection of BISINDO alphabet images (A-Z) obtained from the Kaggle platform. The dataset comprises 11,500 image data divided into 26 alphabet classes. These image data display various hand gesture variations representing the alphabets in BISINDO.

The dataset was enriched through data augmentation processes using several techniques such as image rotation, brightness adjustment, horizontal flipping, noise addition, and scaling. Subsequently, the dataset was labeled using the Roboflow application to create bounding boxes and annotations for each image. The labeling process resulted in files in YOLO (.txt) format, which contain information about the object coordinates and classes for each image to be used in the training process. An example of the dataset can be seen in **Figure 3** below :

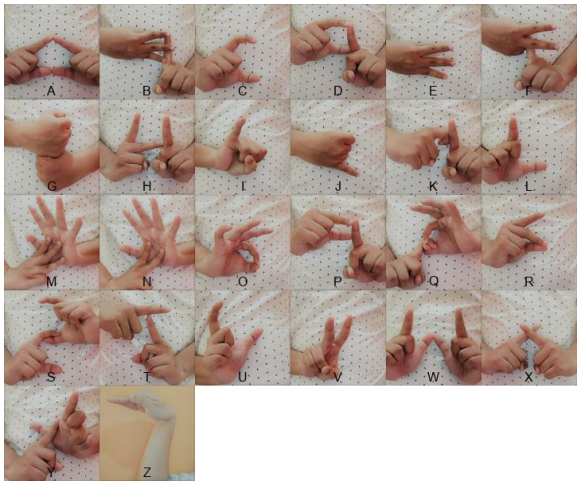


Figure 3. Dataset Image

2.3. *Data Preprocessing*

In this stage, several data augmentation techniques were employed to enrich the dataset's variation. The data augmentation phase is an essential step to modify and expand the dataset so that the model can recognize a wider range of BISINDO alphabet gesture variations more effectively.

2.3.1. Data Resize

All images in the dataset are resized to 640 x 640 pixels in the resize stage. This process is important to uniform the input size that will be processed by the YOLOv5 model. With a consistent size, the model training process becomes more efficient and the recognition results are optimised, ensuring compatibility across various devices, enhancing data preprocessing consistency, and supporting robust model performance.

2.3.2. Data Rotation

The rotation stage is performed by rotating the dataset image in the range of -18 to 18 degrees. This process generates a variety of new viewpoints that help the model to be more adaptive in recognising gestures. This angle variation is important considering that in real use, the angle of image capture may vary.

2.3.3. Data Flip

In the data flip stage, the images in the dataset are mirrored horizontally to add variety to the data. This technique helps the model recognise BISINDO alphabetic gestures from various viewpoints, considering that in practice users may show gestures from different directions.

2.3.4. Brightness Adjustment

Brightness Adjustment At this stage, the image brightness level is modified with a range of -20% to +20%. This adjustment aims to improve the model's ability to recognise gestures in different lighting conditions. This brightness variation helps the model to be more robust to changes in lighting conditions during implementation in the real environment.

2.3.5. Data Annotation

Each image in the dataset was then annotated using the roboflow tool. This process involves placing a bounding box around the hand area and labelling it according to the alphabet shown. The annotation results are saved in a .txt format file that contains the bounding box coordinate information and the class label. This annotation file will be used as a guide for the model in the training process to learn the characteristics of each BISINDO alphabet.

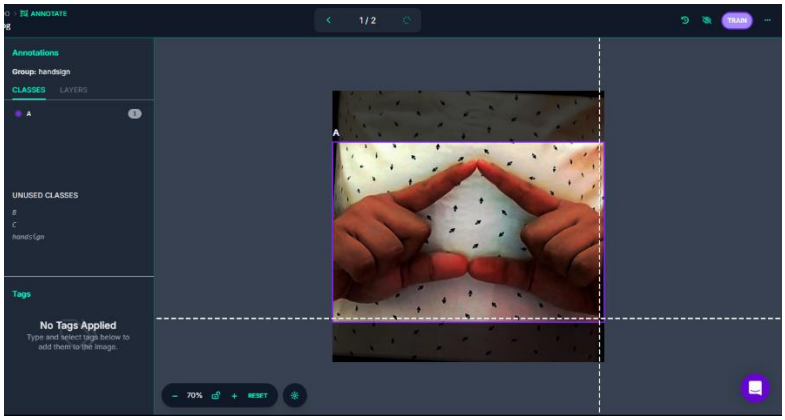


Figure 4. Data Annotation

2.4. *Model Implementation*

In this research, YOLOv5 was used to detect BISINDO alphabets. YOLOv5 is a deep learning model specifically designed for object detection using a single-stage detector approach, where the detection and classification processes are performed in a single processing step. The model has a structure consisting of a CSPDarknet backbone for feature extraction, a PANet neck for feature aggregation, and a head for object detection.

The YOLOv5s model architecture was chosen as the base model because it is a lightweight variant of the YOLOv5 architecture. This model employs a Cross Stage Partial Network (CSP), which allows for more efficient feature extraction by reducing the number of parameters and computations required. The structure also enables the model to detect objects at various scales through the Feature Pyramid Network (FPN).

The YOLOv5 model's detection mechanism divides the input image into grid cells, where each cell is responsible for detecting objects whose centers fall within that cell. Each cell predicts the bounding box, confidence score, and class probability. In the context of this research, the predicted classes are the 26 BISINDO alphabets (A-Z).

2.5. *Evaluation*

The evaluation stage was conducted to assess the performance of the BISINDO alphabet recognition system developed using the YOLOv5 algorithm. The evaluation process involved testing the model on the test dataset and calculating relevant evaluation metrics. These metrics included the accuracy of bounding box detection, prediction of object presence, prediction of object class, as well as visualization of model performance through the confusion matrix. The use of these evaluation metrics allowed for a comprehensive assessment of the system's capabilities in accurately detecting and classifying the BISINDO alphabets.

2.5.1. Box Loss

Box Loss measures how well the model can predict the bounding box coordinates of the detected object. These coordinates include the centre position (x, y) as well as the width (w) and height (h) of the bounding box.

$$Box\ Loss = \sum(x_{pred} - x_{true})^2 + \sum(y_{pred} - y_{true})^2 + \sum(w_{pred} - w_{true})^2 + \sum(h_{pred} - h_{true})^2 \quad (1)$$

Where $xpred, ypred, wpred, hpred$ are the predicted values of the model, and x_true, y_true, w_true, h_true are the true values of the bounding box coordinates. A lower Box Loss value indicates that the model has a better ability to accurately predict the bounding box.

2.5.2. Object Loss

Obj Loss measures the ability of the model to predict the presence of objects in each grid cell. The model must be able to distinguish between grid cells that contain objects and those that do not.

$$Obj\ Loss = \sum(obj_{pred} - obj_{true})^2 \quad (2)$$

Where $xpred, ypred, wpred, hpred$ are the predicted values of the model, and x_true, y_true, w_true, h_true are the true values of the bounding box coordinates. A lower Box Loss value indicates that the model has a better ability to accurately predict the bounding box.

2.5.3. Class Loss

Class Loss measures the accuracy of the model in predicting the class of the detected object. For BISINDO alphabet recognition, the predicted class includes 26 letters from A to Z.

$$Class\ Loss = \sum(class_{pred} - class_{true})^2 \quad (3)$$

Where $class_{pred}$ is the prediction probability distribution for each class, and $class_{true}$ a is the true label of the object class.

2.5.3. Confussion Matrix

The next stage of system testing uses a Confusion Matrix to evaluate classification results. The Confusion Matrix records the number of test data that are correctly and incorrectly classified. In this test, a Multi-Class Confusion Matrix is used to compare prediction results with actual data. From these results, the values of Accuracy, Precision, and Recall are calculated. Accuracy measures the model's accuracy level in correctly classifying data based on the correspondence between predicted and actual values. Below are the equations for calculating accuracy, precision, and recall.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \qquad Precision = \frac{TP}{TP+FP} \qquad Recall = \frac{TP}{TP+FN} \qquad (4)$$

3. Results and Discussion

3.1. Model Implementation

The model used in this research is YOLOv5s, a deep learning-based object detection model designed for efficiency and speed. The model training is done using Google Colab platform with NVIDIA T4 GPU runtime to speed up the computational process. The dataset used consists of images of the Indonesian Sign Language (BISINDO) alphabet from A to Z, with a total of 150 images for each alphabet, making a total of 3,900 images. The model training process was conducted for 50 epochs, with the aim of optimising detection accuracy without causing overfitting. The implementation involved data augmentation, division of the dataset into training and validation data, and hyperparameter settings to ensure optimal model performance.

3.2. Analysis of Model Performance

Performance analysis of the YOLOv5s model was conducted to evaluate its ability to detect Indonesian Sign Language (BISINDO) alphabets based on several standard evaluation metrics including Precision, Recall, Mean Average Precision (mAP), Intersection over Union (IoU), and Loss. Additionally, a Confusion Matrix was used to identify prediction distributions for each category. This performance analysis includes data from both model training and testing processes.

The performance evaluation results in Figure 6 show satisfactory performance with average precision of 0.852 (85.2%), recall of 0.893 (89.3%), and F1-score of 0.872 (87.2%). The model demonstrates good stability with a precision standard deviation of 0.02 across classes, where the majority of classes achieved precision and recall above 0.85. Overall, the model achieved a Mean Average Precision (mAP) of 0.871 and balanced accuracy of 0.882, indicating that the YOLOv5 model has successfully learned the characteristics of each BISINDO alphabet.

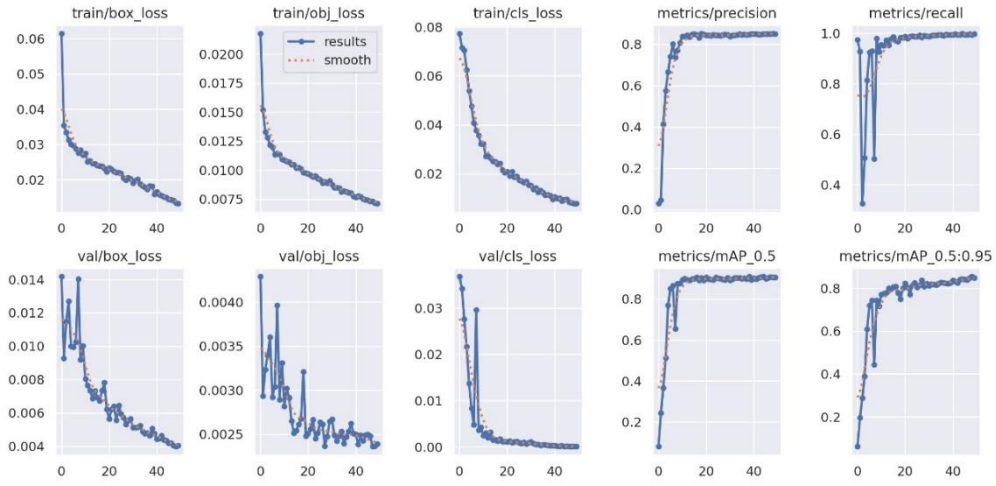


Figure 5. Evaluations Model

Figure 7 shows the model's performance across several testing metrics for easier analysis. The graphs indicate consistent decreases in all loss components. Train box loss decreased from 0.06 to 0.015, while validation box loss stabilized at 0.004. Object loss and class loss showed similar downward trends, with validation loss converging near 0.002. Performance metrics showed significant improvements, with precision and recall achieving stable values above 0.8 after epoch 20. Mean Average Precision (mAP@0.5) reached 0.85 and mAP@0.5:0.95 stabilized at 0.75, indicating the model successfully achieved optimal performance.

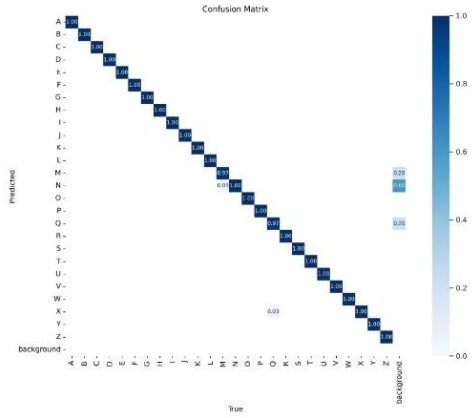


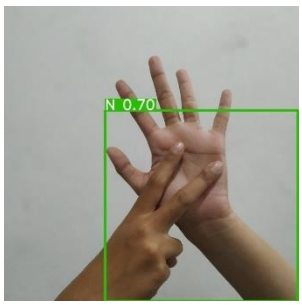
Figure 6. Confussion Matrix

Additionally, the Confusion Matrix shows excellent classification performance with most classes achieving perfect accuracy (1.00). Minor notes include letters M and Q having 0.97 accuracy, and slight classification errors between letters N and X at 0.03. Overall, the matrix demonstrates the model's excellent ability to distinguish each BISINDO alphabet, with minimal classification errors.

3.2. Model Analysis Result

The trained YOLOv5s model can effectively detect Indonesian Sign Language (BISINDO) alphabets from A to Z with high performance. This detection process includes identifying letter positions (bounding box) in images and their corresponding letter classification.

Table 1. Test Data Result

No	Test Image	Actual Label	Predicted Label
1		C	C
2		N	N

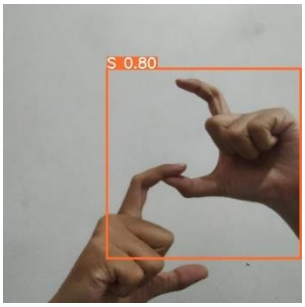
3		S	S
4		Y	Y

Table 2. Real-Time Prediction Result

No	Test Image	Actual Label	Predicted Label
1		L	L
2		V	V
3		E	E

4		I	I

Based on the modeling results in tables 1 and 2, testing using training data successfully classified hand gestures with consistent accuracy. In real-time testing, the system also demonstrated good performance in detecting hand gestures directly. This success in real-time detection indicates that the model has good generalization capability and can adapt to varying lighting conditions, angles, and hand positions in real-world usage.

The consistency between actual and predicted labels in both types of testing shows that the system has good reliability in detection. This serves as a positive indicator that the implemented YOLO model can be used as a practical solution for Indonesian sign language alphabet recognition.

4. Conclusions

a) This research developed a BISINDO (Indonesian Sign Language) alphabet detection system using the YOLOv5 algorithm, an efficient and fast deep learning-based object detection model.
b) The research used a BISINDO alphabet image dataset enriched through data augmentation techniques including rotation, flipping, and brightness adjustments. This dataset was used to train and evaluate the YOLOv5s model.
c) Evaluation results show the YOLOv5s model achieved excellent performance, with average precision of 85.2%, recall of 89.3%, F1-score of 87.2%, and mean average precision (mAP) of 87.1%. The confusion matrix also indicated the model's ability to distinguish each BISINDO alphabet with high accuracy.
d) Testing on training data showed the model achieved consistent decreases in all loss components, with train box loss decreasing from 0.06 to 0.015, and validation loss converging near 0.002 for object loss and class loss.
e) Real-time testing also demonstrated that the YOLOv5-based BISINDO alphabet detection system can work effectively and consistently, indicating the potential practical application of this system to facilitate communication between deaf/mute individuals and the general public.

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Validity analysis of the mathematical literacy test: implementation of the pancasila student profiles in instrument development

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Abstract: The background to this research is based on the need to improve students' mathematical literacy skills, which are integrated with character formation based on Pancasila values. This research aims to analyze the validity of the mathematics literacy test implemented with the Pancasila student profile in developing test instruments. This research uses the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model, with a focus on validation of the instruments developed. The instrument consists of 20 questions that were validated by media experts, material experts, and language experts. The research results show that media validation, material validation, and language validation are in the very valid category. Of the 20 questions, 1 question item was declared valid in the very high category, 2 questions were valid in the high category, 14 questions were valid in the medium category, and 3 questions were valid in the low category. The reliability of the instrument is classified as high with a value of 0.783. Apart from that, 7 questions have good differentiating power, while 13 questions have sufficient differentiating power. Based on the level of difficulty, 4 questions are in the difficult criteria, 14 questions are in the medium criteria, and 4 questions are in the easy criteria. These results indicate that the mathematical literacy test instrument developed generally has good validity and reliability and can be used as an effective measuring tool in evaluating students' mathematical literacy abilities, as well as integrating the values of the Pancasila student profile.

Keywords: Mathematical Literacy; Pancasila Student Profile; Instrument Test

1. Introduction

The rapid development of technology and information requires society not only to understand knowledge but also to utilize that knowledge intelligently and critically to process information and solve increasingly complex problems. The quality of society expected can be enhanced through the significant role of education. Education can provide sustainable improvements in human quality [1]. According to Ningtiyas and Sinaga [2], education, in its process, is capable of developing creative thinking, problem-solving, flexibility, collaboration, and innovation skills in individuals.

Mathematics, as a compulsory subject in education, is expected to contribute to meeting these demands. Mathematics is anticipated to enhance students' abilities in learning, not just limited to computation skills using formulas but also critical thinking, reasoning, problem-solving, and creativity during the process. The expected mathematical abilities can be achieved through mathematical literacy. Mathematical literacy is the knowledge and skills required to understand and use basic mathematics in everyday life [3]-[5]. The higher a person's literacy skills, the greater their problem-solving abilities, reasoning skills, and creativity will develop.

Based on a survey conducted by the Programme for International Student Assessment (PISA), the mathematical literacy skills of students in Indonesia remain very low. This is evidenced by Indonesia's position below the international average. Moreover, the majority of students can only solve problems at levels below Level 2 out of a total of 6 levels. Given this fact, it is clear that the mathematical literacy skills of students in Indonesia still need significant improvement. This situation has been exacerbated by the COVID-19 pandemic, which necessitated remote learning, leading to a decline in students' learning abilities (Learning Loss) [6].

The government has undertaken various efforts to address the need for improving mathematical literacy. One such initiative is the implementation of the Kurikulum Merdeka (Independent Curriculum). According to Feriyanto [7], the Merdeka Belajar policy is a concrete action to strengthen students' numeracy literacy. Assessments within the Merdeka curriculum are divided into three components: Minimum Competency Assessment (AKM), character surveys, and learning environment surveys [8]. The national assessment within the Merdeka curriculum focuses on understanding student literacy and character formation. Therefore, familiarizing students with solving problems in the form of mathematical literacy is expected to enhance their mathematical skills[9], [10].

In addition to improving mathematical abilities, character development is also a crucial focus within the substance of the Merdeka Belajar curriculum. One of the innovations in the Merdeka Belajar curriculum is the Project to Strengthen the Profile of Pancasila Students (P5). This initiative aims to shape a national character that upholds the values of Pancasila [11]. The Profile of Pancasila Students serves as an identity that helps students understand that national character formation significantly influences their success in facing global challenges. One way to meet the demands of the Merdeka Belajar curriculum is by developing a test instrument that encompasses mathematical literacy, wherein the test content reflects the formation of national character [12]-[14]. The mathematical literacy test instrument based on the Profile of Pancasila Students is expected to provide a solution for the education sector in fulfilling the national and state objectives of producing an intellectual and character-driven generation..

2. Research Methods

This research uses the ADDIE (Analysis, Design, Development, Implementation, Evaluation) [15]. development model to develop an integrated mathematical literacy test instrument for the Pancasila Student profile. This research was carried out at SMP N 2 Dewantara involving a sample of 110 students as participants. Samples were randomly selected to take part in trials of the test instruments that had been developed. Sampling was carried out by considering the diversity of student backgrounds so that the results obtained could represent the population.

1. Analysis; At this stage, a needs analysis is carried out to determine the competencies to be achieved through a mathematical literacy test. Surveys, interviews with mathematics teachers, and observations of the existing curriculum were used to identify deficiencies in existing test instruments and student needs.

2. Design; Based on the results of the analysis, the design of the mathematics literacy test instrument was carried out by formulating indicators and learning objectives that were by the Pancasila Student profile. The questions will be developed to cover various aspects of mathematical literacy.

3. Development; Instrument development was carried out by compiling a grid of questions by connecting them with mathematical literacy indicators and Pancasila student profile categories. Next, 20 questions were developed consisting of various levels of difficulty

and categories and equipped with problem-solving along with scoring guidelines. These questions were then validated by media experts, material experts, and language experts to ensure their validity and reliability.

4. Implementation; The validated instrument was tested on 110 students at SMP N 2 Dewantara. This trial aims to determine the readability and effectiveness of the instrument in measuring the integrated mathematical literacy of the Pancasila Student profile. Data obtained from trials is analyzed to determine the level of validity, reliability, distinguishing power, and level of difficulty of the questions.

5. Evaluation; Evaluation is carried out by analyzing test results to assess the effectiveness of the test instrument. The results of the analysis are used to improve and perfect the instrument to better suit student needs and learning objectives.

Data obtained from instrument testing will be analyzed using statistical methods, including analysis of validity, reliability, distinguishing power, and level of difficulty of questions, to evaluate the quality and effectiveness of the instrument being developed. The results of the analysis will be used as a basis for revising the instrument and improving aspects that are still inappropriate. With this approach, it is hoped that the integrated mathematics literacy test instrument for the Pancasila Student profile can be produced validly and reliably and can be used to evaluate students' mathematical literacy abilities effectively

3. Results and Discussion

Assessment of the validity of test instruments includes test instruments, image layout and illustrations, presentation and language, and ease and benefits of use.

Table 1 Aspects of Media Expert Assessment

Assessment Aspects	1st Media Expert Score	2nd Media Expert Score
test instrument	39	40
Image Layout and Illustrations	34	33
Language Presentation	29	30
Ease of Use	11	11
Benefits of Use	26	26
Amount	139	140
Mean	0,914473684	0,921052632
Percentage (%)	91,4	92,1
Category	Very Valid	Very Valid

Based on the table above, the percentage of integrated mathematical literacy test instruments for Pancasila student profiles in media expert validation 1 is 91.4% with the "Very Valid" category and the percentage of media expert validation 2 is 92.1% with the "Very Valid" category. Based on the validation test results of media expert 1 and media expert 2, the integrated mathematical literacy test instrument for the Pancasila student profile that was developed was very valid from the validation calculations.

Assessment of material validity includes suitability of questions to indicators, material content, material presentation, and learning strategies. The results of the material expert validation can be seen in the following table.

Table 2 Aspects of Material Expert Assessment

Assessment Aspects	1st Material Expert Score	2nd Material Expert Score

suitability of questions to indicators	23	21
Contents of the material	66	68
Presentation of material	23	22
Learning strategies	15	14
Amount	127	125
Mean	0,933823529	0,91911765
Percentage (%)	93,82	91,91
Category	Very Valid	Very Valid

Based on the table above, the percentage of integrated mathematical literacy test instruments for Pancasila student profiles in material expert validation 1 is 93.82% with the "Very Valid" category and the percentage of material expert validation 2 is 91.91% with the "Very Valid" category. Based on the validation test results of material expert 1 and material expert 2, the integrated mathematical literacy test instrument for the Pancasila student profile that was developed was very valid from the validation calculations.

Language validity assessment includes linguistics. The results of the validation by language experts can be seen in the following table.

Table 3 Aspects of Language Expert Assessment

Assessment Aspects	1st Language Expert Score	2nd Language Expert Score
Language	47	51
Amount	47	51
Flat	0,839285714	0,91071429
Percentage (%)	83,92	91,07
Category	Very Valid	Very Valid

Based on the table above, the percentage of integrated mathematics literacy test instruments with Pancasila student profiles in language 1 expert validation is 83.92% with the "Very Valid Valid" category and the percentage of language 2 expert validation is 91.07% with the "Very Valid" category. Based on the results of the validation test by Language Expert 1 and Language Expert 2, the integrated mathematical literacy test instrument for the Pancasila student profile that was developed was very valid from the validation calculations.

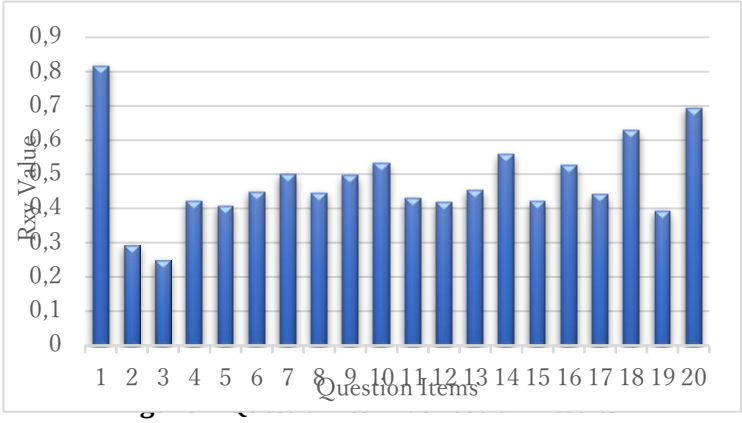
Next, a small class trial was carried out to see the readability of the media which was tested on 10 class VIII middle school students. The aspects assessed in this small-scale trial are aspects of appearance, ease of use, and product usefulness. Test results data can be seen in the following table.

Table 4. Small Class Trial Assessment Results

Assessment Aspects	Assessment Score (%)	Category
Product Display	86,42%	Very Valid
Ease of Use	89,16%	Very Valid
Product Usefulness	86,87%	Very Valid

The table above shows the validity results from small group trials. The product appearance aspect obtained very valid results, the ease of use of the product aspect obtained very valid results and the usability aspect of the media obtained very valid results. Through the results obtained from small-scale trials, it can be said that the product developed has a good readability and can be continued in the instrument feasibility stage in terms of content validity, reliability, distinguishing power, and level of difficulty.

This test instrument has gone through validity testing using the Pearson correlation value (rxy). Based on the calculation results, all question items have a r_{xy} value that is greater than the table r value (0.187), which indicates that all question items are declared valid. This validity shows that the items in the questions can measure well the aspect that is intended to be evaluated in the questions, namely the integrated mathematical literacy of the Pancasila student profile. The r_{xy} value categories which vary from low to very high also show variations in the quality of the questions, but are still valid and suitable for use for this test instrument.



From the figure above, it is found that of the 20 tests developed, there is 1 valid question item in the very high category, 2 valid questions in the high category, 14 valid questions in the medium category, and 3 valid questions in the low category. These results show that overall the 20 questions developed in the integrated mathematical literacy test instrument product for mathematics student profiles are declared valid and can be used.

Reliability testing was carried out using Cronbach's Alpha method to determine the internal consistency of this survey instrument. The calculation results show a Cronbach's Alpha value of 0.783, which means this instrument has a high level of reliability. Values above 0.7 are generally considered reliable, which shows that this instrument is consistent and reliable in measuring the integrated mathematics literacy test of Pancasila student profiles repeatedly with consistent results. Thus, this instrument can be used effectively to evaluate students' mathematical literacy abilities.

The next thing to do is look for the differentiating value in the test being developed. Discriminating power measures how well each question item can differentiate between respondents who have different understandings or attitudes regarding the topic being measured. In this test instrument, the analysis results show that most of the items have sufficient differentiating power. This indicates that the questions prepared were able to differentiate respondents based on their level of ability in the integrated mathematics literacy test of the Pancasila student profile. Items with high discriminating power can be relied upon to identify variations in opinion between groups of respondents.

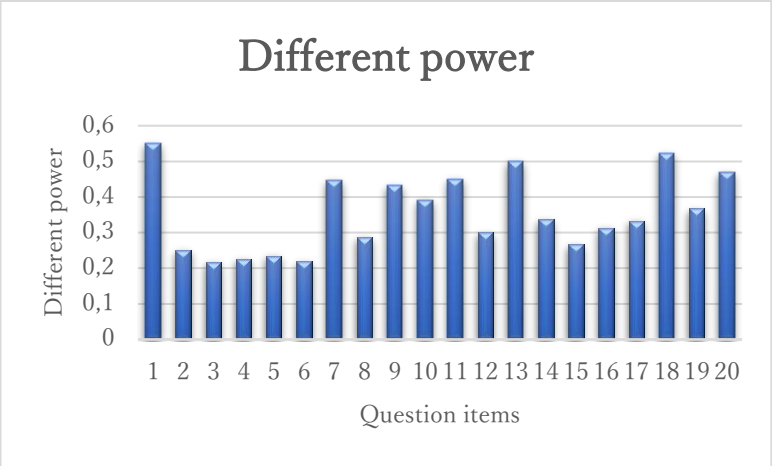


Figure 2. Results of Differentiating Power of Question Items

From the figure above, it is found that of the 20 tests developed, 7 questions have good discriminating power on the criteria and 13 questions have sufficient discriminating power on the criteria. This shows that all the questions developed can represent the differences in abilities of each student who works on the questions.

The level of difficulty shows how easy or difficult a question is to be answered by the respondent. Based on the analysis carried out, most of the items on this test instrument are at a moderate level of difficulty. This means that the questions prepared are not too easy or too difficult so that most respondents can answer them well. A balanced level of difficulty helps ensure that the instrument is inclusive for all respondents, regardless of their background or experience with the collaboration being evaluated.

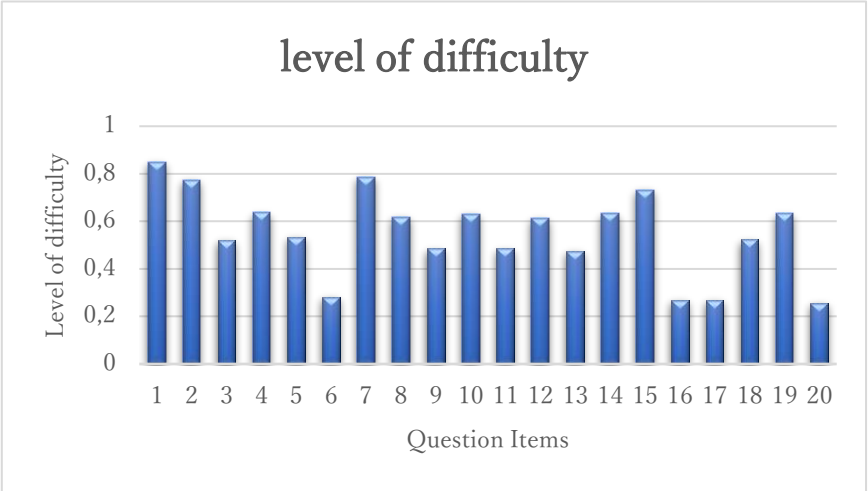


Figure 3. Results of Difficulty Level of Question Items

From the table above, it is found that of the 20 tests developed, 4 questions have a difficulty level on the Easy criteria, 12 questions have a difficulty level on the medium criteria and 4 questions have a difficulty level on the difficult criteria. This shows that all the questions developed have varying levels of difficulty and tend to have criteria for a medium level of difficulty.

Based on the research results, the integrated mathematical literacy test instrument for the Pancasila Student profile was declared very valid from various aspects. Validation by media experts shows that this instrument reached a percentage of 91.4% and 92.1%, with the category "Very Valid". This reflects that the instrument is good in terms of appearance, illustrations, language presentation, ease of use, and benefits. Material expert validation shows percentages of 93.82% and 91.91%, which are also categorized as "Very Valid". This shows that the questions developed are relevant to the indicators and the content of the material is well presented. In terms of language, the instrument achieved validation percentages of 83.92% and 91.07%, with the "Very Valid" category, which shows good readability and language clarity. Small-scale trials on 10 junior high school students also strengthened the validity of the product with very valid results in terms of appearance, ease of use, and product usefulness. Overall, this instrument is suitable for measuring mathematical literacy [16], [17].

The research results show that the integrated mathematical literacy test instrument for the Pancasila Student profile has gone through rigorous validity testing with a Pearson correlation (r_{xy}) value that is greater than the r table value, namely 0.187. All 20 questions were declared valid, with varying categories from low to very high. This indicates that this instrument can measure mathematical literacy effectively. The reliability test using Cronbach's Alpha method showed a value of 0.783, which shows the consistency and reliability of the instrument.

Discriminative power analysis shows that seven items have good discriminating power, while the other 13 items are sufficient. This confirms the ability of the instrument to differentiate the understanding of different students. The difficulty level of most of the questions is in the medium criteria, with varying proportions of questions, making this instrument inclusive and can be used to accurately measure students' mathematical literacy abilities. This instrument, overall, is feasible and effective for evaluating student abilities.

4. Conclusions

Based on the research results, the mathematical literacy test instrument developed was proven to have excellent validity from various aspects. In terms of construct validation, the results show that the 20 questions tested are very valid. Content validation also provides very good results, after going through assessments from several expert validators. Two media expert validators concluded that this instrument was very valid to use, as did two material expert validators who gave a very valid assessment of the test content. Apart from that, two linguist validators also stated that the questions used were very valid from a linguistic perspective. From the question validity category, there is 1 question that is categorized as very high, 2 questions are in the high category, 14 questions are in the medium category, and 3 questions are categorized as low. The reliability value of this instrument is also high, with an Alpha value of 0.781, which shows that this instrument is suitable for consistent use.

The results of the discriminating power analysis show that there are 7 questions with good discriminating power criteria and 13 questions with sufficient criteria. Meanwhile, the difficulty level of the questions is divided into three categories, namely 4 questions with difficult criteria, 12 questions with medium criteria, and 4 questions with easy criteria.

Overall, this mathematical literacy test instrument is considered very valid, and reliable, and can be used to measure mathematical literacy skills that are integrated with the Pancasila Student profile effectively

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Innovative IoT-Based Automatic Gate System with RFID and Electro-Magnetic Lock for Secure Access

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Abstract: In this study, we developed an innovative IoT-based automatic gate system aimed at enhancing security and providing flexible access control. The system incorporates an ESP32 microcontroller with integrated Wi-Fi, enabling seamless remote access via mobile devices. It also features RFID technology for reliable physical access control when an internet connection is unavailable. To ensure user safety, an HC SR-04 ultrasonic sensor is implemented to detect obstacles during gate movement, preventing potential accidents. The security of the system is further reinforced by a dual-layer mechanism utilizing an electromagnetic lock (Emlock), which activates upon gate closure to prevent unauthorized access and deactivates when the gate opens. Experimental results indicate that the system effectively addresses the shortcomings of conventional gate control methods, delivering improved security, convenience, and safety for users. Performance tests confirm the reliable operation of both RFID and mobile control functions, with minimal delays observed in sensor response times. This comprehensive solution is well-suited for residential and commercial properties, offering a modern approach to automatic gate security.

Keywords: IoT-based Automatic Gate, Remote Access Control, RFID Security, Electromagnetic Lock, Ultrasonic Safety Sensor

1. Introduction

In the digital era, the rapid advancement of technology has significantly transformed various aspects of daily life, particularly in the realm of home security and automation. The integration of smart technologies into everyday systems has reshaped how people manage their homes, offering enhanced security, convenience, and efficiency. One of the most prominent innovations is the Internet of Things (IoT), a technology that allows devices to communicate and interact in real-time over the internet [1], [2], [3]. The seamless connection between devices has made IoT a critical tool in improving the automation of numerous systems, including home security [4], [5].

Among the various applications of IoT, automatic gate systems are becoming increasingly popular for controlling access to residential, commercial, and industrial properties. Traditional manual or remote-controlled gates often present challenges such as limited security, ease of unauthorized access, and inadequate integration with other smart systems. These limitations can compromise the overall security of a property, making it essential to explore more advanced solutions that incorporate modern technologies for both improved functionality and safety.

Automatic gate systems have proven to be an effective solution for enhancing property security by allowing controlled access and reducing the need for physical interaction with the gate. These systems are especially valuable in high-traffic areas or residential zones where quick and efficient access control is crucial. However, many of the currently available automatic gate systems rely on basic remote controls, limiting the range of operation and posing security risks in the event of remote-control malfunctions or unauthorized access. Moreover, these systems often lack sufficient integration with other security measures, further weakening their effectiveness in protecting properties.

In recent years, IoT-based automatic gate systems have emerged as an ideal solution to address these challenges. These systems enable remote access control, real-time monitoring, and integration with other security features, offering more flexibility and convenience for users. By using IoT technology, automatic gates can be remotely controlled via smartphones or other connected devices, allowing users to manage gate access from virtually any location. The combination of IoT with other security technologies, such as RFID and electro-magnetic locks, provides enhanced protection and ensures that only authorized individuals can access the property.

While previous studies have explored various aspects of automatic gate systems, many of them still fall short of providing a fully integrated, secure, and reliable solution. For example, some systems use Bluetooth for communication, which offers limited range and may be susceptible to signal interference. Additionally, these systems may lack backup options in case of network failure, such as internet outages or disconnection from the remote control application [6]. Therefore, a more robust system is needed that combines multiple control mechanisms to ensure reliability and security in all circumstances.

This research aims to address these limitations by developing an innovative IoT-based automatic gate system equipped with an ESP32 microcontroller. The ESP32, with its integrated Wi-Fi capabilities, allows the gate system to be controlled remotely via mobile devices, providing users with greater flexibility and convenience. Additionally, the system integrates RFID technology for physical access control, ensuring that authorized users can operate the gate even if internet connectivity is unavailable. This dual control system enhances both security and reliability, offering users a comprehensive solution for managing gate access.

Furthermore, safety is a crucial consideration in automatic gate systems, especially in residential areas where children and pets may be present. To mitigate the risk of accidents during gate operation, this system incorporates an ultrasonic sensor, the HC SR-04, which detects obstacles in the gate's path and prevents it from closing when objects are detected [7]. This safety feature reduces the likelihood of injury or damage caused by the gate's movement [8] , ensuring a safer environment for users and their families.

This paper proposes a highly advanced IoT-based automatic gate system that combines cutting-edge technologies such as remote access, RFID, and safety sensors. By integrating these components into a single, cohesive system, the proposed solution provides a more secure, flexible, and efficient method of controlling access to properties. The development of such a system represents a significant step forward in the evolution of smart home technologies, offering a practical and reliable solution for modern security needs.

2. Research Methods

As a foundation for this research, the author examines relevant studies to comprehend the key concepts that are essential for developing the proposed system. Various studies have explored automatic gate systems and their integration with modern technologies, focusing on enhancing security, efficiency, and user convenience. Many of these systems, however, are limited by traditional control mechanisms, such as basic remote controls, which restrict their functionality and range of operation. To address these challenges, several studies have proposed incorporating Internet of Things (IoT) technologies to enable remote access, real-time monitoring, and integration with other security features.

The Internet of Things (IoT) has significantly influenced the development of advanced automation systems, particularly in the realm of smart home security. IoT enables devices to communicate and share data in real-time, providing enhanced control and flexibility for various applications. In the context of automatic gate systems, previous research has primarily focused on integrating IoT to enable remote access and improve user convenience [9]. For example, studies have explored the use of Bluetooth and Wi-Fi for wireless control of gate systems via mobile applications [10]. Although these systems offer an improvement over traditional remote controls, they often face challenges related to limited range, reliability, and security risks due to signal interference or unauthorized accessance the security of automatic gate systems, many researchers have integrated Radio Frequency Identification (RFID) technology as an additional access control mechanism. RFID offers a secure and contactless method of authentication, enabling authorized users to operate gates without the need for direct interaction. Research has shown that RFID-based systems can effectively prevent unauthorized access and provide a higher level of security compared to standard remote controls. However, despite its benefits, RFID alone may not be sufficient in scenarios where internet connectivity is crucial for real-time monitoring and remote access. Therefore, combining RFID with IoT technologies has been proposed as a solution to bridge these gaps, enhancing both the flexibility and security of gate control systems.

Anothaspect of automatic gate systems is ensuring user safety during operation. Previous studies have highlighted the importance of incorporating safety features, such as obstacle detection sensors, to prevent accidents. Ultrasonic sensors, like the HC SR-04, have been commonly used in various automation systems for their ability to detect objects in close proximity. These sensors provide real-time feedback to the microcontroller, enabling the system to halt or reverse the gate movement if an obstacle is detected. This approach significantly reduces the risk of injury or damage, particularly in residential settings where children and pets may be present.

The choice of miler plays a vital role in the performance and capabilities of automatic gate systems. Recent advancements have led to the adoption of the ESP32 microcontroller, known for its integrated Wi-Fi and Bluetooth modules, low power consumption [11], and dual-core processing capabilities. The ESP32's versatility makes it ideal for IoT applications [12], as it allows seamless integration of various components, such as RFID readers, ultrasonic sensors, and electromagnetic locks. Research has demonstrated the effectiveness [13] of using ESP32 in IoT-based automation systems [14], showcasing its ability to handle multiple tasks simultaneously, thereby enhancing the overall functionality and reliability of the system.

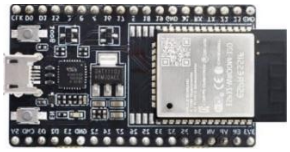

Figure 1. ESP32 WROOM- 32U

While previous studies hanificant strides in improving automatic gate systems, challenges remain in achieving a fully integrated and robust solution. Many existing systems lack comprehensive safety features, reliable remote access capabilities, and dual-layer security mechanisms. This research aims to address these limitations by developing an innovative IoT-based automatic gate system that combines the benefits of RFID technology, ESP32 microcontroller capabilities, and enhanced safety measures. By leveraging these technologies, the proposed system seeks to provide a more secure, flexible, and user-friendly solution for modern access control needs.

3. Material and Methods

This study presents the design and implementation of an automatic gate control system using the Internet of Things (IoT) approach, which will focus on controlling automatic gates with door lock security and implementing a safety system for users by applying sensors to detect any movement or obstacles.

1.1. Research Stage

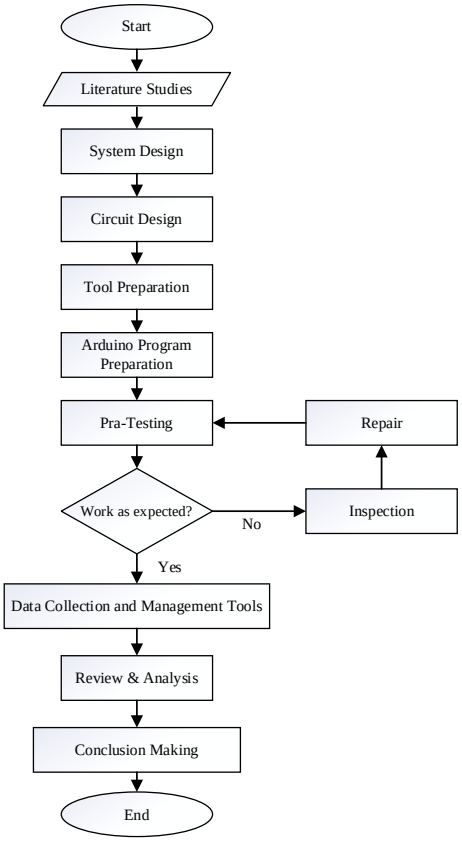

Figure 2. Research Flowchart

Developing a design through literature study, namely by reviewing references related to the topic being discussed. The goal is to gain a deep understanding, ensure the feasibility of this research, and provide guidance in minimizing the risk of errors that may occur during the research process.

After the literature study is continued with the system design followed by the selection of the right technology, as well as designing the communication flow between components to ensure smooth integration. The system must also be tested to ensure that each part functions according to plan and can operate efficiently. The goal of the design system is to create an optimal, functional, and reliable solution, while considering factors such as cost, time, and operational needs. After the literature study, the system design is developed, including selecting suitable technology and designing communication between components for seamless integration. Testing ensures each part functions efficiently. The goal is to create an optimal, functional, and reliable system, considering cost, time, and operational needs.

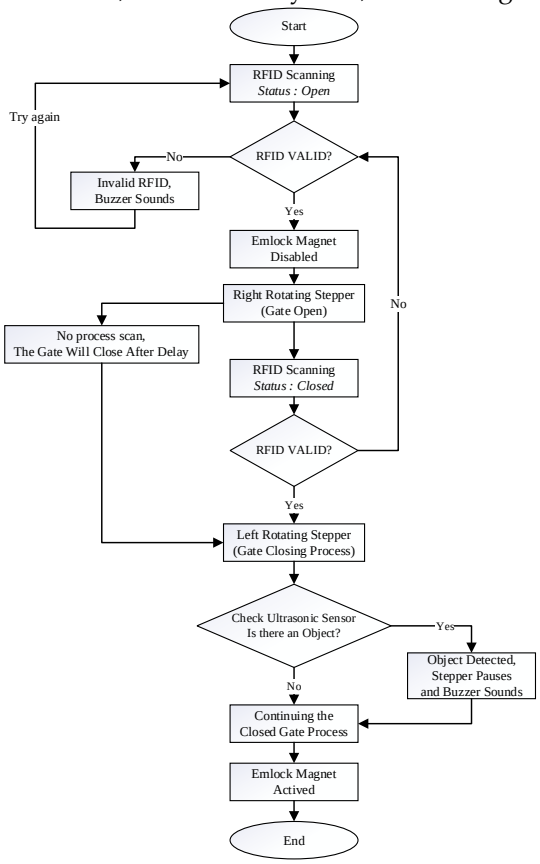

Figure 3. Design System of RFID Control

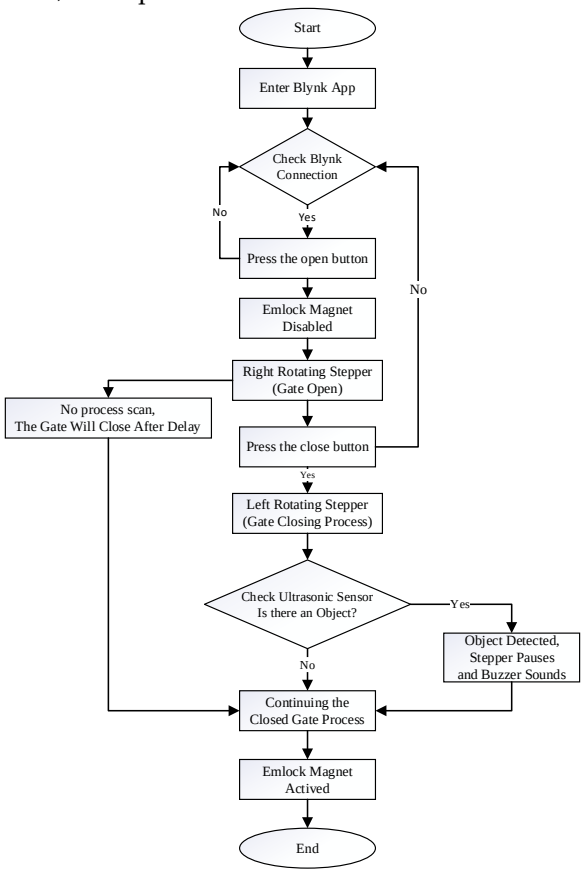

Figure 4. Design System of Mobile Control

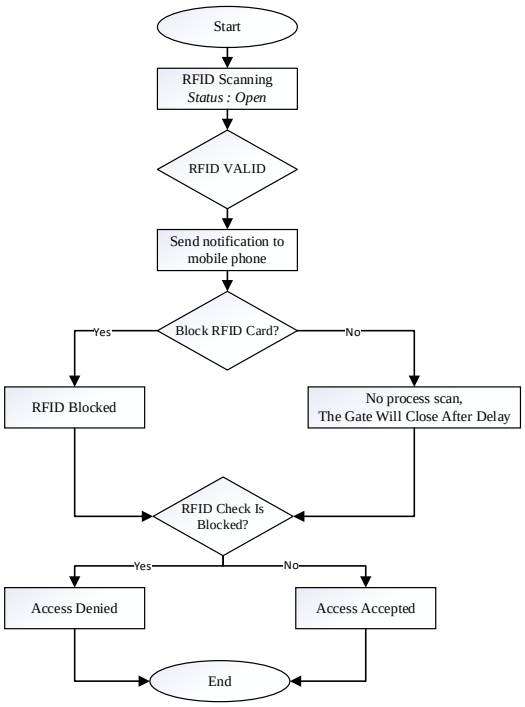

Figure 5. RFID Control Security Integration

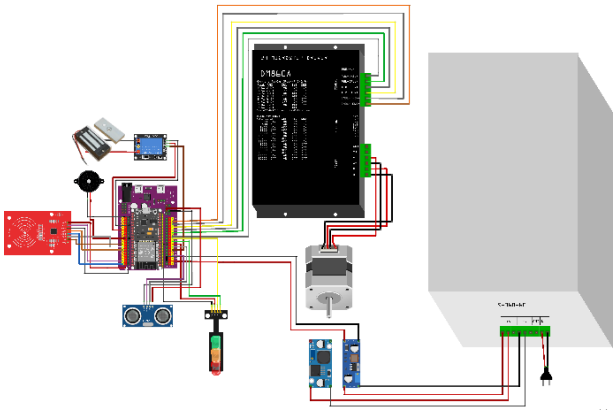

Figure 6. Circuit Design

The circuit design involves selecting suitable components and creating a wooden miniature gate structure. A Nema 17 Stepper Motor powers the gate, with all components connected using jumper cables while ensuring proper power supply. Accurate movement is achieved by matching the gate's teeth with the Stepper Motor's gear. The design also includes an Emlock Magnetic locking system, along with sensors and other components.

Figure 6. Motor Gear Rack

Figure 7. EmLock Magnet

After the entire circuit is designed, the next step is to compile a program using the Arduino IDE software to be programmed into the ESP32 microcontroller. In addition to writing code for circuit operation, this step also includes developing a program for access control using RFID scanning and a mobile application, which will be tested through the Blynk cloud platform. After completing the design and programming, the device is tested to ensure proper performance. If issues arise, further inspection and program adjustments are made. Once functional, the system is reviewed to analyze the microcontroller's performance with all components, ensuring optimal operation and coordination. The analysis stage collects data on performance, flexibility, and safety aspects of the automatic gate control system. This ensures accurate and reliable results, serving as a basis for decision-making and conclusions.

1.2. Related Hardware

The system uses the ESP32 microcontroller as the main control unit. It integrates multiple components, including the Nema 17 Stepper Motor with the TB6600 module, which drives the sliding gate to open and close automatically. Figures 8 and 9 show the Stepper Motor and Microstep Driver.

Figure 8. Motor Stepper Nema 17

Figure 9. Microstep TB6600

The system features a mini magnetic emlock that uses magnets powered by electricity to attract an iron piece on the fence, securing it. When activated, the magnets hold the iron piece, preventing manual opening. A relay controls the activation and deactivation of the lock as needed. Figures 10 and 11 show the magnetic emlock and relay in operation.

Figure 10. Magnetic Emlock

Figure 11. Relay

Meanwhile, the function of the RFID component as access control opens or closes the gate physically by attaching the card to be scanned into the module section. This function will later work carefully by giving signals to several main components to open and close the gate. The RFID component can be seen in the following figure 12:

Figure 12. RC-522 RFID

The safety sensor used for user safety is the HC-SR04 ultrasonic sensor, this sensor is considered capable of detecting the movement of every object or human in its coverage area, where in this case the sensor is used to detect the presence of every object, human, and animal so that they are not trapped when the door closes. For the ultrasonic sensor, this can be seen in the following figure 13:

Figure 13. Sensor HC-SR04

For other sensors, a Reed Switch sensor is used which is equipped with a magnet and a sensor module to realize limiting the range of the fence when closing and opening the gate when the motor is working. For the magnet and reed switch sensor, this can be seen in figures 14 and 15:

Figure 14. Magnetic Reed Switch

Figure 15. Reed Switch Sensor

The resources used by this system use a 12V 5A Power Supply. To see the total voltage and ampere consumption, an Ammeter display is used to measure the exact power consumption. For the power supply and voltmeter, can see Figures 16 and 17 below:

Figure 16. Power Supply

Figure 17. Volt&Amp Meter

Because the system of each component uses 12V, 5V and 3.3V, an LM2596 step down module is needed which is converted down to 3.3V, and an XL7015 step down module which is converted to 5V. Both step downs can be seen in the differences in figures 18 and 19 below.

Figure 18. Step Down LM2596

Figure 19. Step Down XL7015

Other supporting components such as LED Traffic Light and Buzzer are only used as a form of visualization of each performance or process of each gate control. For LED Traffic light can be seen in figure 20 and buzzer in figure 21:

Figure 20. LED Traffic Light

Figure 21. Buzzer

1.3. Related Software

In this research, software integration is needed to support the control system on the automatic gate fence. The software will be designed to support every process needed in the operation of the system efficiently and effectively.

1.3.1. Arduino IDE

Arduino IDE supports ESP32 programming, enabling users to write, upload, and manage code in C/C++. It provides access to features like Wi-Fi, Bluetooth, and GPIO. Known for its simplicity and large community support, it offers examples and libraries for IoT projects, including multi-controller automatic gate systems.[13], [14].

1.3.2. Blynk Application in IoT Systems

This research aims to advance knowledge in remote control automation by integrating the Blynk application into an automatic gate control system. The system enables users to open and close the gate as needed while also offering real-time door status monitoring whether open or closed via mobile devices[15]. The Blynk application features advanced security. If a user's RFID card is lost and misused, the system will automatically send a notification to the user's phone. Users can block the lost card via the app, rendering it unusable for door access. This feature ensures optimal protection for home security.

4. Conclusions

The automatic gate control prototype uses a Nema 17 Stepper Motor system combined with a 12V TB6600 driver. The motor is installed on the gate with a gear mechanism featuring a 32 mm diameter gear, enabling smooth opening and closing of the gate. The system also integrates a security feature using a 12V magnetic emlock, ensuring the gate remains securely locked when closed. Additionally, other components are designed using an ESP32 as a multicontroller to seamlessly coordinate the entire system. The following are the prototype results, as shown in Figures 23,24,25 and 26:

Figure 23. Design Architecture

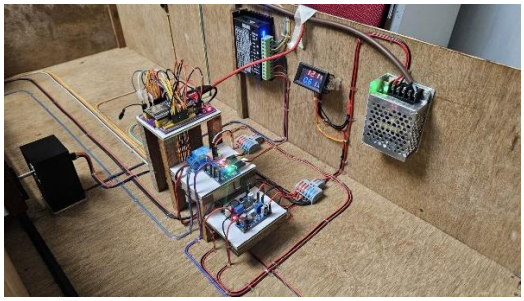

Figure 24. Microcontroller Placement

1.4. RFID Scanning Distance Test

The RFID scanning test was carried out in a simple way. This study tested the distance between the RFID card and the scanning module in centimetres, ranging from 1 to 5 cm. The results showed that the RFID scan worked well at distances of 1 to 4 cm. However, at a distance of 5 cm, the RFID could no longer function.

Table 1. RFID Card Scan Distance Test

No	Distance (Cm)	Status
1	5	Not Working
2	4	Working
3	3	Working
4	2	Working
5	1	Working

1.5. Mobile Control Testing with Blynk

The testing using mobile access control with the Blynk system showed excellent results. The prototype works well for opening and closing the gate, similar to the RFID scanning system. However, the mobile access control using Blynk has the advantage of being operable anytime and anywhere without the need for physical interaction. This testing can be seen in Figures 27 and 28 below.

Figure 25. Open Control Test

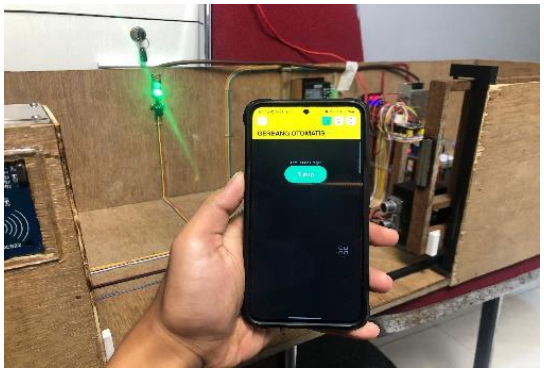

Figure 26. Close Control Test

1.6. Sensor Ultrasonic Reading Analysis

The sensor works by detecting objects within its detection range. For testing the HC-SR04 ultrasonic sensor, the study conducted three rounds of testing, with each round consisting of six trials. The detection distance was predetermined in centimeters for each trial. From the results

of the three tests, there were some detection times that took longer than others, such as in the first test during the first trial (5.16 seconds) and in the second test during the sixth trial (4.20 seconds). Overall, the average time required by the sensor to detect objects at each specified distance was approximately 3 seconds.

Table 2. Object Detection Sensor Testing

No	Distance to (Cm)	Sensor Reading Delay (Sec)		
		Testing 1	Testing 2	Testing 2
1	33	5,16	3,09	2,84
2	27,5	2,99	2,51	2,99
3	22	2,77	2,59	2,93
4	16,5	3,06	3,05	3,02
5	11	3,05	3,05	3,15
6	5,5	2,35	4,20	2,43

1.7. Gate Opening and Closing Time Analysis

The analysis of the gate's opening and closing time involves calculating the wheel's circumference, determining the number of revolutions needed, and measuring the time taken for one revolution. These calculations are used to estimate the total time required for the gate to complete its opening and closing operations efficiently. Using theoretical calculations, the estimated time is as follows, while the measured time using a stopwatch is shown in Figure 29 below:

- Calculate Wheel Circumference:
  $C = \pi \times D$
  $C = 3{,}14 \times 0{,}032 = 0{,}10053\ m$ $(10{,}052\ cm)$
  Each wheel rotation covers a distance of **10,053 cm**

- Determine the Number of Revolutions (N)
  $N = \frac{Distance}{Wheel\ Rotation} = \frac{33}{10{,}053} \approx \mathbf{3{,}28\ rotation}$

- Calculate the Time for One Revolution
  $T_{rev} = \frac{60}{RPM} = \frac{60}{7{,}7} = 7{,}79\ sec/rev$

- Calculate Total Time
  $T_{total} = N \times T_{rev} = 3{,}28 \times 7{,}79 = \mathbf{25{,}5\ seconds}$

Figure 17. Fence Rate Measurement

1.8. RFID Block Based Security

The RFID blocking system ensures the security of users if the RFID is lost or stolen and used by an unauthorized person to open the door. With this additional security feature, users will receive notifications on their mobile devices when the door is opened or closed using RFID. The system not only provides notifications but also allows users to block RFID access if the action is not made by them or someone they know. If the action is legitimate, the user can simply ignore the alert.

Figure 28. RFID Blocking Access

1.9. Total Power Consumption

A 12V 5A power supply is used as the power source for this prototype. Power consumption is measured using a digital multimeter, comparing the theoretical calculations of each component's power usage with the actual measurement results. Comparison data between RFID scan control and Mobile Blynk control is presented in tables 1 and 2 below.

Table 3. Total Power Consumption RFID Control

RFID SCAN	Close Door Mode	Open/Close Process Mode	Open Door Mode
Calculation	300 mA	930 mA	60 mA
Actual Result	**340 mA**	**880 mA**	**40 mA**

Table 4. Total Power Consumption Mobile Control

MOBILE BLYNK	Close Door Mode	Open/Close Process Mode	Open Door Mode
Calculation	0.38 A	1.30 A	0.36 A
Actual Result	**0.34 A**	**1.18 A**	**0.34 A**

5. Conclusions

This research presents an innovative IoT-based automatic gate system that integrates multiple advanced features, including RFID technology, an ESP32 multicontroller, an HC SR-04 ultrasonic sensor, and an electromagnetic lock (Emlock). The experimental evaluation demonstrates that the proposed system effectively addresses the limitations of traditional gate control mechanisms by offering enhanced security, flexible access control, and improved user safety.

The system's dual-layer security approach, combining RFID access control with an electromagnetic lock, successfully prevents unauthorized entry and ensures that the gate remains secure when closed. The use of the ESP32 microcontroller allows for efficient integration and coordination of various components, providing seamless remote access via mobile devices and stable performance in diverse operating conditions. The ultrasonic sensor's integration further enhances safety by detecting obstacles during gate movement, reducing the risk of accidents

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Spatial Analysis of Socioeconomic Influences on Generation Z's Transportation Mode Choices in Sidikalang City

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Abstract. This research analyzes the socio-economic influence of Generation Z on transportation mode selection in Sidikalang City using a spatial approach. The main objective of this study is to understand the socio-economic characteristics that affect Generation Z's preferences in choosing transportation modes, both private and public vehicles, as well as to measure the probability of mode selection through regression analysis and binary logit models. Data were collected through questionnaires from 100 Generation Z respondents. The results indicate that 69% of respondents prefer private vehicles for travel, while 31% opt for public transportation. The dominant socio-economic characteristics include male gender (60%), age 22-26 years (48%), students/university students (59%), and monthly income of less than Rp500,000 (56%). Multiple linear regression analysis shows that vehicle ownership (X3) and comfort (X9) are two significant factors influencing transportation mode selection. The spatial movement pattern displays a strong point of origin from Sidikalang City regarding transportation mode selection, especially for those who own private vehicles. This pattern supports the importance of comfort and the availability of private vehicles in Generation Z's transportation preferences. These findings provide a basis for policymakers to improve public transportation by enhancing comfort, in order to encourage Generation Z to shift from private vehicles.

Keywords: *Generation Z, mode selection, spatial analysis*

1. Introduction

Generation Z, born between 1997-2012 and aged around 8-26 years, is known as the internet generation due to their rapid adaptability to technology and high creativity. This generation excels at leveraging technological advancements, which impacts their socio-economic conditions. Socio-economics describes a person's position in society, determined by their job, education, and income. Low education reduces job opportunities, thus affecting income and welfare. Generation Z takes advantage of broader access to education and information technology, but other aspects such as transportation also need to support this.

The choice of transportation modes is an important component in transportation planning, especially since public transportation usually has more efficient routes than private vehicles. Switching to public transportation can reduce congestion, save road space, and optimize infrastructure. Sidikalang, the capital of Dairi Regency, is a center of activity, including recreation in city parks. However, Generation Z in Sidikalang prefers private vehicles due to comfort and lifestyle preferences, resulting in suboptimal use of public transportation. Therefore, there is a need for efficient transportation mode selection that considers the socio-economic behavior of Generation Z to support their activities and reduce congestion in the city of Sidikalang.

This study will analyze the spatial probability of transportation mode choices between private and public vehicles by Generation Z. Understanding the socio-economic characteristics and their influence on Generation Z's transportation choices will enable improvements and enhancements in related transportation services.

2. Literature Review

2.1 Mode Selection

According to Tamin (2000), the factors influencing the choice of transportation modes are divided into three main groups, namely:

- Road User Characteristics. The individual characteristics of those using transportation modes, such as age, income, and personal preferences.
- Movement Characteristics. Travel patterns, destinations, frequency, and distances traveled that affect the choice of transportation modes.
- Transportation Mode Facility Characteristics. The availability, comfort, and quality of transportation facilities provided, including the accessibility and efficiency of the mode.

2.2 Sampling Method

To calculate the required sample size, Slovin's formula is used.

$$n = \frac{N}{1+(N.e^2)} \quad (1)$$

Information:
n : number of samples studied
N : number of population studied
e : level of accuracy

2.3 Discrete Choice Model

The utility function can be formulated into a multiple linear equation as follows:

$$U = a + b1\ X1 + b2\ X2 + \ldots\ldots + bnXn \quad (2)$$

Information:
U : utility value mode
a : constant
b1 s/d bn : regression coefficient

2.4 Bxinary Logit Biner

The binary logit model is a model that selects the mode with the highest satisfaction value among two transportation options, such as public transport and private transport. The following is the equation used.

$$P(1) = \frac{x^y}{1+e^y} \quad (3)$$

$$P(2) = \frac{1}{1+e^y} \quad (4)$$

Information:
P(1) : private vehicle opportunity
P(2) : public vehicle opportunity
y : value of multiple linear regression
e : exponential

2.5 Spatial Analysis

Spatial analysis is an approach in geography using geographic data to understand patterns, relationships, and spatial distribution. Spatial analysis is depicted by the thickness of the color and the size of the dots according to the number of answers from each respondent, which is carried out on all independent variables.

3. Research Methods

The stages of the research activities in this study are as follows:

- The first stage is to formulate the problem. by identifying the transportation modes to be studied and the current conditions of public transport and motorcycles.
- The second stage is a literature review. that includes the theoretical framework and calculation methods to be used for data processing or analysis.
- The third stage is to formulate the questionnaire.
- The fourth stage is the collection of primary and secondary data.
- The fifth stage is the discussion or processing of data. The data obtained from the questionnaire results are collected, processed, and presented in a simpler form (percentage of respondents' choices) to facilitate the next stage.
- The sixth stage is data analysis. In this stage, the processed data is analyzed using regression models with the SPSS program. Then, the probability values are calculated using a binary logit model.
- The seventh stage is spatial analysis. In this stage, the questionnaire data is analyzed for the distribution of movements from each respondent using ArcGIS Pro.
- The eighth stage is conclusions and recommendations. In this stage, conclusions are drawn regarding the factors influencing transportation mode choice and their probability values.

4. Result and Discussion

4.1 Questionnaire results and discussion

Tabel 1. variable description and summary statistics.

Dependent Variable		
Variable	Mean	Modus
Types of transportation modes	0.6	1
Independent Variable		
Variable	Mean	Modus
Gender	0.6	1
Income	1.310.000	500.000
Vehicle ownership	0.58	1
Driver license ownership	0.33	0
Time of travel	1.77	2
Travel time	0.25	1
Distance traveled	0.23	1
Travel cost	0.35	1
Comfort	2.18	2
Safety	2.24	2

Based on the descriptive analysis of the questionnaire results as shown in the table above, the highest average value for variable X (categorized with a dummy variable) is the gender variable at 0.6, while the lowest is the travel distance variable at 0.23. Meanwhile, the highest average value for the variables that are not categorized as dummy variables is the safety variable at 2.24, and the lowest is the travel time variable at 1.77.

4.2 Results and Discussion of Multiple Linear Regression

Tabel 2. Significance of independent variables using multiple linear regression analysis.

Variable	A	Significant	Information
X1	0.05	0.053	Not Significant
X2	0.05	0.071	Not Significant
X3	0.05	0.000	Signifikan
X4	0.05	0.902	Not Significant
X5	0.05	0.017	Significant
X6	0.05	0.592	Not Significant
X7	0.05	0.320	Not Significant
X8	0.05	0.539	Not Significant
X9	0.05	0.007	Significant
X10	0.05	0.680	Not Significant

From the table, it is evident that the variables that have been shown to be significant in the choice of transportation mode are X3 (ownership of private vehicles), X5 (travel time), and X9 (comfort).

Tabel 3. recapitulation of variables with value B.

Variable	B	Significant
X1	0.144	0.053
X2	- 0.107	0.071
X3	0.603	0.000
X4	- 0.009	0.902
X5	- 0.095	0.017
X6	0.043	0.592
X7	- 0.080	0.320
X8	- 0.043	0.539
X9	0.134	0.007
X10	0.023	0.680

Based on the results of multiple linear regression in the table above, the following linear regression equation is obtained.

$$Y = 0.074 + 0.144\ X1 - 0.107\ X2 + 0.603\ X3 - 0.009\ X4 - 0.095\ X5 + 0.043\ X6 - 0.080\ X7 - 0.043\ X8 + 0.134\ X9 + 0.023\ X10$$

4.2.1. Simultaneous F Test

Table 4. Simultaneous f test

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.258	10	1.826	28.300	.000[b]
	Residual	5.742	89	.065		
	Total	24.000	99			

a. Dependent Variable: Mode selection
b. Predictors: (Constant), Safety, Vehicle ownership, Traveling time, Travel time, Monthly income, Travel expense, SIM ownership, Comfort, Travel distance, Gender

The table anova explains whether there is a significant effect of the variables of safety, vehicle ownership, travel time, journey duration, monthly income, travel costs, driving license ownership, comfort, distance traveled, and gender. Based on the ANOVA table above, the calculated F value (Fhit) is 28.300, and the tabulated F value (Ftab) from Appendix A.4 is 1.94, thus Fhit > Ftab. Additionally, the significance value is 0.00, which means 0.00 < 0.05. Therefore, it can be concluded that the independent variables (safety, vehicle ownership, travel time, journey duration, monthly income, travel costs, driving license ownership, comfort, distance traveled, and gender) have a significant effect on the dependent variable (mode of transportation choice) simultaneously.

4.2.2. Partial T Test

Table 5. Partial t test

Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.074	.153		.484	.630
	Gender	.144	.074	.144	1.964	.053
	Monthly income	-.107	.058	-.108	-1.825	.071
	Vehicle ownership	.603	.086	.608	7.001	.000
	SIM ownership	-.009	.070	-.008	-.123	.902
	Travel time	-.095	.039	-.137	-2.430	.017
	Traveling time	.043	.080	.038	.538	.592
	Travel distance	-.080	.080	-.070	-1.000	.320
	Travel expense	-.043	.069	-.042	-.616	.539
	Comfort	.134	.048	.186	2.771	.007
	Safety	.023	.055	.026	.413	.680
a. Dependent Variable: Mode selection						

From the table partial, it is known that the constant value is 0.074, the Thit values, and the significance values of each variable. Meanwhile, the Ttab value in Appendix A.3 is 1.986. Thus, there are two variables that have a significant partial effect on the choice of transportation mode, namely X3 and X9. X3 has a Thit value of 7.001 > 1.986 and a significance value of 0.00 < 0.05, leading to the conclusion that X3 (vehicle ownership) has a significant partial effect on the dependent variable (choice of transportation mode). X9 has a Thit value of 2.771 > 1.986 and a significance value of 0.007 < 0.05, leading to the conclusion that X9 (comfort) has a significant partial effect on the dependent variable (choice of transportation mode).

On the other hand, the variables X1, X2, X4, X5, X6, X7, X8, and X9 (gender, monthly income, driver's license ownership, travel time, travel duration, distance traveled, travel costs, and safety) do not have a partial effect on the choice of transportation mode because the Thit values are < Ttab and the significance values are > 0.05.

4.2.3. R Square

Table 6. R square

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.872a	.761	.734	.254
a. Predictors: (Constant), Safety, Vehicle ownership, Traveling time, Travel time, Monthly income, Travel expense, SIM ownership, Comfort, Travel distance, Gender				

The table R square explains the magnitude of the correlation/relationship (R), which is 0.872, and clarifies the percentage of influence of the independent variables on the dependent variable, referred to as the coefficient of determination, which is the square of R. From the regression results above, it can be seen that the R square value is 0.761 or 76.1%. This value indicates that the variables of security, vehicle ownership, travel time, journey duration, monthly income, travel costs, driving license ownership, comfort, distance traveled, and gender can explain the dependent variable by 76.1%. Meanwhile, the remaining 23.9% is explained by other variables that are unknown or not accounted for in this research analysis.

4.3 Binary Logit Model Analysis

Tabel 7. Generation Z's probability of transportation mode selection.

No	Means of transportation	Persentase
1	Private vehicles	69%
2	Public vehicles	31%

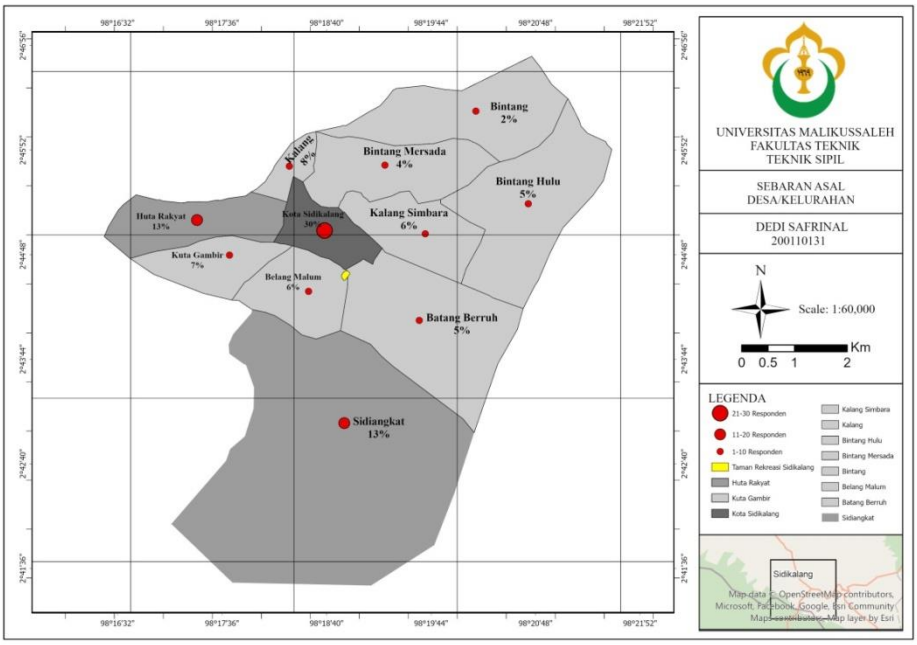
Based on the table above, it can be seen that private vehicle users account for 69% of trips to the Sidikalang recreational park attraction. Meanwhile, public transportation users make up 31% of trips to the Sidikalang recreational park attraction.

4.4Spatial Analysis

Tabel 8. Origin village sub-district.

No	Origin Village sub-district	Total Generation Z
1	Sidiangkat	13
2	Batang Berruh	5
3	Belang Malum	6
4	Bintang	2
5	Bintang Mersada	4
6	Bintang Hulu	5
7	Kalang	8
8	Kalang Simbara	6
9	Kota Sidikalang	31

10	Kuta Gambir	7
11	Huta Rakyat	13
Total		100



Gambar 1 Distribution of movement of origin of village/sub-district.

From the table and image above, it can be seen that only respondents from the city of Sidikalang have a score of 21 – 30, with a total of 31 respondents. Huta Rakyat and Sidiangkat have scores of 11 – 20, with 13 respondents each. Additionally, the respondents with scores of 1 - 10 are Kalang Simbara with 6 respondents, Kalang with 8 respondents, Bintang Hulu with 5 respondents, Bintang Mersada with 4 respondents, Bintang with 2 respondents, Bellang Malum with 6 respondents, and Batang Berruh with 5 respondents.

5. Conclusion and Suggestion

The conclusion is the result of an analysis conducted based on field facts in the form of questionnaires from 100 respondents of Generation Z in Sidikalang City. The following is the conclusion of the research titled "Spatial Analysis of the Socio-Economic Influence on Generation Z's Transportation Mode Choices in Sidikalang City."

5.1 Conclusion

1. The questionnaire results reveal key characteristics influencing transportation mode selection among respondents. The socio-economic profile indicates a predominance of male travelers (60%), primarily aged 22 to 26 years (48%), with a majority being students (59%) and having completed Senior High School (SMA)/Madrasah Aliyah (MA) (75%). Most respondents report a monthly income of less than Rp.500,000 (56%), own private vehicles (58%), and a significant portion does not possess a driver's license (67%).
   Travel characteristics show that 30% of respondents originate from the village/sub-district of Sidikalang City, with a notable 90% traveling for recreational purposes. Private vehicles are the

preferred mode of transportation (60%), with travel typically occurring during non-peak hours (10:00 AM to 12:00 PM) for 45% of respondents. The majority travel for 5 to 10 minutes (51%) over distances of 1 to 3 kilometers (46%), with travel costs ranging from Rp.5,000 to Rp.10,000 (50%).

Regarding land transportation facilities, comfort while using vehicles is rated as sufficient by 50% of respondents, while safety is rated as sufficient by 64%. These insights highlight the socio-economic factors, travel patterns, and perceptions of transportation facilities that influence mode selection.

2. After analyzing the factors influencing transportation mode selection using multiple linear regression analysis with SPSS software, the utility function equation obtained is Y = 0.074 + 0.144 X1 – 0.107 X2 + 0.603 X3 – 0.009 X4 – 0.095 X5 + 0.043 X6 – 0.080 X7 – 0.043 X8 + 0.134 X9 + 0.023 X10. It is found that there are two variables that significantly affect transportation mode selection, namely; X3 (vehicle ownership) and X9 (comfort). Therefore, the socio-economic characteristic that influences transportation mode selection is X3 (vehicle ownership). Meanwhile, the other variables X1 (gender), X2 (monthly income), and X4 (driver's license ownership) do not have a significant effect on transportation mode selection.
3. Two significant variables were used in the binary logit model equation, resulting in a probability of Generation Z choosing private vehicles at 69%. Meanwhile, the probability of Generation Z opting for public transportation is 31%.
4. The results of the spatial analysis show the distribution of significant movement points based on the origin of the Village/Subdistrict, where the significant points range from 21-30, is the City of Sidikalang with a total of 31 respondents.

5.2 Suggestion

1. From the characteristics found in the research questionnaire, it can be illustrated how the Dairi Regency Environmental Agency plans or improves the quality of services for the recreational park facilities in Sidikalang. As a result, the people of Sidikalang, from any generation, can easily access the Sidikalang recreational park.
2. To enhance the use of public transportation, efforts are needed from public transport service providers to improve vehicle quality, along with regulations from the local government, specifically the Dairi District Transportation Office, regarding the arrangement of bus stops and the operation of routes from each village/sub-district in Sidikalang.

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Machine Learning Algorithms Comparison for Gender Identification

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Abstract: In this study, we presents a comprehensive analysis of gender identification methods utilising eight distinct classification models: K-Nearest Neighbors (KNN), Naive Bayes, Decision Tree, Random Forest, Logistic Regression, XGBoost, Support Vector Machine (SVM), and Neural Network. Gender identification is a critical task with significant applications in marketing, social analysis, and security systems, necessitating the exploration of various methodologies to achieve optimal performance. The dataset employed in this research underwent normalisation using the Min-Max scaling technique, which enhances the performance of classification models by ensuring that all features contribute equally, particularly when the data exhibits varying ranges of values. The results reveal that the K-Nearest Neighbors (KNN) model significantly outperformed the other models, achieving an impressive accuracy of 0.9758 with a support of 951, underscoring the effectiveness of the KNN algorithm in gender identification tasks and establishing it as a reliable choice for applications requiring high accuracy. Furthermore, the study emphasises the critical importance of selecting appropriate models in machine learning tasks and the substantial impact of data normalisation on model performance. Overall, this research provides valuable insights into the KNN algorithm, demonstrating its ease of implementation and exceptional effectiveness in achieving high precision in gender identification tasks, with implications for future research and practical applications across various fields

Keywords: classification models; data normalisation; gender identification; K-Nearest Neighbours; machine learning.

1. Introduction

Gender identification has become an essential task in various domains, including marketing, social analysis, security systems, and human-computer interaction. With the increasing availability of digital data, the demand for accurate and efficient gender classification methods has risen [1], enabling tailored services and enhanced user experiences. Traditional approaches to gender identification relied heavily on demographic and psychological surveys, which are often time-consuming and prone to bias. However, advancements in machine learning have

opened new avenues for automating this process with higher accuracy and efficiency, making it a focal point for research in recent years.

Machine learning algorithms offer promising solutions for gender identification by learning patterns from data and generalising these patterns to unseen cases [2]. Among the most widely used models are K-Nearest Neighbors (KNN), Naive Bayes, Decision Trees, Random Forest, Logistic Regression, Support Vector Machine (SVM), XGBoost, and Neural Networks. Each of these algorithms has its strengths and limitations, making it critical to assess their performance comprehensively. Previous studies have explored the use of these models in gender classification tasks, demonstrating varying degrees of success depending on the dataset characteristics and preprocessing techniques employed.

Data preprocessing, particularly feature scaling and normalisation, plays a crucial role in enhancing the performance of machine learning models. For instance, distance-based algorithms like KNN and SVM are highly sensitive to the range of input features, where differences in feature magnitudes can disproportionately influence model outcomes. The Min-Max scaling technique is widely adopted to address this issue by transforming feature values into a uniform range. The normalisation significantly boosts model performance by ensuring that all features contribute equally during the training process. This step is especially important when dealing with datasets containing features with varying scales.

Despite the significant progress made in gender identification using machine learning models, there remains a need for a thorough comparison of these algorithms to identify the most effective model for this task. Many studies have focused on individual models or small subsets of algorithms without providing a comprehensive evaluation across a broad range of classifiers. Additionally, the impact of data preprocessing techniques [3][4] such as Min-Max normalisation on different models' performance has not been fully explored [5]. Understanding these factors is vital to developing robust gender classification systems that can be applied across various contexts and applications.

This study aims to address these gaps by conducting a comprehensive analysis of eight popular machine learning models for gender identification. By applying Min-Max normalisation to the dataset and carefully evaluating each model's performance using standard metrics, this research provides valuable insights into the effectiveness of different classification algorithms. The findings of this study are expected to contribute to the growing body of knowledge on gender identification and offer practical guidance for selecting suitable machine learning models in various real-world applications.

2. Materials and Methods

This research aimed to analyse and compare the performance of eight distinct machine learning classification models for gender identification. The methodology was carefully designed and executed in several stages, including data preprocessing, model selection, training, evaluation, and performance metrics analysis. Each of these stages was integral to achieving a robust and accurate comparison of the chosen algorithms. The models selected for this study were K-Nearest Neighbors (KNN), Naive Bayes, Decision Tree, Random Forest, Logistic Regression, XGBoost, Support Vector Machine (SVM), and Neural Network, providing a diverse range of classifiers with varying underlying mechanisms.

2.1 Preprocessing Data

Data preprocessing is a crucial step in machine learning to enhance the quality of input data and ensure it aligns with the requirements of various algorithms. In this study, the dataset underwent several preprocessing steps, starting with data cleaning to handle missing or

inconsistent values. Following this, normalisation was performed using the Min-Max scaling technique [6][18]. This method transforms feature values into a fixed range, typically [0, 1], which is essential for distance-based algorithms like KNN and SVM [7]. By applying Min-Max normalisation, we ensured that features with larger ranges did not disproportionately affect the model, thereby improving the overall performance and convergence speed of the classifiers.

2.2 Feature Selection

Feature selection is a vital step in reducing model complexity and enhancing predictive performance by identifying the most relevant features. In this research, a statistical approach was employed to select key features that significantly contribute to gender classification [8]. Specifically, the mean values of the features were calculated, and an evaluation of their significance was conducted. The analysis identified three key features—meanfreq, meanfun, and IQR—as the most influential in distinguishing between male and female labels. This selection process effectively reduced the dimensionality of the dataset, enhancing the model's efficiency without compromising its accuracy.

2.3 Model Training and Evaluation

After data preprocessing and feature selection, the next phase involved training the chosen classification models. The dataset was split into training and testing. Each model was then trained on the training dataset and evaluated on the testing dataset to assess its performance. Hyperparameter tuning was performed for each model to optimise their configurations and improve accuracy. For instance, the number of neighbors in KNN, the maximum depth of Decision Trees, and the kernel type in SVM were fine-tuned to achieve the best results. The models' performance was evaluated using standard metrics, including accuracy, precision, recall, and F1-score, to provide a comprehensive comparison of their capabilities.

KNN is a distance-based algorithm that classifies data based on the majority label of the k nearest neighbors. The distance is cal culated using matrics such as Euclidean or Manhattan[9].

$$d(x, x_i) = \sqrt{\sum_{j}^{n} = 1((x_j - x_{ij})^2}$$

Naïve Bayes assumes that features are independent and calcutes probabilities using Bayes'theorem. It is suitable for large datasets with simple assumptions[10].

$$P(y|x) = \frac{P(x|y)P(y)}{P(x)}$$

A Decision Tree builds a tree structure by splitting data based on metrics like Gini Impurity or Informtion Gain. Each branch represents a decision-making condition[11].

$$Gini = 1 - \sum_{i=1}^{c} p_i^2$$

Random Forest is an ensemble of multiple decision trees. The algorithm combines the predictions of individual trees to achieve higher accuracy and robustness[12][13].

$$\hat{f}(x) = \frac{1}{B}\sum_{b=1}^{B} f_b(x)$$

Logistic Regression predicts the probability of the target class by modeling a logistic relationship between independent variables and the dependent variable[14].

$$P(y = 1|x) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x)}}$$

XGBoost is a boosting algorithm that iteratively improves model performance by adding decision trees and minimizing loss efficiently [15].

$$F_t(x) = F_{t-1}(x) + \eta h_t(x)$$

SVM finds the optimal hyperplane that separates data from different classes with maximum margin, ensuring better generalization[16].

$$min_{w,b} \frac{1}{2} \| w \|^2 \quad s.t \quad y_i(w . x_i + b) \geq 1$$

A Neural Network consists of layers of interconnected neurons. Each neuron processes information using an activation function to model complex relationships in data[17].

$$a^{(l)} = f(W^{(l)} a^{(l-1)} + b^{(l)})$$

Each model was trained using a consistent training procedure. The dataset was divided into training and testing subsets. In this study, the **random splitting technique** was applied, with a proportional split of 70:30, where 70% of the data was allocated for training and 30% for testing. The training subset was used to fit the model, while the testing subset was reserved for evaluating the model's performance.

3. Results and Discussion

In this study, the performance of eight machine learning models was evaluated for the task of gender identification using voice data. Each model was assessed based on several key metrics, including accuracy, precision, recall, and the area under the Receiver Operating Characteristic (ROC) curve (AUC). The models demonstrated varying levels of effectiveness, with K-Nearest Neighbors (KNN) emerging as the top performer. This section presents a detailed discussion of the results obtained from each model and explores their implications for gender identification.

K-Nearest Neighbors (KNN) showed exceptional performance, achieving the highest accuracy of 0.9758. The confusion matrix analysis (Figure 2) revealed a balanced classification with minimal false positives and false negatives, indicating the model's robustness. The precision-recall curve (Figure 4) exhibited a strong trade-off between precision and recall, while the ROC curve (Figure 5) confirmed high discriminative power. The success of KNN in this task can be attributed to its ability to leverage local data patterns effectively. The application of Min-Max normalisation played a crucial role in enhancing the model's performance by ensuring that all features were on a comparable scale, which is essential for distance-based algorithms like KNN.

	precision	recall	f1-score	support
female	0.9704	0.9808	0.9756	468
male	0.9812	0.9710	0.9761	483
accuracy			0.9758	951
macro avg	0.9758	0.9759	0.9758	951
weighted avg	0.9759	0.9758	0.9758	951

Figure 1. Result of KNN model train

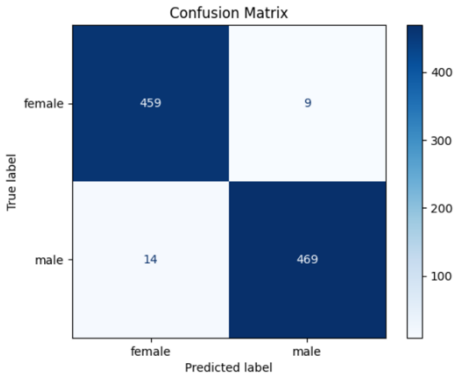

Figure 2. Confusion Matrix of KNN model

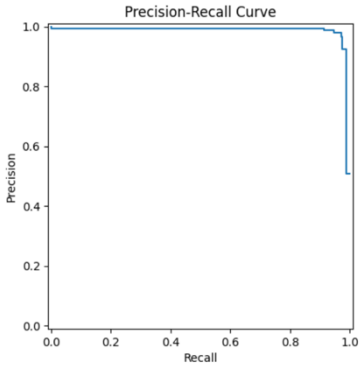

Figure 4. Precision-Recall Curve of KNN model

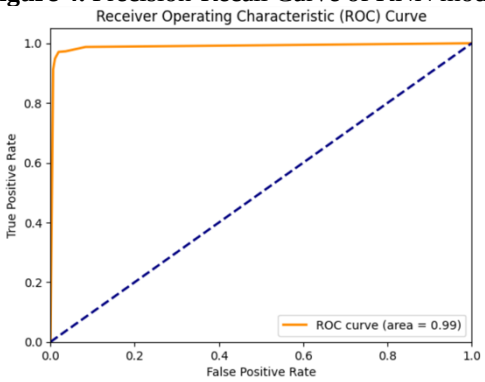

Figure 5. Receiver Operating Characteristic of KNN model

Naive Bayes, with an accuracy of 0.9664, demonstrated a reliable performance, albeit slightly lower than KNN. The confusion matrix (Figure 7) indicated a higher number of misclassifications compared to KNN, particularly in distinguishing between closely related voice features. The model's strong performance is primarily due to its probabilistic approach, which works well when the features are independent. However, this assumption may not always hold in real-world datasets, where features can be correlated. The precision-recall curve (Figure 8) and ROC curve (Figure 9) suggested that while Naive Bayes performs well in general, it might struggle with feature dependencies, highlighting the need for further feature engineering or alternative probabilistic models.

	precision	recall	f1-score	support
female	0.9658	0.9658	0.9658	468
male	0.9669	0.9669	0.9669	483
accuracy			0.9664	951
macro avg	0.9663	0.9663	0.9663	951
weighted avg	0.9664	0.9664	0.9664	951

Figure 6. Result of Naive Bayes Model

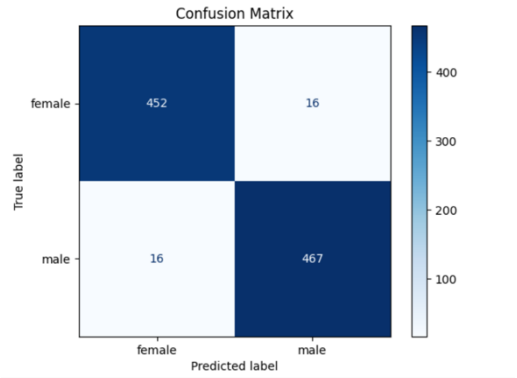

Figure 7. Confusion Matrix of Naive Bayes Model

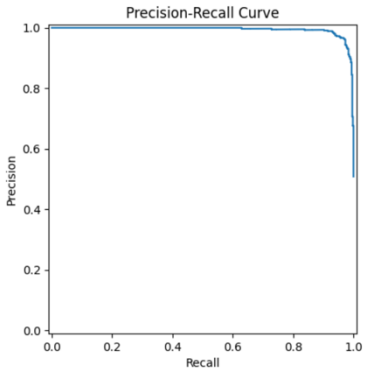

Figure 8. Precision-Recall Curve of Naive Bayes Model

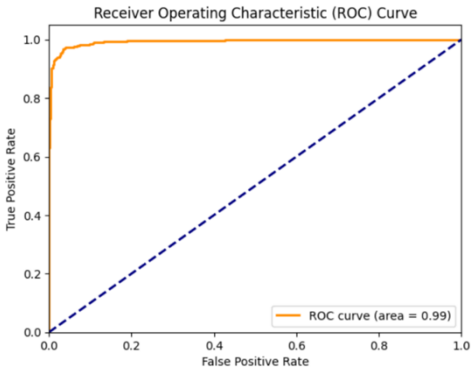

Figure 9. Receiver Operating Characteristic of Naive Bayes Model

Decision Tree achieved an accuracy of 0.9653, closely following Naive Bayes. The model's confusion matrix (Figure 11) highlighted a moderate level of misclassifications. Decision Tree algorithms can handle both numerical and categorical data effectively, making them versatile. However, their tendency to overfit can reduce their generalisability to new data, as observed in this study. Despite employing techniques such as pruning, the model showed slightly lower precision and recall, as seen in the precision-recall curve (Figure 12). The ROC curve (Figure 13) also suggested that while the model distinguishes well between classes, there is room for improvement through advanced ensemble methods like Random Forest or Gradient Boosting.

	precision	recall	f1-score	support
female	0.9448	0.9872	0.9655	468
male	0.9870	0.9441	0.9651	483
accuracy			0.9653	951
macro avg	0.9659	0.9656	0.9653	951
weighted avg	0.9662	0.9653	0.9653	951

Figure 10. Result of Decision Three Model

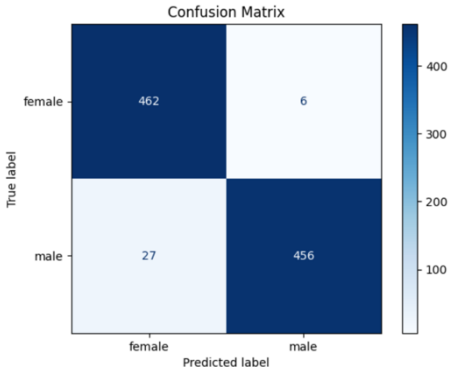

Figure 11. Confusion Matrix of Decision Three Model

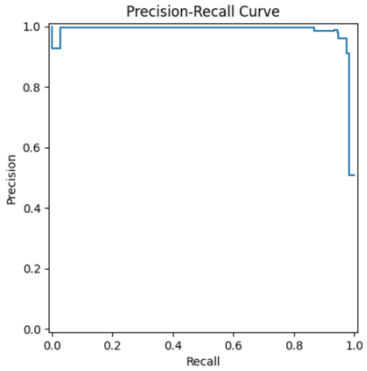

Figure 12. Precision-Recall Curve of Decision Three Model

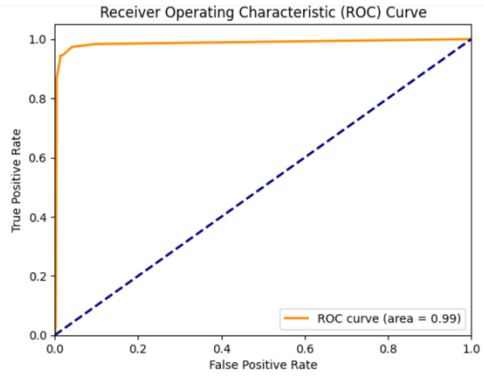

Figure 13. Receiver Operating Characteristic of Decision Three Model

Random Forest, an ensemble learning model, demonstrated robust performance with an accuracy of 0.9632. By aggregating the predictions of multiple decision trees, Random Forest reduces the risk of overfitting. The confusion matrix (Figure 15) showed fewer misclassifications compared to the standalone Decision Tree model, indicating improved stability. The precision-recall curve (Figure 16) and ROC curve (Figure 17) further affirmed the model's capability to balance precision and recall effectively. However, its slightly lower accuracy compared to KNN and Naive Bayes may be due to the inherent randomness in feature selection and data partitioning during the model's training phase.

	precision	recall	f1-score	support
female	0.9501	0.9765	0.9631	468
male	0.9766	0.9503	0.9633	483
accuracy			0.9632	951
macro avg	0.9633	0.9634	0.9632	951
weighted avg	0.9636	0.9632	0.9632	951

Figure 14. Result of Random Forest Model

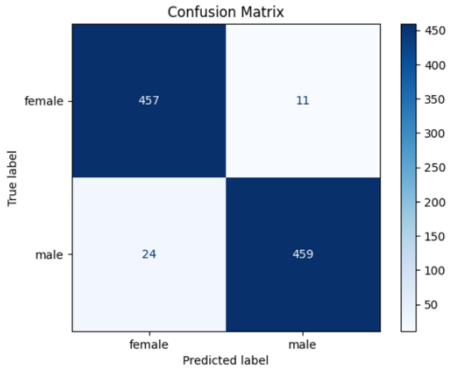

Figure 15. Confusion Matrix of Random Forest Model

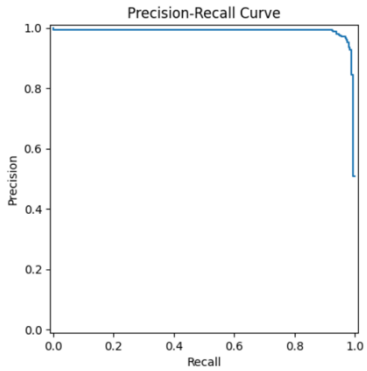

Figure 16. Precision-Recall Curve of Random Forest Model

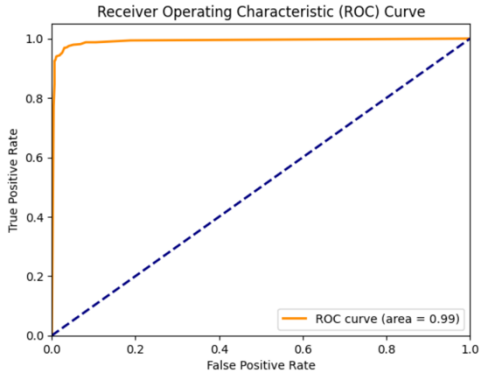

Figure 17. Receiver Operating Characteristic of Random Forest

XGBoost, a gradient boosting technique, achieved an accuracy of 0.9716, positioning it among the top-performing models. The confusion matrix (Figure 19) indicated a strong predictive capability with fewer misclassifications. XGBoost's ability to handle complex data patterns through iterative boosting makes it a powerful tool for gender identification. Its precision-recall curve (Figure 20) and ROC curve (Figure 21) showcased high performance, particularly in precision, indicating effective handling of imbalanced data. The model's hyperparameter tuning and handling of missing values contributed to its strong results, making it a viable option for large and complex datasets.

	precision	recall	f1-score	support
female	0.9603	0.9829	0.9715	468
male	0.9831	0.9607	0.9717	483
accuracy			0.9716	951
macro avg	0.9717	0.9718	0.9716	951
weighted avg	0.9719	0.9716	0.9716	951

Figure 18. Result of Xgboost Model

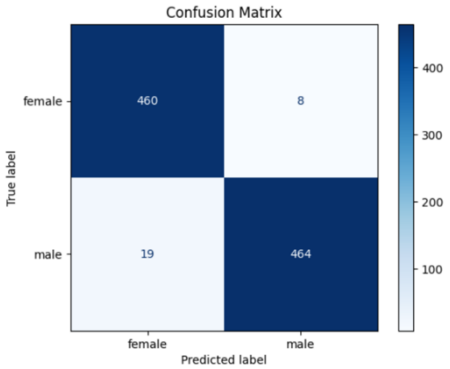

Figure 19. Confusion Matrix of Xgboost Model

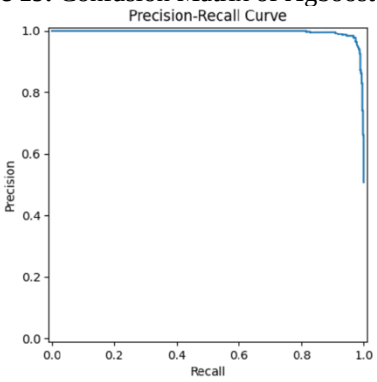

Figure 20. Precision-Recall Curve of Xgboost Model

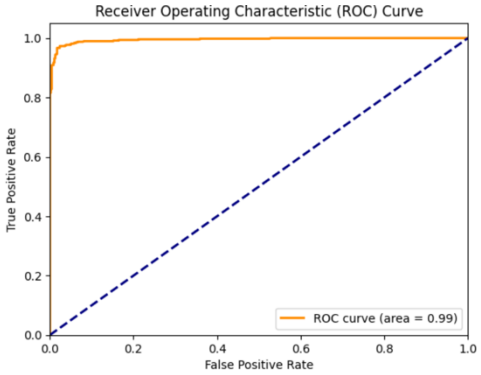

Figure 21. Receiver-Recall Characteristic of Xgboost Model

Support Vector Machine (SVM), with an accuracy of 0.9653, performed comparably to Decision Tree but slightly lower than XGBoost and KNN. The confusion matrix (Figure 23)

suggested some challenges in correctly classifying instances near the decision boundary. SVM's strength lies in its ability to find an optimal hyperplane that maximises class separation. However, it is sensitive to feature scaling, which was mitigated by applying Min-Max normalisation. The precision-recall curve (Figure 24) and ROC curve (Figure 25) indicated a robust model performance, though it could benefit from techniques like kernel trick enhancements to capture more complex data structures.

	precision	recall	f1-score	support
female	0.9560	0.9744	0.9651	468
male	0.9747	0.9565	0.9655	483
accuracy			0.9653	951
macro avg	0.9653	0.9654	0.9653	951
weighted avg	0.9655	0.9653	0.9653	951

Figure 22. Result of SVM Model

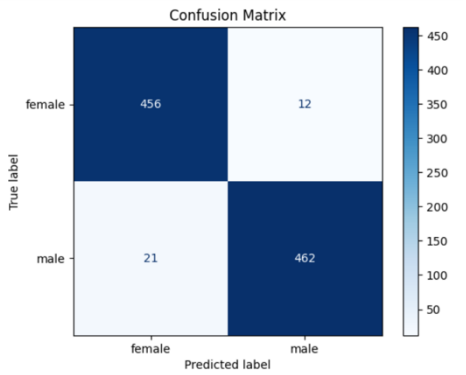

Figure 23. Confusion Matrix of SVM Model

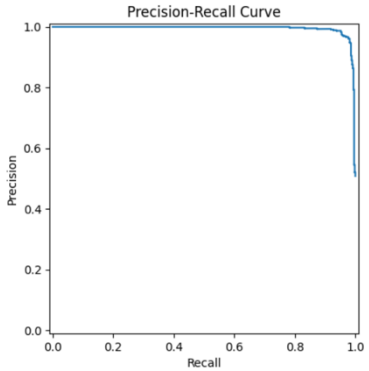

Figure 24. Precision-Recall Curve of SVM Model

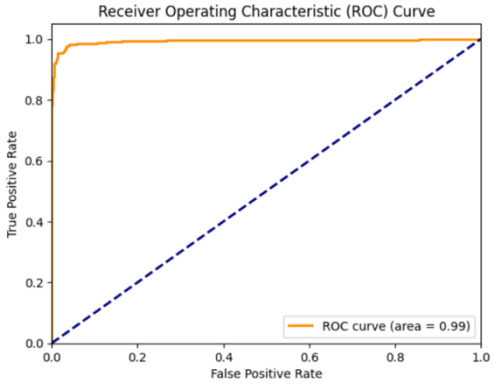

Figure 25. Receiver Operating Characteristic of SVM Model

Neural Network achieved an accuracy of 0.9748, closely trailing KNN. The confusion matrix (Figure 27) showed minimal misclassifications, suggesting that the model effectively captured complex patterns in the data. Neural Networks are particularly suited for tasks with non-linear relationships, benefiting from multiple hidden layers that learn hierarchical feature representations. The precision-recall curve (Figure 28) and ROC curve (Figure 29) demonstrated the model's ability to maintain high precision and recall across various thresholds. However, the computational cost and time for training were higher compared to simpler models like KNN, highlighting a trade-off between performance and efficiency.

	precision	recall	f1-score	support
female	0.9784	0.9701	0.9742	468
male	0.9713	0.9793	0.9753	483
accuracy			0.9748	951
macro avg	0.9749	0.9747	0.9748	951
weighted avg	0.9748	0.9748	0.9748	951

Figure 26. Result of Neural Network Model

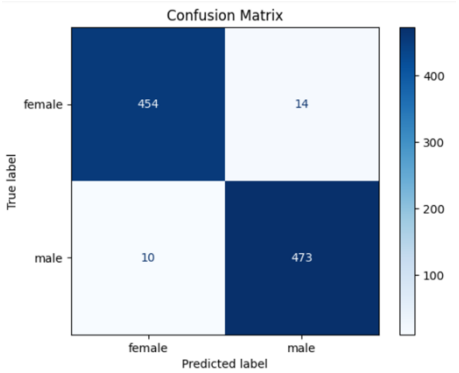

Figure 27. Confusion Matrix of Neural Network Model

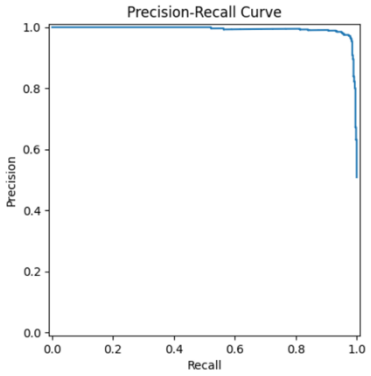

Figure 28. Precision-Recall Curve of Neural Network Model

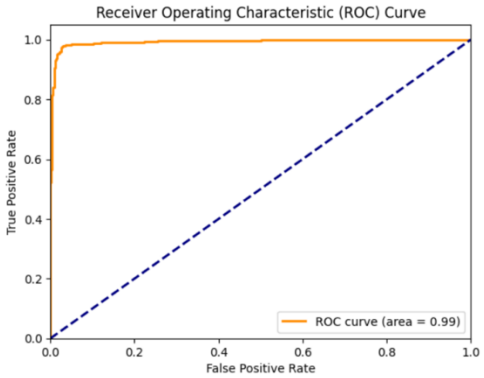

Figure 29. Receiver Operating Characteristic of Neural Network Model

Logistic Regression, while traditionally considered a baseline model, showed strong performance with an accuracy of 0.9727. The confusion matrix (Figure 31) revealed a slightly higher number of false negatives compared to KNN and Neural Networks. Logistic Regression's simplicity and interpretability make it a reliable choice for binary classification tasks, although it may struggle with non-linear data patterns. The precision-recall curve (Figure 32) and ROC curve (Figure 33) indicated satisfactory performance, but the model's assumptions of linearity could limit its applicability in cases with more complex data distributions.

	precision	recall	f1-score	support
female	0.9784	0.9658	0.9720	468
male	0.9673	0.9793	0.9733	483
accuracy			0.9727	951
macro avg	0.9728	0.9726	0.9726	951
weighted avg	0.9727	0.9727	0.9727	951

Figure 30. Result of Logistic Regression

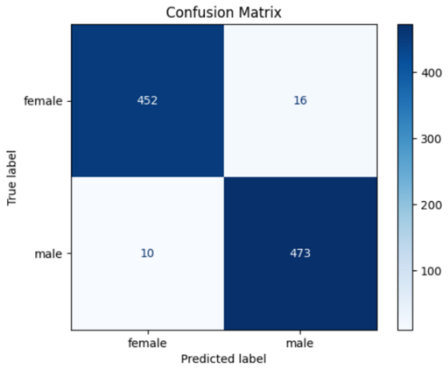

Figure 31. Confusion Matrix of Logistic Regression

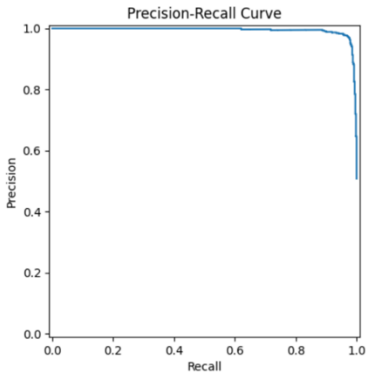

Figure 32. Precision-Recall Curve of Logistic Regression

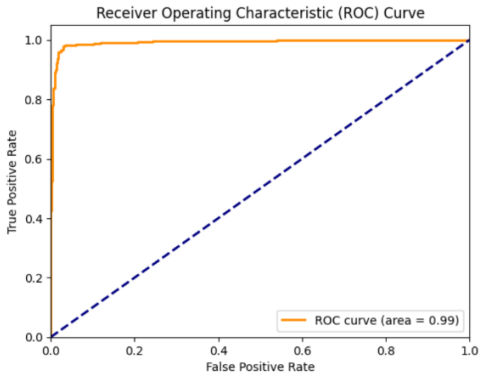

Figure 33. Receiver Operating Characteristic of Logistik Regression

This comparative analysis highlights the strength of KNN in gender identification tasks, especially when the dataset is well-normalised. Models like XGBoost and Neural Networks also show promising results, offering robust alternatives in scenarios where high computational power is available. The findings underscore the importance of selecting appropriate models based on the dataset characteristics and the specific requirements of the application, paving the way for further research into optimisation techniques and feature engineering to enhance classification accuracy.

4. Conclusions

This study has presented a comprehensive comparison of eight machine learning algorithms—K-Nearest Neighbors (KNN), Naive Bayes, Decision Tree, Random Forest, Logistic Regression, XGBoost, Support Vector Machine (SVM), and Neural Network—for the task of gender identification using voice data. Among these models, KNN emerged as the top performer, achieving the highest accuracy of 0.9758. The outstanding performance of KNN can be attributed to its capability to effectively capture the local structure of the data, making it highly suitable for tasks with well-defined clusters, as demonstrated in the gender identification dataset used in this research.

The results also highlighted the critical role of data preprocessing, particularly normalisation using Min-Max scaling, in enhancing the performance of machine learning models. By scaling the features to a uniform range, normalisation ensured that each feature contributed equally to the model's decision-making process, which was especially beneficial for distance-based algorithms like KNN and SVM. This finding underscores the importance of thorough data preparation in machine learning workflows, as it can significantly impact the performance and generalisability of the models.

While KNN showed superior performance, other models such as XGBoost and Neural Network also demonstrated strong predictive capabilities, offering viable alternatives in scenarios where higher computational power is available, or complex data patterns are present. The robust performance of ensemble models like Random Forest and XGBoost indicates their potential for handling diverse and complex datasets, reducing the risk of overfitting and improving generalisation. Additionally, simpler models like Logistic Regression provided competitive accuracy with the added benefit of interpretability, making them suitable for applications where model transparency is crucial.

This comparative study offers valuable insights into the strengths and limitations of different machine learning algorithms for gender identification tasks. It highlights the need for careful model selection based on specific dataset characteristics and application requirements. Future work could explore advanced feature selection techniques, optimisation strategies, and the integration of deep learning architectures to further enhance performance. These findings have significant implications for practical applications in areas such as marketing, social analytics, and security, where accurate gender identification can provide valuable insights and improve user experience.

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Improving mathematical problem-solving ability through models of problem based learning

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Abstract: students who receive conventional learning One of the aims of learning mathematics at school is to develop students' mathematical problem-solving abilities. This is in accordance with the objectives of mathematics learning in the independent curriculum set by the Curriculum and Educational Assessment Standards Agency. In the learning process using the Problem Based Learning model, students will be faced with various mathematical problems which are also related to daily life, so diligent and persistent efforts are needed from students to solve these various problems. This research is experimental research because the researcher applies a treatment to the research sample and then wants to know the effect of this treatment, namely in the form of increasing mathematical problem-solving abilities. The treatment given is learning using the Problem Based Learning model in the experimental class and conventional learning in the control class. The statistical test used to analyze data on increasing mathematical problem-solving abilities is the t* test. Based on the results of the t test, it was found that the sig value was 0.000 < 0.05 so that H0 was rejected, it could be concluded that the average mathematical problem-solving ability of students who receive learning through the problem based learning model is better than.

Keywords: problem based learning, problem solving, t test, educational assessment.

1. Introduction

Mathematics is a scientific discipline that has a big influence in advancing thinking power. Mathematics is also very useful in everyday life to prepare and develop logical, flexible and precise thinking skills to solve problems [1]-[3]. Therefore, mathematics has become an existing subject and must be taught at all levels of education. One of the aims of learning mathematics at school is to develop students' mathematical problem-solving abilities. This is in accordance with the objectives of mathematics learning in the independent curriculum set by the Educational Curriculum and Assessment Standards Agency or BSKAP [4], namely (1) understanding mathematics learning material in the form of facts, concepts, principles, operations and mathematical relationships and applying them flexibly, accurately, efficient, and precise in solving mathematical problems (mathematical understanding and procedural skills); (2) using reasoning on patterns and properties, carrying out mathematical manipulations in making generalizations, compiling evidence, or explaining mathematical ideas and statements (mathematical reasoning and proof); (3) solving problems which includes the ability to understand problems, design mathematical models, complete models or interpret the solutions obtained (mathematical problem solving); (4) communicating ideas using symbols, tables, diagrams, or other media to clarify situations or problems, as well as presenting a situation in symbols or mathematical models (mathematical communication and representation); (5) linking mathematics learning material to a field of study, across fields of study, across fields of science, and with life (mathematical connections); and (6) have an attitude of appreciating the usefulness

of mathematics in life, namely having curiosity, attention and interest in studying mathematics, as well as a creative, patient, independent, diligent, open, tough, tenacious and confident attitude in solving problems.

Developing and improving students' abilities to solve problems both in mathematics, other fields and in everyday life is very important to pay attention to and must be a top priority. However, the reality on the ground is just the opposite. Students' mathematical problem-solving abilities, especially junior high school students, are still very low. This can be seen from the results of the TIMMS and PISA studies which show that the abilities of junior high school students, especially in mathematics, are still below international standards. The 2015 TIMSS results placed Indonesia in 44th place out of 49 participating countries with an average score of 397, while the average score international 500 [5]. Meanwhile, the results of the 2018 PISA study were not much different, where Indonesia was ranked 73rd out of 79 participating countries with an average mathematics score of 379 with an OECD average score of 487 [6]. The TIMSS and PISA results show that there are still many students who cannot solve international standard mathematics problems. This is because the test questions tested in both TIMSS and PISA are non-routine questions or mathematical problem-solving questions.

Mathematical problem solving is an ability that requires students to be able to solve mathematical problems, especially problems related to everyday life. Problem solving ability is the ability or potential of students to solve problems and apply them in everyday life [7][8]. Problem solving abilities are also students' efforts to analyze and find solutions to the problems they face. According to Flavell and McCormick [9] metacognition in problem solving involves the process of planning, monitoring and evaluating problems as well as choosing the right strategy. Meanwhile, problem solving process uses various knowledge which leads to decision making, students in solving problems must have a strategy, namely understanding the problem carefully, distinguishing between what is known and what is the problem that is being asked or must be solved, then looking for the relationship between what is asked and what is known [10][11].

Apart from problem solving abilities, another aspect that is also needed in learning mathematics is the attitude that students must have, including enjoying mathematics, appreciating the beauty of mathematics, having high curiosity and enjoying learning mathematics. With this attitude, students are expected to continue to develop their mathematical skills, using mathematics to solve the problems they face in their lives. This is in accordance with the objectives of learning mathematics in the sixth point of the Independent Curriculum, namely having an attitude of appreciating the usefulness of mathematics in life, namely having curiosity, attention and interest in studying mathematics, as well as a creative, patient, independent, diligent, open, tough, tenacious attitude and confident in problem solving. A similar thing is also found in the National Council of Teachers of Mathematics [12] in its seventh point regarding the objectives of learning mathematics, namely the formation of a positive attitude towards mathematics.

According to Polya, there are four steps that can be taken in solving mathematical problems, namely understanding the problem, planning a solution (devising a plan), implementing the solution plan (carrying out the plan), and checking the results again. completion (looking back) [13]. In line with Polya's opinion, indicators for solving mathematical problems were also expressed by Wardhani and Rumiati, namely: (1) Identifying elements that are known, asked about, and the adequacy of the elements needed; (2) Formulate everyday situation problems in mathematics or develop mathematical models; (3) Selecting a solution approach or strategy; (4) Applying strategies to solve various problems, both similar and new problems within or outside

mathematics; and (5) Explain or interpret the results according to the original problem or check the correctness of the answers [14].

The low ability of students to solve mathematical problems in learning mathematics needs serious attention from all groups, especially mathematics teachers. Many factors cause students' low mathematical problem-solving abilities in the mathematics learning process. One of them is that learning is still too dominated by teachers (teacher centered). Therefore, an appropriate learning model is needed so that it can change the learning process from a teacher teaching situation to a student learning situation. One innovation that is thought to be able to realize a learning process like this is mathematics learning with the Problem Based Learning (PBL) model or problem-based learning. Problem-based learning or PBL is effective learning for high order thinking processes. This learning helps students to process information that has already been created in their minds and construct their own knowledge about the social world and their surroundings [3][15]. Learning with the PBL model, which begins by exposing students to real everyday problems or simulated problems, is expected to improve problem solving abilities. In the learning process using the PBL model, students will be faced with various mathematical problems, so diligent and persistent efforts are needed from students to solve these various problems.

Based on the background and problem formulation described above, the aim of this research is to examine the increase in mathematical problem-solving abilities of students who receive learning using the Problem Based Learning model better than students who receive conventional learning.

2. Materials and Methods

This research is experimental research because the researcher gave treatment to the research sample and then wanted to know the effect of the treatment. The treatment given is learning using the Problem Based Learning (PBL) model in the experimental class and conventional learning in the control class. The experimental research used in the research is a quasi-experimental type with a quantitative approach. The design used in this research is the Pretest Post-test Control Group Design [16]. The research design used can be described as follows:

Experimental class	A:	O	X	O
Control class	A:	O		O

Description:
A: Random sample selection class
O: Pre-test and post-test
X: Mathematics learning with the Problem Based Learning (PBL) model

The data in this research were obtained from a set of instruments used, namely mathematical problem-solving ability test instruments. Mathematical problem-solving ability tests were given to experimental class and control class students before and after learning. The initial test was given to see the equality of the initial abilities of the two classes, while the final test was given to find out how much the students' mathematical reasoning abilities had improved after learning using the Problem Based Learning (PBL) model. The mathematical problem-solving ability test questionnaire was first validated by several validators and tested on students.

The data analyzed is quantitative data in the form of test results of students' mathematical problem-solving abilities. The statistical test used in this research is the average difference test with the following steps:

1. Determine the pretest and post-test scores for mathematical problem-solving abilities for the experimental class and control class
2. Determine the score for increasing mathematical problem-solving abilities using the normalized N-gain formula.
3. Normality test of pretest score data and N-gain using the Shapiro Wilk test.
4. Homogeneity test of the N-gain variance using the Levene Statistics Test.
5. After the data meets the normal and not homogeneous, then test it using the t* test.

a. Calculating Normalized Gain (N-Gain)

Normalized Gain is calculated after the pretest and post-test are carried out. According to Hake normalized gain formula (Normalized Gain) = g [17]:

$$g = \frac{posttest\ score - pretest\ score}{maximum\ possible\ score - pretest\ score} \quad (1)$$

The N-gain points obtained are then analyzed using the criteria in the following Table 1 [18]:

Table 1. N-Gain Interpretation

N-Gain Scores	Interpretation
$\boldsymbol{g \geq 0,7}$	High
$\boldsymbol{0,3 \leq g < 0,7}$	Medium
$\boldsymbol{g < 0,3}$	Low

Based on the gain score criteria, learning is said to be effective if the learning results students get an n-gain score > 0.3 with medium or high criteria.

b. Normality Test

The normality test is used to determine whether the research data to be analyzed is normally distributed or not. Normality test can calculate by using SPSS software.
The hypothesis used to normality test in this research are:
H0 : data is normally distributed
H1 : the data is not normally distributed

The hypothesis for testing normality is reject H0 if Sig value < 0,05. and H0 is accepted if the Sig value. $\geq 0{,}05$ with a significant level by 5% or $\alpha = 0.05$.

c. Homogeneity Test

The homogeneity test is used to determine whether the research population have the same variance (homogeneous) or not. Homogeneity test can calculate by using SPSS software. Homogeneity test of the N-gain variance using the Levene Statistics Test.
The hypothesis of homogeneity test in this research are:
H0: the variance of the two groups is homogeneous
H1: the variance of the two groups is not homogeneous

The hypothesis for testing homogeneity is reject H0 if Sig value < 0,05. and H0 is accepted if the Sig value. $\geq 0{,}05$ with a significant level by 5% or $\alpha = 0.05$.

d. t* test

The t* test aims to determine whether there are differences in students' mathematical problem-solving abilities in classes that use the problem based learning model and classes that use conventional learning. The hypothesis used to test the average difference in this research are:

H0 : the average mathematical problem-solving ability of students who receive learning using the problem based learning model is the same as students who receive conventional learning

H1 : the average mathematical problem-solving ability of students who receive learning using the problem based learning model is better than students who receive conventional learning

The hypothesis for testing homogeneity is reject H0 if Sig value < 0,05. and H0 is accepted if the Sig value. $\geq 0{,}05$ with a significant level by 5% or $\alpha = 0.05$.

3. Results and Discussion

This research was carried out on class VII junior high school students consisting of 26 students in the experimental class and 27 students in the control class. The data used is data from pretest and post-test results in both classes. Pre-test and post-test data were obtained by giving test instruments in the form of problem-solving ability questions to each student. The questions used are valid questions. The following are the results of the pretest, post-test and N-gain from each class shown in the Table 2:

Table 2. Mean of Pretest, Post Test and N-Gain

	Experimental		Control	
	N	$\bar{x}$	N	$\bar{x}$
Pretest	26	34,65	27	29,01
Post Test	26	78,92	27	65,70
N-Gain	26	0,68	27	0,52

Based on the table above, it can be seen that the average pre-test score for the experimental class is 34.65, which is slightly higher than the control class with an average score of 29.01. The average post test score for the experimental class increased by 44.27 compared to the average pretest score. Meanwhile, in the control class, the average post-test score increased by 36.69. At a glance, it appears that the mathematical problem-solving abilities of the experimental class are better than those of the control class. This also shows that the treatment given to the experimental class had a more significant impact on learning outcomes than the control class. In addition, the N-gain value for the experimental class is higher than the control class, which shows that the intervention or treatment applied to the experimental class is more effective in improving students' abilities compared to the control class which was not given special treatment. The average N-gain for the experimental class was 0.68 and the average N-gain for the control class was 0.52 and both were in the medium category.

Table 3. Normality Test Results

	Class	Shapiro Wilk		
		Statistic	df	Sig.
Pretest	Experimental	0,933	26	0,093
	Control	0,958	27	0,338
N-Gain	Experimental	0,958	26	0,357
	Control	0,975	27	0,728

Based on the table above, it can be seen that the results of the normality test using Shapiro Wilk for both classes, namely experimental and control, have a sig value > 0.05, so H0 is accepted, which means that the pretest scores for students' mathematical problem-solving abilities in both classes are normally distributed. Likewise, the N-gain value of students' mathematical problem-solving abilities for both classes has a sig value > 0.05, so H0 is accepted, which means the N-gain value for both classes is normally distributed.

Table 4. Results of the N-Gain Data Homogeneity Test

	Levene Statistic	N	Sig.
N-Gain	7,031	53	0,11

Based on the table above, it can be seen that the N-gain value appears to have a sig value of 0.11<0.05 so that H0 is rejected, which means that the N-gain variance for the two classes is not homogeneous. Because the N-Gain values for both classes are normally distributed but not homogeneous, hypothesis testing uses the t* test.

Table 5. t* Test Results for N-Gain Data

	Class	t* test	
		t*	Sig.
N-Gain	Experimental	20,041	0,000
	Control		

Based on the table above, it can be seen that the sig value is 0.000 < 0.05 so that H0 is rejected, it can be concluded that the average mathematical problem-solving ability of students who receive learning through the problem based learning model is better than students who receive conventional learning.

4. Conclusions

Based on the average pretest, post-test and N-gain scores, it can be seen that the average test score for mathematical problem- solving ability of experimental class students was higher than that of the control class and increased from pretest to post-test. At a glance, it appears that the mathematical problem-solving abilities in the experimental class are better than those in the control class. This also shows that the treatment given to the experimental class had a more significant impact on learning outcomes than the control class.

Based on the results of data analysis, a sig value of 0.000 < 0.05 is obtained so that H0 is rejected and it can be concluded that the average mathematical problem-solving ability of students who receive learning through the problem based learning model is better than students who receive conventional learning.

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Finite Element Analysis On T-Type Bone Plate Using Stainless Steel 316l

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Abstract: Bone fractures refer to the phenomenon of bone breakage or detachment caused by intensive loads. The primary causes of bone damage include incidents, traffic accidents, and sports injuries. One of the materials commonly used for bone support applications is 316L stainless steel. The design process for T-type bone supports involves creating mechanical drawings and simulations to demonstrate the material's behavior when subjected to mechanical and thermal loads during use by patients.In this study, the researchers aim to examine the mechanical and thermal properties of T-type bone plates using the Finite Element Analysis (FEA) method. The technical drawing of the T-type bone support is developed in Autodesk Fusion 360. The simulations involve the application of static and thermal loads. The loads applied to the T-type bone plate include compressive forces of 1 N, 10 N, 50 N, 85 N and 500 N, as well as temperatures of 28°C, 500°C, 800°C, 950°C, and 1400°C. The smallest stress is observed at a force of 1 N, resulting in a stress of 4.64 MPa, while the highest stress is recorded at a force of 500 N, producing a stress of 2319.70 MPa. Forces below 50 N are considered the safest to avoid deformation during loading. Additionally, temperatures below 912°C are optimal for the operation of bone supports.

Keywords: Mechanical Properties, Thermal Properties, Bone Plate, Finite Element Analysis

1. Introduction

Fractures are a phenomenon where bones break or detach due to intensive loads. The causes of bone damage include incidents, traffic accidents, and sports injuries. When a fracture occurs, the human body biologically responds to the phenomenon. Patients will experience discomfort when they have a fracture. Additionally, the human body loses its biomechanical functions. The management of fracture healing is conducted in two stages. The first stage is to prevent the body from infection, and the second stage involves reconstructing the bone after the fracture. Bone reconstruction is usually assisted by bone supports, which aid the healing process. These supports facilitate bone regeneration, bear the body's weight, and maintain stability during activities [1]. Several biomaterials are used as bone supports to return the bone to its original position after a fracture. Some materials used for this application include titanium alloys and 316L stainless steel. These materials possess superior mechanical properties and are biocompatible with the human body. Their elastic modulus is approximately 110 GPa, which is significantly higher than that of bone, which ranges between 0.5 and 20 GPa [2]. With excellent mechanical properties, these materials can distribute the load applied to the fractured bone, facilitating bone remodeling.

Bone supports must effectively stabilize the bone. Therefore, various types of bone supports must be capable of stabilizing and connecting fractured bones. One commonly used bone support is the T-type bone support, which can stabilize bones from multiple sides. The design process for T-type bone supports involves mechanical calculations and drawings. Once the mechanical drawings are completed, the next step is to simulate the loading on the bone support under various loads. When a T-type bone support is used in a patient's body, it will experience compressive and tensile forces, as well as exposure to the human body's temperature. Hence, it is essential to simulate the bone support's loading using mechanical and thermal loads, ranging from low to critical levels.This research investigates the behavior of T-type bone support materials made of 316L stainless steel when subjected to mechanical and thermal loads, ranging from low to critical levels**.**

1.1. Mechanical Properties

Stainless steel used for T-type bone plate applications is inevitably subjected to compressive loads. This necessitates an in-depth evaluation of the mechanical properties of 316L stainless steel utilized for T-type bone plate applications. Mechanical properties refer to a material's response to force or load. These properties can be identified by observing the material's behavior under mechanical loads [3]. The mechanical property analyzed in this case is the compressive strength experienced by the 316L stainless steel material in T-type bone plate applications.

When stainless steel is subjected to tensile forces, it undergoes dimensional changes. Before the tensile force is applied, the material's cross-sectional dimensions do not experience elastic or plastic deformation. However, upon applying tensile force, the cross-sectional dimensions undergo elastic and plastic deformation. The material's behavior under such loads is illustrated in **Figure 1** If the applied tensile force remains below the material's yield strength, the material exhibits elastic deformation, meaning that the cross-sectional dimensions will revert to their original state once the load is removed.

Conversely, if the tensile force exceeds the yield strength, the material experiences plastic deformation, meaning that the cross-sectional dimensions will not return to their original state when the load is removed. As the tensile force increases to the maximum tensile strength (TS), the material undergoes necking, forming a narrow section. Point M represents the maximum stress and strength of the material. If the force continues to increase, the cross-sectional area continues to decrease until the material fractures. Point F denotes the stress and strain at the material's fracture [4]. Compressive forces follow the same principles as tensile forces. However, under compressive loads, the force direction opposes that of tensile forces, causing an increase in cross-sectional dimensions. Mechanical properties can be determined through testing, such as tensile testing. This test involves applying force perpendicularly to a specimen, which is typically shaped like a "dog bone" to mimic bone structure. The material is then loaded on both sides of the cross-sectional surface [5]. Results from tensile testing include values for stress and strain. The parameters are calculated using the following formulas:

$$\boldsymbol{\sigma = \frac{F}{A_0}} \text{ and } \boldsymbol{\varepsilon = \frac{\Delta l}{l_0}}$$

Where :

σ = stress (N/mm^2)
F = force(N)
A_0 = Initial Cross Area (mm^2)
ε = strain
Δl = Deformation (mm)
l_0 = Intial Length (mm)

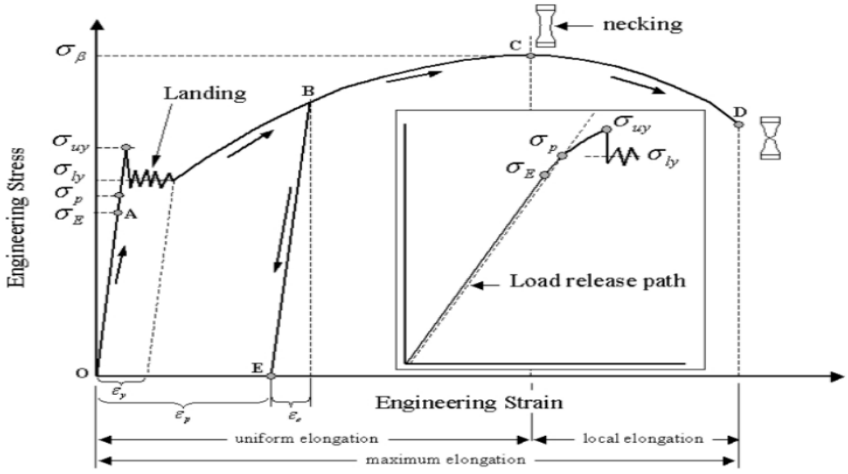

Figure 1 Material Behavior Under Tensile Force

2.2. Thermal Properties

Thermal properties describe a material's response to heat loads. Heat energy absorbed by a material affects its dimensions. Heat transfers from high-temperature regions to low-temperature regions within the material. Thermal properties include thermal expansion, thermal capacity, and thermal conductivity (Joshi, 2023). Understanding these properties is crucial to avoid thermal shock, which occurs due to localized thermal stress in specific regions of the material. Thermal shock results from high temperatures affecting thermal conductivity and specific heat [6]). To mitigate thermal shock, various methods can be employed, such as adding kaolin to the material to enhance its thermal stability [7]. The thermal property analyzed in this study is thermal conductivity, which reflects the material's behavior under heat loads. Thermal conductivity represents heat transfer from high-temperature to low-temperature regions. It is measured using heat flux, calculated as follows (Callister Jr & Rethwisch, 2020) [8] :

$$q = -k\frac{dT}{dx}$$

Where:

q = Heat flux (W/m²)
k = Thermal conductivity (W/m.K)
dT/dx = Temperature gradient (K/m)

2.3 Bone Support (Bone Plate)

Bone fractures occur due to intense loads around the bone, commonly caused by accidents [1], traffic injuries [9), sports activities, or pathological fractures [2] According to WHO data, approximately 40 million patients globally undergo bone repair and joint reconstruction annually [10]. Bone fractures often result in mechanical damage and mental health challenges for patients.

Bone fracture management involves reducing bone infection and reconstructing long bones. Advanced technology is required for reconstruction to enable bones to bear loads and accelerate healing. Using advanced bone support technologies aids in repairing, replacing, and restoring bone function while alleviating pain and enhancing patient quality of life. One method of repairing bone fractures is by implanting bone supports in the fractured area. Current research focuses on designing implants for intensive biomechanics. Materials used for bone support applications include 316L stainless steel and titanium alloys. These materials are biocompatible, interact well with the implanted bone, and possess excellent mechanical strength, aiding in stress distribution and bone remodeling.

2.4. Finite Element Analysis (FEA)

Finite Element Analysis (FEA) is a method for simulating physical systems based on mechanics, mathematics, and computational theories [11]. This method divides materials into small components delineated by lines, allowing the behavior of the smallest material components to be analyzed. The results from these components are aggregated to determine the material's overall properties. The outcomes of FEA include load distribution diagrams showing how applied loads transfer across the material's surface **Figure 2** demonstrates FEA applied to a biodiesel reactor.

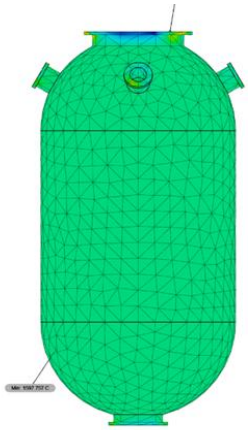

Figure 2 Finite Element Analysis on a Biodiesel Reactor

FEA can analyze stress caused by external forces on a material. It reveals material characteristics, such as stress, strain, and deformation, which indicate the material's strength and stiffness. This analysis is popular due to its speed and ability to test various loads and materials. FEA addresses complex mechanical challenges by selecting suitable materials and applying loads to external surfaces. It provides data on stress, strain, and deformation while also illustrating mechanical load distribution across the material's surface. Additionally, it shows thermal load distribution within the material [13].

2. Materials and Methods

The tools and materials used include a computer with the following specifications: Intel Core i5 10300H processor, minimum 4 GB RAM, 512 GB NVMe SSD, 15.6" Full HD 144Hz display, operating system of at least Windows 10 Home, and Autodesk Fusion 360 version 2.0.16009. The data utilized includes the specifications of the T-Type Bone Plate and the dimensions of the T-Type Bone Plate.

3. Results and Discussion

3.1. Mechanical Properties

The mechanical properties of the T-type bone support using 316L stainless steel are shown in **Table 1.** The force applied to the T-type bone support ranges from 1 N to 500 N, causing stress variations due to the applied force. Additionally, the force also affects the deformation and strain within the T-type bone support

Table 1. Stress and Strain in T-Type Bone Support

Force (N)	Stress (MPa)	Deformation (mm)	Strain (%)
1	4,64	0,00	0,003
10	46,40	0,02	0,027
50	231,97	0,08	0,001
85	394,35	0,13	0,002
500	2319,70	0,75	0,014

The force applied to the T-type bone support induces stress in the material. **Figure 3** illustrates the increase in stress within the T-type bone support caused by the applied force. The smallest stress occurs at a force of 1 N, producing a stress of 4.64 MPa. The highest stress is observed with a force of 500 N, generating a stress of 2319.70 MPa.

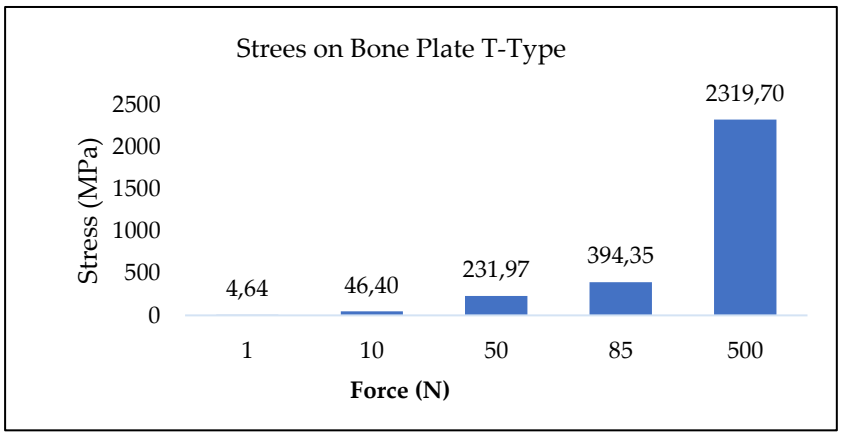

Figure 3 Stress in T-Type Bone Support

Deformation also occurs due to the stress applied to the external part of the T-type bone support. **Figure 4** shows the deformation in the T-type bone support. Deformation starts at a force of 10 N, resulting in a deformation of 0.02 mm and a strain of approximately 0.027%. The highest deformation is observed at a force of 500 N, resulting in a deformation of 0.75 mm and a strain of 0.014%.

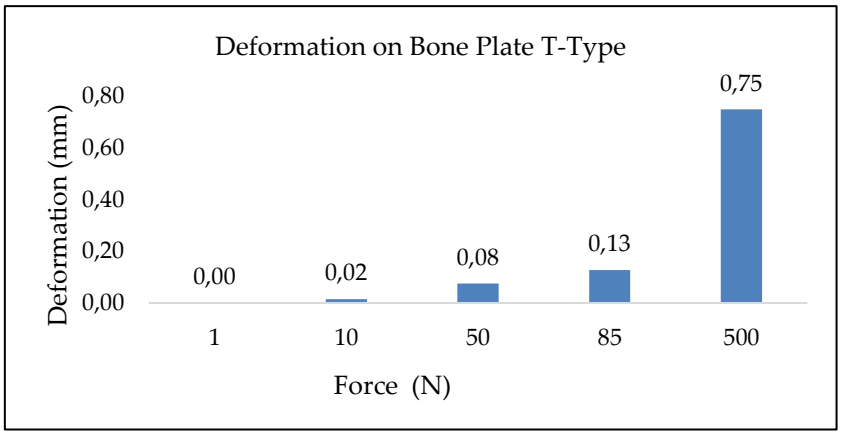

Figure 4 Deformation in T-Type Bone Support

The greater the force applied to the T-type bone support, the higher the internal stress generated. This corresponds to the stress equation, which shows a direct relationship between

the applied force and the resulting stress. At the atomic scale, the applied force causes a very small elastic strain between the grains, with interatomic bonds stretching and creating interatomic spacing in the stainless steel. In contrast, during plastic deformation, atomic bonds between one grain and its neighbor break and form new bonds with neighboring grains. This phenomenon causes stress and strain in the 316L stainless steel material due to the applied force [3]. Forces below 50 N are considered the safest to prevent deformation during loading. However, forces of 85 N and 500 N cause the T-type bone support to undergo plastic deformation and fracture.

4.2 Thermal Properties

External heating of the T-type bone support affects the thermal properties of the material. Heat loads applied range from 28°C to 1400°C. The smallest heat flux is observed at 28°C, measuring . Similarly, the thermal gradient increases with the rise in temperature. The smallest thermal gradient is observed at 28°C, measuring 641.4 $x10^{-8}$ ^{o}C/mm, while the highest is at 1400°C, measuring 43,230 $x10^{-8}$ ^{o}C/mm. The effects of temperature on heat flux and thermal gradient in the T-type bone support are shown in **Table 2**.

Table 2. Heat Flux and Thermal Gradient in T-Type Bone Support

Material	Suhu (^{o}C)	Heat Flux (W/mm^2) ($x10^{-8}$)	Termal Gradient (^{o}C/mm) ($x10^{-8}$)
Stainless Steel 316L	28	10,45	641,4
	500	193,3	11860
	800	223,7	20080
	950	358,8	22010
	1400	704,6	43230

The temperature increase on the external part of the material shows a rise in heat flux and thermal gradient throughout the reactor. At the atomic scale, external heat causes the metal bonds in stainless steel to stretch [4]. Continuous heating eventually leads to bond chain elongation and rupture. The elongation process changes the phase of the stainless steel material. **Figure 5** shows the phase changes in stainless steel due to temperature and chromium (Cr) content. Stainless steel 316L contains about 11–15% chromium. Below 912°C, the phase formed in stainless steel is the α phase, and the material remains solid.

The structure does not change until the temperature exceeds 912°C. At temperatures above 912°C, part of the stainless steel transitions to the γ phase, altering its structure. Grain diffusion begins within the internal material, leading to changes in all mechanical and thermal properties, rendering them non-compliant with standards. Therefore, temperatures below 912°C are optimal for operations in bone plate.

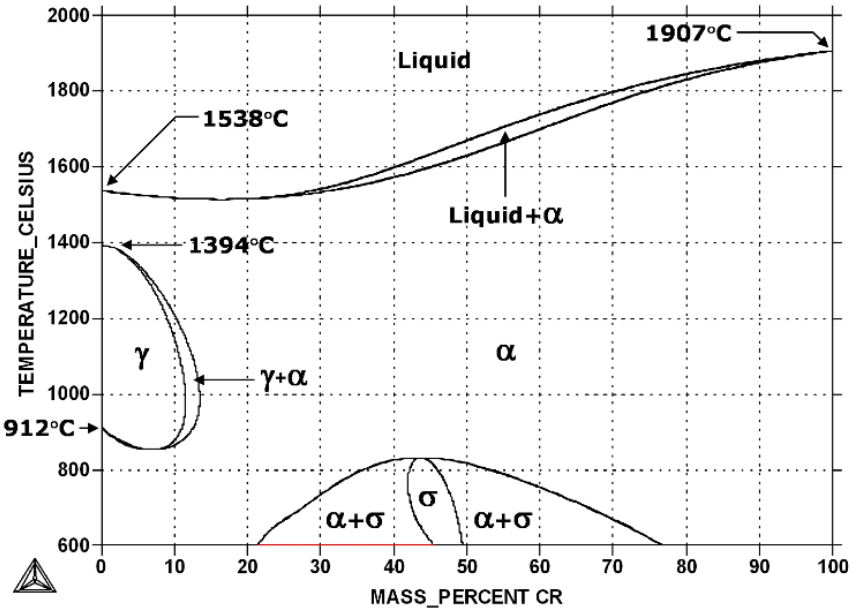

Figure 5 Stainless Steel Phase Diagram

4. Conclusions

The larger the force applied to the T-type bone support, the greater the stress generated internally. This corresponds to the stress equation, which indicates a direct relationship between the applied force and the resulting stress. The lowest stress occurs with a force of 1 N, producing a stress of 4.64 MPa. In contrast, the highest stress is observed with a force of 500 N, producing a stress of 2319.70 MPa. Additionally, the applied force affects the deformation and strain within the T-type bone support. This is because the stress applied to the T-type bone support causes an increase in deformation and strain values. The smallest deformation and strain are observed at the lowest force of 1 N, resulting in a strain of 0.003%. Meanwhile, the largest deformation occurs at a force of 500 N, with a deformation of 0.75 mm and a strain of 0.014%. Heat flux and thermal gradient increase with the rise in temperature applied to the T-type bone support. This is due to structural changes in the internal parts of the T-type bone support caused by the temperature increase.

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Analysis of Briquettes Characteristics Made of Oil Palm Frond Waste and Sugarcane Bagasse with

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Abstract: Oil palm frond waste and sugarcane bagasse are high-fiber biomass materials that can be converted into alternative energy sources like briquettes. The carbonization method is used to create charcoal briquettes, converting raw organic materials into carbon. The produced charcoal is mixed with a adhesive and molded into cylindrical or block shapes. This study aims to determine the characteristics of briquettes with varying compositions of palm fronds and bagasse (50:50 ; 40:60 ; 30:70 ; 20:80 ; 10:90 (b/b)) and different tapioca starch adhesive amounts (40% ; 45% ; 50% ; 55% (v/b)). In this study, tests were conducted on moisture content, ash content, calorific value, and combustion rate. The research findings indicate that the best-quality charcoal briquettes were produced by combining sugarcane bagasse and palm fronds in a 50:50 ratio with a adhesive containing 40% tapioca starch. These briquettes have the following properties: moisture content of 4.4545%, ash content of 4.62021%, combustion rate of 0.2283 g/min, and calorific value of 6,232.67 cal/g. These results indicate that the briquettes made from a mixture of oil palm frond waste and sugarcane bagasse using tapioca starch as a adhesive have met the SNI 01-6235-2000 standard criteria.

Keywords: Charcoal briquettes, carbonization, sugarcane bagasse, oil palm fronds, and tapioca starch

1. Introduction

Energy is an essential component of many commercial activities and communal life. Fossil fuels, as non-renewable energy sources, continue to play a crucial role in meeting current energy needs. Since 1995, Indonesia's fuel demand has exceeded domestic production, and the country's oil reserves are projected to be depleted within 10 to 15 years. The scarcity of gasoline in various regions supports this projection. Despite the relatively low demand for chemical raw materials in Indonesia, it continues to grow and is fulfilled through imports. Indonesia is rich in biodiversity, which can be utilized for energy production.

Biomass energy is one type of alternative energy that can be used. Biomass is generally referred to as dry organic matter or the material remaining after plants or other organic materials have lost their water content. Burning is a common way to eliminate biomass, often regarded as waste. Biochar, a fuel with a relatively high calorific value, can be made from this biomass for daily use. Biomass is readily found from waste-producing activities such as agriculture, livestock, forestry, plantations, and fisheries.

On the other hand, biomass contains less carbon and a large amount of volatile substances. Although its calorific value is moderate, the ash content varies depending on the type of material.

Biomass combustion is initiated at a low temperature due to its high volatile component content. This low-temperature devolatilization process indicates that biomass combustion is simple. According to Jamalitun (2008), combustion occurs very quickly and can be difficult to control [1]. Biobriquettes made from sugarcane bagasse and oil palm frond waste are one such alternative fuel. Due to the ease of obtaining sugarcane bagasse and oil palm frond biomass, both high in cellulose content, they hold potential for conversion into biobriquettes. The quality of biobriquettes improves with higher cellulose content [2].

The sugarcane plant (Saccharum officinarum) grows well in tropical regions, including Indonesia. Generally, sugar factories process sugarcane into sugar, producing bagasse as a byproduct. Bagasse is a common term for sugarcane waste. Currently, bagasse is often used as boiler fuel in sugar factories and as a raw material for compost. Bagasse contains 48–52% water and its chemical composition includes 3.01% silica, 22.09% lignin, 37.65% cellulose, 27.97% pentosan, 3.82% ash, and 3.3% reducing sugars [3].

Given the above, researchers are considering utilizing sugarcane bagasse and oil palm frond waste as raw materials for briquette production to reduce waste accumulation, historically a human challenge. The most common oil palm plantation waste suitable for briquette production is oil palm fronds. To ensure optimal quality in accordance with SNI standards, researchers are experimenting with various combinations of bagasse and palm frond charcoal.

2. Materials and Methods

Materials and tools required for this study are: sugarcane bagasse, oil palm fronds, tapioca starch, porcelain crucible, analytical balance, spatula, basin, stirrer, desiccator, oven, 60-mesh sieve, cylindrical briquette mold, combustion furnace, beaker, hot plate, and measuring cylinder.

The preparation of raw materials for this research involves several stages. For sugarcane bagasse, it is cleaned, cut into 3-5 cm pieces, and sun-dried. Once dry, it is gradually burned in a furnace at 300°C for 30 minutes, cooled, ground into fine powder, and sieved with 50-mesh. Similarly, oil palm fronds are separated, cut, dried, and burned at 300°C for 60 minutes before being processed into powder. Tapioca starch adhesive is prepared by mixing it with distilled water, heated until clear and thick. The briquette mixture of oil palm frond powder and sugarcane bagasse (50:50, 40:60, 30:70, 20:80 and 10: 90) with adhesives of 40, 45, 50 and 55% is pressed into cylindrical molds, baked at 105°C for 2 hours, cooled, and tested for moisture, ash content, combustion rate and calorific value.

3. Results and Discussion

3.1. Moisture content analysis

The effect of the ratio of sugarcane bagasse and oil palm fronds with adhesive concentration variations on moisture content can be seen in Figure 1 as follows:

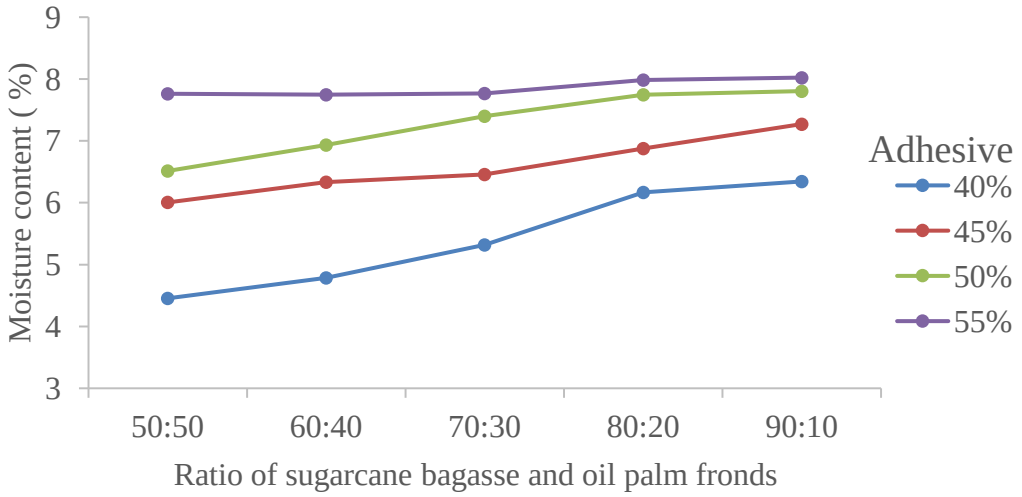

Figure 1. Effect of the ratio of sugarcane bagasse and oil palm fronds with adhesive concentration variations on moisture content

Based on Figure 1, it is shows that as the adhesive concentration increases, the resulting moisture content also increases. This is due to the adhesive's sticky and hard properties, which influence the bonding strength in briquettes. This observation aligns with the research conducted by Smith and Idrus (2017), which states that higher adhesive usage tends to increase the moisture content in briquettes [4]. The figure also demonstrates that the higher the proportion of sugarcane bagasse, the higher the resulting moisture content. This is because sugarcane bagasse has a higher moisture content compared to oil palm fronds. This finding is supported by another research stated that the variation in results is influenced by raw materials with significantly high moisture content [5].

From the analysis and testing of briquettes made from sugarcane bagasse and oil palm fronds, the lowest moisture content is 4.4545% was observed in a mixture of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with 40% tapioca flour adhesive. Meanwhile, the highest moisture content is 8.0229% was observed in a mixture of 90 grams of sugarcane bagasse and 10 grams of oil palm fronds with 55% tapioca flour adhesive.

The variation in moisture content percentages in the briquettes made from sugarcane bagasse and oil palm fronds with tapioca flour adhesive demonstrates that mixing these materials leads to an increase in moisture content in the charcoal briquettes. However, it can be concluded that the sugarcane bagasse and oil palm frond briquettes with tapioca flour adhesive meet the standards of SNI 01-6235-2000, which specify a maximum moisture content of 8% for charcoal briquettes. The test results in this study show an average moisture content of <8%, as illustrated in Figure 1.

Moisture content significantly affects the quality of the produced charcoal briquettes. The lower the moisture content, the higher the calorific value of the briquettes. High moisture content makes briquettes difficult to ignite during combustion, produces more smoke, and reduces ignition temperature and combustion efficiency [6].

3.2. Ash Content Analysis

The effect of the ratio of sugarcane bagasse and oil palm fronds with tapioca flour adhesive concentration show that the lowest ash content was found in the ratio of 90 grams of sugarcane bagasse and 10 grams of oil palm fronds with a 40% adhesive concentration, producing an ash content of

4.6172%. Meanwhile, the highest ash content is 7.877%. was observed in the ratio of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with a 55% adhesive concentration. The influence of sugarcane bagasse and oil palm fronds on the ash content is illustrated in Figure 2.

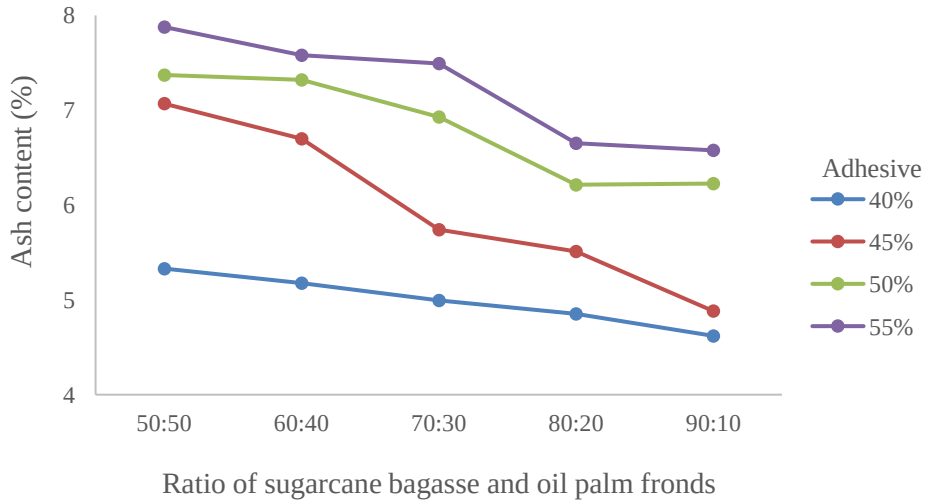

Figure 2. Effect of the ratio of sugarcane bagasse and oil palm fronds with adhesive concentration variations on ash content

The analysis in figure 2 shows that the adhesive concentration of 40% has a lower ash content compared to adhesive concentrations of 45%, 50%, and 55%. High ash content affects the calorific value produced; the higher the ash content, the lower the quality of the resulting charcoal briquettes. This is because ash contains silica, which can lower the calorific value. Ash content is also influenced by the type of raw material used. The higher adhesive concentrations increase the ash content of briquettes [7].

Based on the Indonesian charcoal briquette quality standard, SNI 01-6235-2000, which states that the maximum allowable ash content is 8%, the ash content produced in the study is in accordance with the SNI standard.

3.3. Combustion Rate Analysis

The results of the combustion rate analysis on briquettes made from sugarcane bagasse and oil palm fronds are shown in Figure 3.

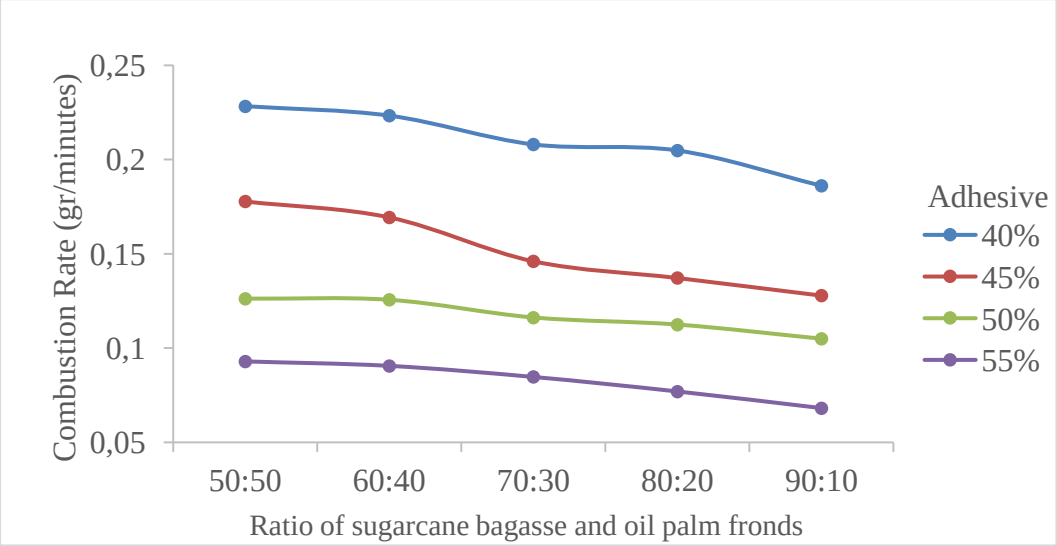

Figure 3. Effect of the ratio of sugarcane bagasse and oil palm fronds with adhesive concentration variations on combustion rate

Based on the above figure, it shows that the greater the amount of adhesive in the briquette, the longer the combustion time. This is because the higher the proportion of adhesive, the higher the moisture content, which slows down the combustion rate. A higher adhesive content also causes the briquette to become denser, making it harder for oxygen to penetrate, which results in a longer combustion process. This finding is consistent with the another research, which states that the higher the adhesive percentage, the lower the combustion rate of the briquette [8].

From the analysis and testing of sugarcane bagasse and oil palm frond briquettes conducted, the lowest combustion rate 0.0681 g/min was obtained in the mixture of 90 grams of sugarcane bagasse and 10 grams of oil palm fronds with a 55% adhesive. Meanwhile, the highest combustion rate 0.2283 g/min was obtained in the mixture of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with a 40% adhesive. Based on figure 3, the combustion rate of sugarcane bagasse and oil palm frond briquettes ranged from 0.0681 to 0.2283 g/min. The graph shows that as the composition of oil palm frond increases, the combustion rate also increases.

3.4. Calorific Value Analysis

The calorific value determining the quality of the briquettes produced. The higher the calorific value, the higher the quality of the briquettes [9]. The calorific value is important to know in order to determine the heat output that the briquettes can generate as fuel. This is because the combustion process requires carbon to react with oxygen to produce heat. The calorific value of charcoal briquettes is influenced by the amount of bound carbon in the briquette [10].

The calorific value is the amount of heat produced per unit weight from the combustion process of a combustible material [11]. The primary parameter in determining the quality of briquette fuel is the calorific value. The results of the calorific value analysis of the sugarcane bagasse and oil palm frond briquette mixture are shown in the table below.

Table 1. Calorific Value Analysis Results

No	Composition (grams)	Adhesive (%)	Calorific Value (J/g)	Calorific Value (Kal/g)
1	50 : 50	40	26077	6.232,67
2	50 : 50	50	25755	6.155,59
3	50 : 50	55	25650	6.130,497

The table above shows that the lower the adhesive concentration, the higher the calorific value obtained. This is because, as seen from the moisture content and ash content, the higher the moisture content in the briquette, the lower the calorific value of the resulting briquette. The higher the calorific value, the better the quality of the briquette, so the amount of briquettes needed for combustion decreasing [12].

From the analysis and testing of sugarcane bagasse and oil palm frond briquettes conducted, the lowest calorific value 6.130497 kcal/g was obtained in the mixture of 50 grams of oil palm fronds and

50 grams of sugarcane bagasse with 55% tapioca flour adhesive. Meanwhile, the highest calorific value 6.23267 kcal/g was obtained in the mixture of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with 40% tapioca flour adhesive. Based on the calorific value analysis, the sugarcane bagasse and oil palm frond briquette mixture meets the SNI 01-6235-2000 standard, with a minimum calorific value of 5000 kcal/gram

4. Conclusions

The best results from this research is the composition of sugarcane bagasse and oil palm fronds with tapioca flour adhesive at 40% adhesive, with a moisture content of 4.4545%, ash content of 4.6202%, a combustion rate of 0.2283 grams/minutes, and a calorific value of 6232.67 kcal/g. The less adhesive used, the higher the calorific value, the lower the moisture and ash content in the briquette, and the higher the combustion rate. The results of the charcoal briquette tests meet the SNI 01-6235-2000 standard, and the best briquette is found in the mixture of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with 40% tapioca flour adhesive.

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Feasibility Of Developing An Augmented Reality (Ar) Science Module With Audio Integration Using Assemblr Edu: A Case Study On Matter And Its Changes

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Abstract: The study aims to evaluate the feasibility of Augmented Reality (AR)-based science learning media with audio features, using the 4D development model (Define, Design, Develop, Disseminate). The media was developed to facilitate more interactive and immersive science learning through AR visualizations and audio explanations that assist in understanding complex concepts. The development stages include: (1) Define, to analyze the needs and learning objectives; (2) Design, to design AR and audio-based media; (3) Develop, to create the media prototype and conduct feasibility tests through validation by subject matter and media experts; and (4) Disseminate. Data were collected through questionnaires and observations, then analyzed descriptively. The evaluation results show that the learning media was rated as "highly feasible" by experts, particularly in terms of content accuracy, interactivity, and audio quality. With these positive results, the AR and audio-based media is deemed feasible for use in science learning and has the potential to enhance teaching methods in schools.

Keyword: *Augmented Reality, Science Learning, Learning Media*

1. Introduction

The term science refers to a wide variety of knowledge and is also an objective way of gaining that abstract information based on facts regarding the natural world1 beaming with both tangible and intangible things. Matter and its changes are one of the important topics that introduced in elementary school with a part of the science learning objectives in Phase B based on currently implemented Merdeka Curriculum in Indonesia. It is vital that students understand this topic because it also accounts for a wide variety of natural occurrences in their everyday lives such as the evaporation and freezing of water, and condensation [1]. These topics provide a solid foundation for students that is necessary to grasp more complex scientific concepts when they reach higher levels of education.

The research revealed the urgency of the education due to the implications that matters in state changes have started to be more clear and present in daily life [2]. For example, the transformations of solids to liquid and gas and vice versa, is an important property as they apply to areas such as environmental science while also solving everyday problems that we face at home. But this is only one of the reasons so many students struggle with what matter is and how it changes. Misconception is common in science education, students often have misconceptions of basic science concepts [3].

Misconceptions in this area have a lasting impact on student learning. Such misconceptions can make it more challenging for them to build upon existing understanding, and thus more difficult to grasp advanced concepts later on. Make matters worse, it will stop them from applying what they have learned to the real world and it could show poor reasoning or decision making with bigger consequences. If students have a wrong understanding of the water cycle, which is based entirely on

changes in matter, they may be confused by aspects of weather or environmental issues [4]. Moreover, students who struggle to comprehend science constructs are more likely to lose interest and confidence in themselves leading into decreasing achievement [5].

Learning modules, which are designed to help students learn and understand concepts, are one solution to some of these learning challenges. An excellent learning module is an important link between both types of teachers and students, by offering information in a structured and comprehensive way. This is to ensure that the concept or material taken by learners would be further understood along with high engagement in the learning process [6]. Learning modules that engage students' attentiveness and motivation result in better learning outcomes [7].

21st-century technology is changing the future of education by sharing devices with the whole classroom, as advancements in digital tools can prove to enhance learning significantly. It encourages to interact, promotes and enhance learning experience. An exciting technological tool with a lot of buzz in the past few years is Augmented Reality (AR). Augmented reality (AR) is a technology for interactive learning that combines elements of the real world with a virtual environment, by superimposing real two- or three-dimensional objects into physical space [8].

Integrating AR into the teaching and learning process in educational settings is still relatively novel and unexplored. However, AR has already been implemented in subjects like science, specifically the concepts of matter and its transformations. Students now have the opportunity to interact with difficult subjects in a unique and more operative approach. The use of AR-based elements significantly increases the level of student engagement and overall learning outcomes by enhancing students' ability to understand science even for abstract phenomena [9].

Besides having the ability to interact with the user, AR can also be enhanced further by the inclusion of audio features. The integration of the visual and audio elements improves the overall learning experience for different learners as well as make the process of learning more interesting. Assemblr Edu, an AR platform, allows its users to produce AR content effortlessly with the use of 3D models and audio. Considering its ease of use, it is less complicated than other 3D modeling softwares owing to its minimal programming requirements. Users of Assemblr Edu are not limited to the use of its internal features since it supports external 3D modeling images, thus increasing the potential for content development and remains an efficient tool in the development of educational modules [8].

The goal of this research is to create a science module based AR using Assemblr Edu that focus on topic matter and its changes. Some audio integration features are also included in the module to improve students' interest and understanding. The objective is to evaluate if AR and audio can be effectively integrated into educational modules, so as to make the learning of science concepts more engaging to learners. Such a module design is anticipated to alleviate the misconceptions and the challenges that students encounter when learning about matter and its change making the learning of the subject more efficient and enjoyable. The combination of Augmented Reality and audio-visual aids in particular science modules is a promising approach in enhancing the quality of the science curriculum. Through the use of the technology which is interactive and interesting, teachers are able to assist the learners understand complex scientific ideas, encourage them and in the end, improve their understanding and performance. This research intends to expand the existing literature regarding the use of AR in primary science education.

2. **Researh Methods**

This study employs a Research and Development (R&D) methodology aimed at developing a product, specifically an Augmented Reality (AR) science module integrated with audio, using Assemblr Edu for the topic of matter and its changes. The development process follows the 4-D model, which includes the stages of Define, Design, Develop, and Disseminate.

The parameters measured in this study include feasibility of media by experts. The Feasibility Level of the AR Science with Audio Module assesses how appropriate and effective the module is for educational purposes. The feasibility test will be carried out by two media experts and two subject matter experts, each of whom assesses the module based on their area of expertise. The assessment will focus on aspects such as the layout of the design and illustration of the images, audio aspects, ease of use, and benefits for users. Material validation by subject matter experts assesses several aspects, including content quality, presentation and communication, as well as aspects of learning strategies.

The percentage of validity can be calculated using the formula:

$$\text{Results} = \quad \times 100\%$$

The feasibility categories are determined according to the following criteria:

Table 1. Media Feasibility Criteria.

Score in percent (%)	Feasibility Criteria
81 – 100 %	Highly feasible
61 – 80 %	Feasible
41 - 60 %	Quite Feasible
21 – 40 %	Not feasible
< 21%	Very not feasible

3. Results and Disscusion

This research aims to develop and assess the feasibility of Augmented Reality (AR)-based science modules with audio integration using the Assemblr EDU platform, with a focus on the material and its changes. The 4D model (Define, Design, Develop, Disseminate) guides the development process.

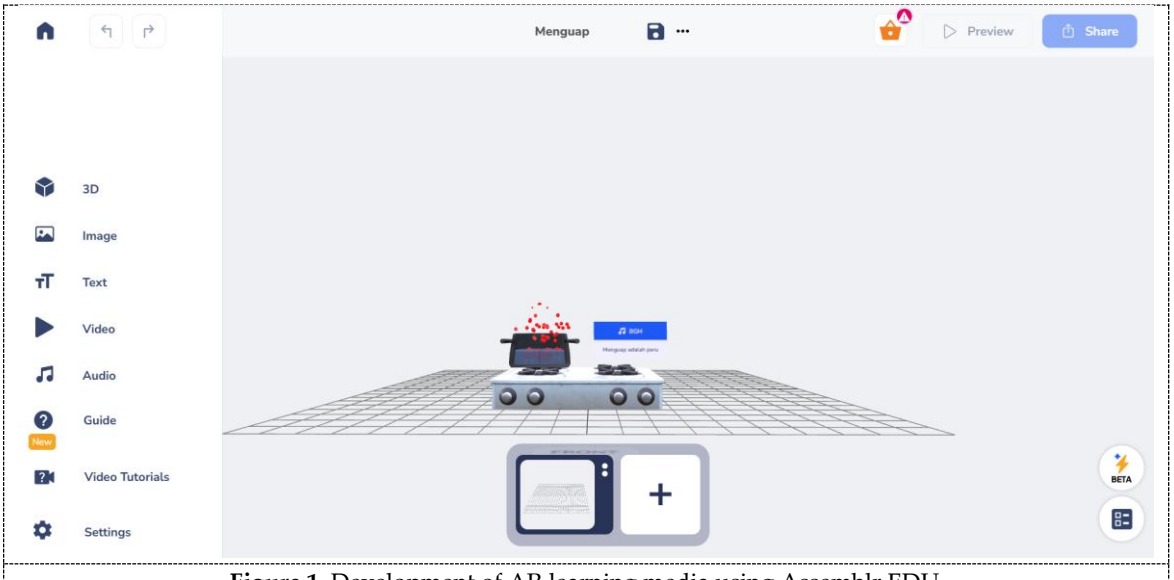

Figure 1. Development of AR learning media using Assemblr EDU.

In the Define stage, the needs analysis reveals students' difficulties in understanding physical and chemical changes. The Design stage involves identifying key concepts, creating a content framework with the teacher, and ensuring coverage of important topics such as the properties of the material and changes. In the Develop stage, 3D objects representing solid, liquid, and gaseous states, along with examples of changes, are created. Audio explanations are synced with AR visuals for a holistic learning experience. Prototypes are tested to ensure functionality, by engaging media and subject matter experts to get feedback. Revisions are carried out before the classroom trial, to ensure the module is informative and effective in improving students' understanding of science concepts.

After completing the module's prototype, the internal testing is done by the team who checks, for example, how objects are being interacted with, the quality of audio, or the responsibility of the platform. Then, the feasibility of the modules is tested, which includes sending them to media and material experts. The feedback from the expert make it possible to suggest appropriate revisions and improvements. This process of hastening towards vetting the modules is to make sure that its quality for student-teacher testing has already been achieved. Hence the idea is to ensure that the module will be educative while at the same time promoting students' understanding of elaborate scientific ideas. It is also possible, and it is the case here, that plain-text comments had to be provided by the project experts in order to assure the conceptual coherence of the module. This aspect of development is key in making the module suitable for broader classroom application by enhancing its functionalities and suitability in actual learning situations. The validation results from the experts are summarized in the following table.

Table 2 Media expert validation

Statement	Percentage (%)
Media Design	87.5%
Layout and Image Illustration	95.8%
Presentation and Language Aspect	93.8%
Ease of Use	87.5%
User Benefits	96.4%
Average	**92.2%**

The Validation results of the Augmented Reality (AR) science module with sound affirm that the module has been highly feasible in almost all the scored parameters. A 92% score was recorded for the media design which has corroborated with earlier research findings emphasizing the relevance of efficiently designed digital learning tools in captivating the students [6]. In this aspect, several parameters were assessed by media experts such as the appearance of the AR science module cover, the suitability of the AR media size with android standards, the attractiveness of the AR science module cover, the suitability of the letters used, the selection of the right typeface, the clarity of the letters, spacing and spacing in normal text, whether the module displays a supportive color contrast, color attractiveness, the suitability of the color of the writing, display an attractive background. The layout and illustrations aspect which assesses the arrangement of layout elements on the cover gives a good impression, displays the center of view, the placement of layout elements is consistent based on the writing pattern, the use of illustrations of problems related to daily life received 87.5%, and text

inconsistency still remained a target area for future improvement. Most respondents 95.8% mentioned, the highest score that the audio part obtained, emphasized the importance of clear and synchronized audio in achieving the desired learning outcomes [10]. Audio-visual synchronization in learning media can attract children's attention to the word they are currently hearing. In addition, it also helps improve children's reading skills so that children's understanding of texts also increases [11]

Figure 2. Cover of the AR science learning module.

The language and presentations of the module also performed well at 93.8%, which lends credence to the fact that the use of precise and simple language helps in improving understanding [7]. Efficacy of application smartphones rated at 87.5% suggests that the module does not require much technical knowledge to handle, although some improvements must be made on application speed. In general, an overwhelming 92.2% was the total validity score of the developed AR-based module and therefore it is readily applicable in science education as it employs creative and captivating techniques to support students learning experiences.

Table 2 Subject matter expert validation

Statement	Percentage (%)
Content of the Media	96.8%
Presentation and Communication	97.5%
Aspect for Learning Strategy	96.9%
Average	**97%**

Based on the results of validation by two material experts on Augmented Reality (AR)-based science modules and Assemblr Edu-based audio, it can be concluded that this media has a very high feasibility. The assessment shows an overall average score of 97%, which indicates that the module meets the standards for use in science learning. This score is obtained by assessing the following statements: learning in the media is in line with the basic competencies (KD) and core competencies, the material presented in the media is in accordance with the basic competencies (KD) and core competencies, the presentation of the material is carried out in order, the material in the media is presented in complete,

the material presented can help understanding other topics, the material in the media is delivered clearly without complication, Dialogue or story text in the media is right on target with the material, the learning topic is presented clearly, the concept of the material is conveyed in accordance with scientific standards, the formulas and symbols are written in accordance with scientific standards, the audio explains the material appropriately, the problems in the media are related to daily life, the illustrations are in accordance with the content of the material in the media, the evaluation questions are presented clearly in the media, Evaluation questions include all the material that has been presented and the image objects displayed in accordance with the material taught.

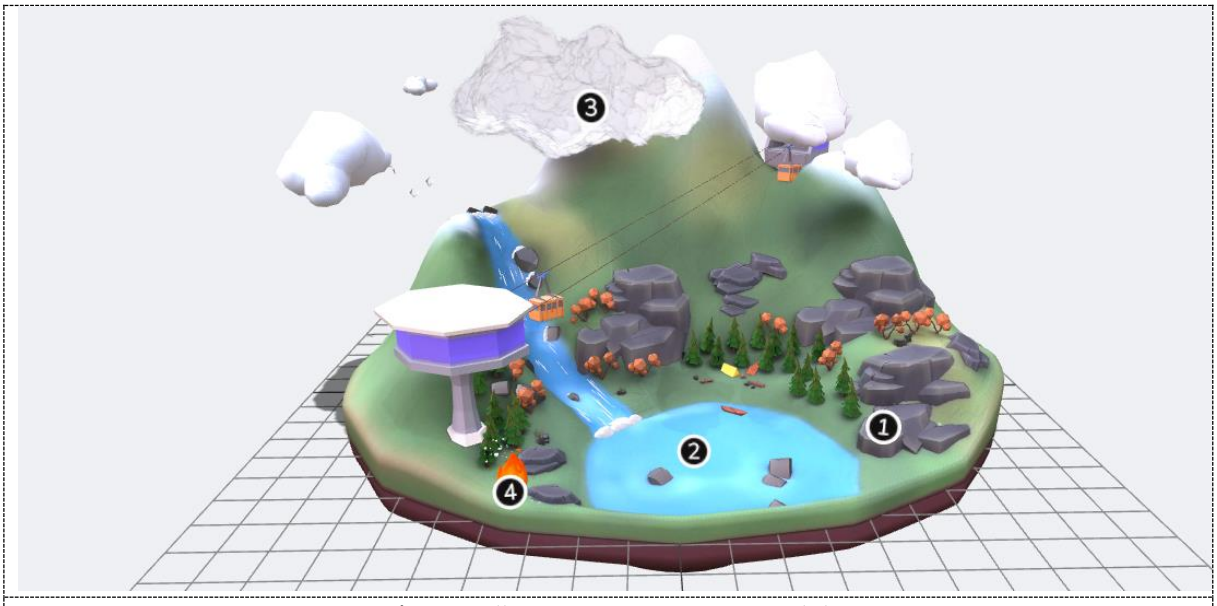

Figure 3. Illustration in AR science modul.

In terms of media content, the validity reached 96.8%, emphasizing that the learning objectives and materials presented were in accordance with the basic competencies and core competencies. The material is delivered in order, complete, and relevant to daily life, helping students in understanding important concepts. The suitability of illustrations and evaluation questions with the material also received high scores, showing that this media supports students' understanding comprehensively.

In terms of presentation and communication, this module is rated very good with a validity score of 97.5%. The language used is easy for learners to understand, while the use of audio helps clarify the material. The use of the right language flow allows students to understand the material effectively.

The aspect of learning strategies also received a validity score of 96.9%. This module is considered to be able to increase student motivation, support the learning process, and can be used in various other learning models. Based on these results, the AR science module based on Assemblr Edu is declared very feasible to be used as an innovative learning media. Learning media that has been deemed suitable based on the assessment of media experts and material experts, needs to be further tested, namely practicality and effectiveness tests [12, 13]. Science learning using AR improves students' analytical skills and provides a better understanding of science learning [14, 15]

4. Conclusion

Based on the research results, the development of the Augmented Reality (AR)-based science module, enhanced with audio via the Assemblr Edu platform, has been deemed highly feasible as a teaching medium. Media validation testing by experts achieved a score of 92.2%, categorized as highly

feasible, while content validation by subject matter experts received a score of 97%, also in the highly feasible category.

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Analysis of Prospective Teachers' Abilities to Designing Artificial Intelligence-Based Learning Media

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Abstract: This research evaluates the capability of prospective teachers to design learning media that effectively incorporates Artificial Intelligence (AI). Conducted within the Mathematics Education Study Program at Malikussaleh University, the study highlights the significant role of AI in education during the Society 5.0 era, particularly in enhancing the quality of learning. Using a descriptive quantitative research method, data was collected through a questionnaire distributed to 60 students in the Mathematics Education Study Program. The findings clearly indicate that 33,33% of respondents fall into the medium ability category, while 53.33% are classified as high and 13.33% as very high in their ability to design AI-based learning media. These findings suggest that while a majority of prospective teachers demonstrate strong competencies in designing AI-based learning media, a notable 33,33% remain in the medium category and may require additional support. It is crucial to enhance skills in creating AI-based learning media to ensure that prospective teachers are well-prepared to address the challenges of education in the digital age. This research provides valuable insights into the abilities of prospective teachers and is expected to serve as a key reference for developing more effective training programs in the future.

Keywords: Ability, Prospective Teachers, Learning Media, Artificial Intelligence.

1. Introduction

The current technological advancements in the era of Society 5.0 are progressing at an unprecedented pace, particularly in the field of education. These developments have significantly impacted various aspects of education, aiming to enhance its quality. A notable trend in this technological landscape is artificial intelligence (AI). In the educational sphere, AI is frequently utilized to support teachers in the implementation of learning processes. AI, a branch of computer science, focuses on creating systems capable of performing tasks that typically require human intelligence [1].

The integration of AI in education can significantly enhance the ability of teachers to develop learning tools, particularly interactive learning media. By utilizing AI in the educational process, teachers can implement adaptive and engaging learning experiences [2]. Additionally, AI enables educators to create diverse learning resources that reflect current trends, preventing the learning experience from becoming monotonous. It is widely recognized that effective learning media is essential for a successful educational process..

The use of learning media is essential in the teaching and learning process. It serves as a bridge for educators to convey the material, fostering greater enthusiasm among students

during learning activities. Learning media plays a crucial role in enhancing both the effectiveness and efficiency of achieving educational objectives [3]. Previous research conducted by Mukarromah & Andriana [4] stated that learning media can quickly and easily increase students' understanding of the material being studied. Furthermore, learning media can increase students' motivation to learn and master the material independently [5]. This shows that learning media is really needed in the teaching and learning process. So in terms of creating AI-based learning media it can be used as a solution for teachers to increase enjoyable learning.

Based on the explanation provided, it is evident that AI-based learning media plays a crucial role in facilitating practical, effective, and efficient learning. However, in practice, challenges remain in the development of such AI-driven resources. Many teachers still rely on conventional teaching methods and struggle to incorporate technology into their learning media creation [6]. In addition to that, there are numerous issues associated with selecting learning media that align with students' needs. These challenges should be addressed, as they can impede learning and lead to a decline in academic performance, ultimately making it difficult to enhance the quality of education.

To mitigate these issues related to the development of learning media, particularly those based on AI, researchers will undertake a study to analyze the capabilities of prospective teachers in designing AI-driven educational resources. This initiative aims to prepare qualified and competent educators.

2. Materials and Methods

This research employs a descriptive quantitative method, grounded in positivist philosophy, to examine research samples and populations [7]. The descriptive quantitative approach is utilized to present data in numerical form, reflecting the findings of the study. In this context, the researchers aim to quantitatively assess the abilities of prospective teachers in designing artificial intelligence-based learning media.

The study's population consists of prospective mathematics teacher students from Malikussaleh University. The sample includes 60 students from the mathematics education program, specifically those in their fifth and seventh semesters. These students were selected because they have completed coursework related to the fundamentals of learning media, the use of technology, basic pedagogy, and both basic and advanced mathematics..

Data collection techniques refer to the methods researchers employ to gather information pertinent to their studies. In this research, data was collected through a questionnaire utilizing a Likert scale, which offers five response options: Always (SL), Often (SR), Sometimes (KD), Ever (P), and Never (TP). Consequently, the percentage of responses can be calculated by dividing the frequency of each answer by the total population surveyed using this scale.

The researcher opted for a Likert scale to assess the varying degrees of responses, ranging from very positive to very negative. This questionnaire was administered to prospective teachers to evaluate their abilities in designing AI-based learning media. Below is a scoring guideline table for assessing the prospective teacher's proficiency in developing AI-driven educational resources..

Table 1. Scoring Guidelines for Prospective Media Design Teachers' Ability Scale AI-based learning

	Skor				
Statement Type	SL	SR	KD	P	TP
Positive	5	4	3	2	1
Negative	1	2	3	4	5

Source : [8]

The formula used to calculate the percentage is as follows:

Index Formula (%) =) $= \frac{\textit{total score obtained}}{\textit{maximum score}} \boldsymbol{x100}\%$ (1)

Table 2. Percentage Value Categories

Persentase (%)	Categories
$0 \leq S < 20$	Very Low
$20 \leq S < 40$	Low
$40 \leq S < 60$	Medium
$60 \leq S < 80$	High
$80 \leq S \leq 100$	Very High

Source : [8]

Data collected through a questionnaire on the ability of prospective teachers to design AI-based learning media will be processed statistically using Microsoft Excel and SPSS version 26 software.

3. Results and Discussion

3.1 Results

This research aims to assess the capability of prospective teachers in designing learning media that incorporates Artificial Intelligence. The study was conducted within the Mathematics Education Study Program at the Faculty of Teacher Training and Education, Malikussaleh University. Data collection involved distributing a questionnaire to 60 prospective teachers.

The findings reveal that all 60 respondents completed the questionnaire, which evaluated their ability to design AI-based learning media across five specific aspects. The collected data was subsequently categorized into five criteria: very low, low, medium, high, and very high. Below is the distribution of the categories reflecting the prospective teachers' abilities in designing AI-based learning media.

Table 3. Categories of Prospective Teachers' Ability in Designing Media AI Based Learning

Persentase	Categories	**Number of Respondents**
$0 \leq S < 20$	Very Low	0
$20 \leq S < 40$	Low	0
$40 \leq S < 60$	Medium	20
$60 \leq S < 80$	High	32
$80 \leq S \leq 100$	Very High	8
Amount		60

Based on table 3, the number of respondents was 60 prospective teachers. It is known that 33,33% of prospective teachers have the ability to design AI-based learning media in the medium category with the number of respondents being 20 prospective teachers, 53.33% of prospective teachers have the ability to design AI-based learning media in the high category with the number of respondents being 32 prospective teachers, and 13,33% There are 8 prospective teachers who have the ability to design AI-based learning media in the very high category. This can be seen from the fact that there are still respondents who fall into the medium category, so attention is still needed to improve the ability to design AI-based learning media for prospective teachers.

3.2 Discussion

AI-based learning media plays a pivotal role in enhancing the quality of education, particularly in today's digital age. The capacity of future educators to design learning media that

incorporates AI technology is essential for creating interactive and effective learning experiences. Key aspects of this ability include understanding AI concepts, technological proficiency, readiness for implementation, innovation and creativity, as well as collaboration. These elements are vital for developing media that engages learners and facilitates optimal educational outcomes.

This research was conducted within the Mathematics Education Study Program at FKIP, Malikussaleh University, with 60 prospective teachers participating in the completion of a questionnaire. With this representative sample size, the research aims to accurately portray the capabilities of prospective teachers in designing AI-based learning media. According to Sugiyono[9], systematic data collection is the key to ensuring the validity and reliability of research results, so that the findings can be trusted and used for further development. In addition, it is important for prospective teachers to continue developing skills in dealing with rapid technological change.

Research has indicated that 33,33% of prospective teachers possess the ability to design AI-based learning media at a medium proficiency level, highlighting the need for targeted attention in this area. However, the majority of prospective teachers fall into the high and very high proficiency categories. This finding aligns with Piaget's constructivism theory, which posits that knowledge is developed through experience. Supporting this, research conducted by [10] confirms that incorporating technology into education enhances students' skills and comprehension. According to Yanti et al [11], adapting to new technology is essential in the realm of education to ensure effective teaching and to enrich students' learning experiences. Therefore, having a solid understanding and skill set in designing AI-based learning media is crucial for preparing prospective teachers to meet the challenges of future educational landscapes..

4. Conclusions

Based on the previous discussion, it was concluded that the overall average ability to design AI-based learning media among prospective teachers is 33,33%, placing them in the medium category. This conclusion is drawn from a group of 20 respondents. In contrast, 53,33% of the prospective teachers, comprising 32 individuals, fall into the high category, while 13,33% represent the very high category, accounting for 8 respondents.

It is important to improve the skills of prospective teachers in designing AI-based learning media, considering the increasingly important role of AI in education in this digital era. Increasing these skills will not only prepare prospective teachers to face future educational challenges, but can also enrich students' learning experiences through the use of more interactive, adaptive and interesting learning media. Therefore, it is necessary to develop more effective and sustainable training programs so that prospective teachers can be better prepared to utilize technology, especially AI, to improve the quality of education.

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Improving Efficiency and Accuracy of Quantity Take-Off Through BIM Integration: A Case Study of the D Lecture Hall Building at Malikussaleh University

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Abstract. Quantity Take-Off (QTO) calculation is a crucial step in construction planning to determine material needs with high accuracy. However, traditional methods such as manual calculations often fail to meet accuracy demands, especially in projects with complex designs. This study compares manual methods, Revit, and Clash Detection in generating QTO for the D Lecture Hall building project at Malikussaleh University. The aim of this research is to analyze the quantitative differences between methods and assess which method is the most effective. The research method involves calculating the QTO for structural and architectural elements using the three methods, followed by an analysis of the average differences in results. The findings show that the manual method has an average difference of 35.76% for structural elements and 43.14% for architectural elements when compared to Revit. The difference between manual and Clash Detection is slightly smaller, with 33.09% for structural elements and 42.41% for architectural elements. Conversely, the difference between Revit and Clash Detection is very small, only 1.51% for structural elements and 3.98% for architectural elements. While the QTO results between Revit and Clash Detection are almost identical, Clash Detection offers the additional advantage of validation, ensuring that the design is free from clashes between elements. This study concludes that Clash Detection is the most effective method in generating QTO because it not only provides accurate results but also ensures that the design is ready for implementation without technical errors. By integrating BIM technology, this research offers a more efficient and accurate approach to QTO calculation, serving as a guideline for construction project managers in handling complex designs more effectively.

Keywords: *Quantity Take-Off (QTO), Clash Detection, Building Information Modeling (BIM).*

1. Background of the Research

Infrastructure development in Indonesia is one of the main priorities of the government at present (Indrayani, 2022). Infrastructure development in Indonesia is becoming increasingly massive, requiring greater efficiency, accuracy, and quality in construction projects. One of the crucial steps in construction projects is Quantity Take-Off (QTO), which is used to calculate the material requirements of a project. QTO is an effort by contractors to calculate the volume, which will later be used as material for preparing the Bill of Quantities (BOQ) in tenders and

also serve as a basis for procurement. (Laorent et al., 2019). However, traditional methods such as manual calculations often fail to meet the standards of efficiency and accuracy, especially for projects with complex designs.

With the advancement of technology, Building Information Modeling (BIM) has become a modern solution that allows for more accurate QTO calculations through 3D digital modeling. The application of BIM results in more accurate calculations, faster work, and facilitates communication and integration (Setiawan & Abma, 2021). Software such as Revit and Navisworks enable model integration and clash detection between elements, providing more consistent results and eliminating design errors. This study uses the D Lecture Hall building at Malikussaleh University as a case to evaluate the effectiveness of manual methods, Revit, and Clash Detection in generating QTO.

2. Problem Statement

How does the comparison of QTO results using manual methods, Revit, and Revit-Navisworks integration in the D Lecture Hall building project at Malikussaleh University?

Which method is the most effective in producing accurate and efficient QTO?

3. Research Objectives

Comparing the QTO results between manual methods, Revit, and Clash Detection.

Determining the most effective method to improve the efficiency and accuracy of QTO in the context of construction projects.

4. Research Significance

This research is expected to provide the following benefits:

QTO Method Selection Guide: Providing a data-driven foundation for construction practitioners to choose the appropriate QTO method based on project needs.

Improvement in Efficiency and Accuracy: Offering insights into the effectiveness of BIM technology in minimizing errors and enhancing project productivity.

5. Caku Scope of Analyzed Elements

This table presents the structural and architectural elements that are the focus of the QTO analysis in this research.

Table 1. Structural and Architectural Elements Compared

NO	Structural	Architectural
1	Footing and Pile Cap	Ceramic Flooring
2	Columns K1, K2, and Pedestal	Masonry and Plastering
3	Practical Columns	Facade
4	Pit Lift Column	Ceiling (Interior Area)
5	Sill Beam	Ceiling (Exterior Area)
6	Sill Beam and Pit Lift Beam	Conwood
7	Beam	0.3 mm Spandek Metal Roof Tiles
8	Floor Beam	
9	Floor Slab	
10	Staircase	

11	Steel Roof Truss	

6. Basic Concepts of QTO and BIM

QTO is the calculation/measurement of materials and labor required to complete a construction project based on the working drawings and specifications that have been determined. (Wiranti et al., 2022). QTO is often used as the basis for preparing the Bill of Quantity (BoQ) and project cost estimation. The traditional QTO method is done manually using spreadsheets based on two-dimensional drawings, which are often prone to errors.

BIM is a process that begins with creating a 3D digital model, which contains all the information about the building. It serves as a tool for planning, designing, constructing, and maintaining the building. (Suasira et al., 2021). The advantages of BIM include accuracy, efficiency, and collaboration among stakeholders. BIM dimensions can extend up to 7D, including geometry (3D), time (4D), cost (5D), sustainability (6D), and maintenance (7D).

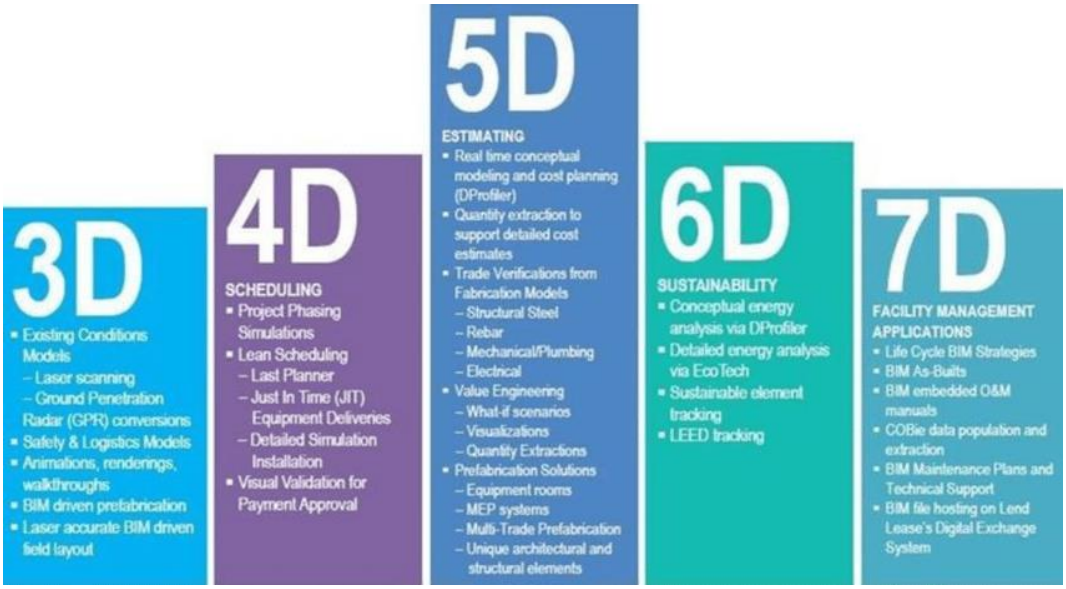

Figure 1. BIM Dimension Terminology
Source: https://www.researchgate.net

7. Software Used

Revit is a BIM software from Autodesk for architectural, structural, and mechanical, electrical, and plumbing (MEP) design. With this software, users can design buildings from structure to MEP by modeling 3D components and displaying 2D working drawings, as well as analyzing QTO simultaneously across all work disciplines (Arissaputra & Yaya, 2023).

Navisworks is an application that assists in the design and scheduling process of structural, architectural, mechanical, electrical, and plumbing work within a project (Afriani et al., 2024). In complex construction projects, collaboration between various disciplines becomes crucial.

8. Research Methodology

This research uses a quantitative approach to evaluate the effectiveness of three Quantity Take-Off (QTO) methods:

Manual Method: This method involves analyzing working drawings and BoQ using spreadsheets. It serves as a reference for comparing the results of the calculations.

Revit Method: This method involves modeling structural and architectural elements in 3D format using Autodesk Revit software, which automatically calculates volumes and material requirements.
Clash Detection Method: This method integrates the Revit model with Navisworks to detect and resolve clashes between design elements. This process ensures the accuracy and validity of the QTO results.
The statistical analysis method in this study aims to compare the QTO results from the three methods: manual, Revit, and Clash Detection. The comparison is made by measuring the absolute differences between methods to identify variations in results. The percentage difference is used to evaluate the relative differences between the methods. Additionally, the average difference identifies trends in errors between methods, while the average percentage difference measures the average deviation compared to the manual method. This analysis helps assess the accuracy and efficiency of each method.

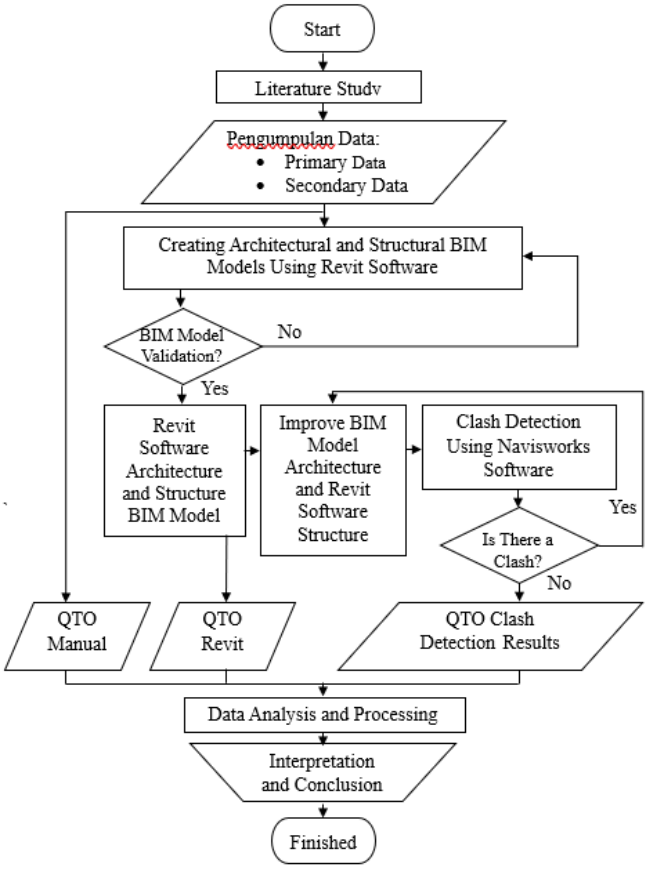

Figure 2. Research Flowchart

9. Data Collection Techniques

Primary Data: QTO data calculated directly using Revit software (with and without Clash Detection).
Secondary Data: BoQ documents and working drawings (As-Built Drawings) of the General Lecture Building D project at Universitas Malikussaleh.

10. Results and Discussion

Table 2 presents the QTO calculation results for structural elements using the manual, Revit, and Clash Detection methods. These calculations include concrete volume, steel weight, and

formwork area for the structural elements.

Table 2. Calculations of Methods for Structural Elements

Structural Elements							
N0	**Elements**	**Sub-Elements**	**Code**	**Unit**	**Method**		
					Manual	**Revit**	***Clash Detection***
1	Shallow Foundation and Pile Cap	Concrete Volume	S1	m3	1.00	1.00	1.00
2		Steel Weight	S2	kg	1.00	0.98	0.98
3		Formwork Area	S3	m2	1.00	1.00	1.00
4	Columns K1, K2, and Pedestal	Concrete Volume	S4	m3	1.00	0.99	0.99
5		Steel Weight	S5	kg	1.00	0.88	0.88
6		Formwork Area	S6	m2	1.00	1.07	1.07
7	Practical Columns	Concrete Volume	S7	m3	1.00	1.84	1.60
8		Steel Weight	S8	kg	1.00	1.52	1.34
9		Formwork Area	S9	m2	1.00	3.68	3.20
10	Pit Lift Columns	Concrete Volume	S10	m3	1.00	1.12	1.12
11		Steel Weight	S11	kg	1.00	1.23	1.23
12		Formwork Area	S12	m2	1.00	1.15	1.15
13	Sill Beam	Concrete Volume	S13	m3	1.00	1.03	1.02
14		Steel Weight	S14	kg	1.00	1.02	1.02
15		Formwork Area	S15	m2	1.00	1.08	1.08
16	Sill Beam and Pit Lift Beam	Concrete Volume	S16	m3	1.00	1.87	1.87
17		Steel Weight	S17	kg	1.00	0.72	0.72
18		Formwork Area	S18	m2	1.00	4.10	4.10
19	Beam	Concrete Volume	S19	m3	1.00	0.90	0.91
20		Steel Weight	S20	kg	1.00	0.85	0.85
21		Formwork Area	S21	m2	1.00	1.30	1.30
22	Floor Beam	Concrete Volume	S22	m3	1.00	0.89	0.89
23		Steel Weight	S23	kg	1.00	0.92	0.92
24		Formwork Area	S24	m2	1.00	1.24	1.24
25	Floor Slab	Concrete Volume	S25	m3	1.00	1.00	1.00
26		Steel Weight	S26	kg	1.00	1.17	1.17
27		Formwork Area	S27	m2	1.00	0.98	0.98
28	Staircase	Steel Weight	S28	kg	1.00	0.78	0.76
29	Steel Roof Truss	Pipe SCH 40, 10 Inch Diameter, 9.3 mm Thickness	S29	kg	1.00	0.67	0.65
30		SCH 40 Pipe, 6 Inch Diameter, 7.1 mm Thickness	S30	kg	1.00	0.91	0.89

31		SCH 40 Pipe, 3 Inch Diameter, 5.5 mm Thickness	S31	kg	1.00	0.85	0.85

Figure 3 shows the visualization of the structural model generated using Revit, covering key elements such as foundations, columns, and beams. This modeling illustrates the coordination between elements in the final design.

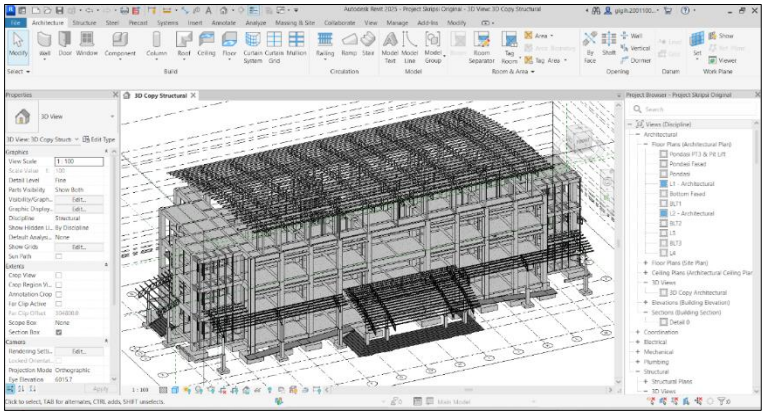

Figure 3. Structural

Figure 4 shows the results of Clash Detection analysis on the structure using Navisworks, with a total of 98 clashes detected between structural elements.

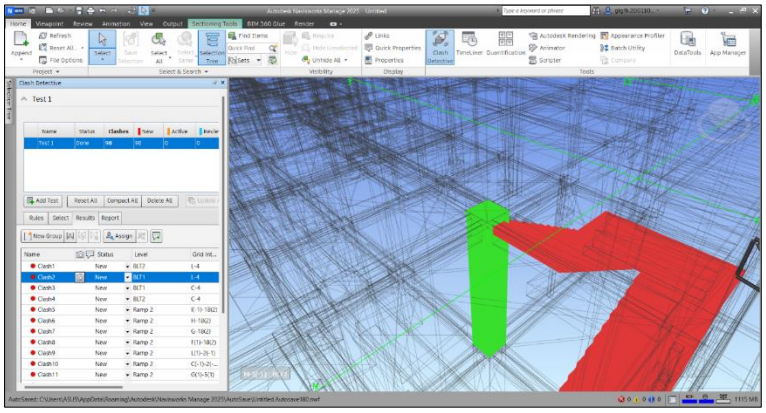

Figure 4. *Clash Detection* Structural

Table 3 presents the results of QTO calculations for architectural elements using the manual method, Revit, and Clash Detection, including calculations for ceramic flooring, brickwork, ceilings, and roofing.

Table 3. Calculation Methods for Architectural Elements

Architectural Elements							
No	**Elements**	**Sub-Elements**	**Code**	**Unit**	**Method**		
					Manual	**Revit**	***Clash Detection***
1		Floor 1	A1	m2	992.96	1011.19	1003.70

2	Ceramic Flooring	Floor 2	A2	m2	1015.75	861.91	861.02
3		Floor 3	A3	m2	1034.96	861.93	861.91
4	Masonry and Plastering	Brick Wall Masonry 1:4	A4	m2	2491.20	2939.14	2339.78
5		Plaster 1:4, thickness = 10 mm	A5	m2	4982.40	5878.28	4679.56
6		Installation of Gypsum Partition Wall, thickness = 9 mm	A6	m2	53.89	274.35	274.20
7	Fasade	FD1, FD2, FD3	A7	m2	487.49	446.53	445.91
8	Ceiling (Interior Area)	Floor 1	A8	m2	947.15	868.91	865.15
9		Floor 2	A9	m2	1028.08	858.45	857.80
10		Floor 3	A10	m2	1043.32	921.85	921.85
11	Ceiling (Exterior Area)	Floor 1	A11	m2	390.66	317.47	266.01
12		Floor 3	A12	m2	209.95	324.50	323.52
13	Conwood	Conwood	A13	m2	231.32	281.49	281.30
14	Metal Roof Tile Spandek 0.3 mm	Floor 2	A14	m2	390.69	280.95	278.85
15		Floor 3	A15	m2	1012.46	1017.63	1017.63

Figure 5 shows the architectural modeling generated using Revit, including key elements such as ceramic flooring, brickwork, ceiling, and metal tile roofing. This modeling allows the QTO calculation to be performed automatically and with higher accuracy.

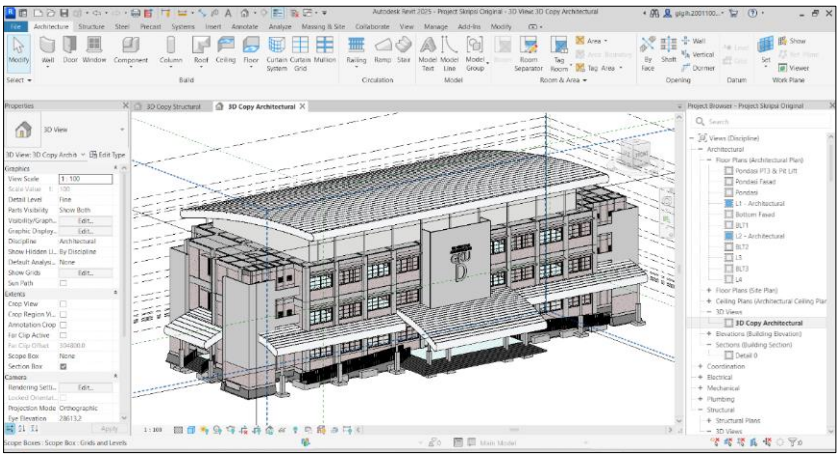

Figure 5. Architectural

Figure 6 shows the results of Clash Detection analysis on architectural elements using Navisworks, with 1,393 clashes detected between structural and architectural elements.

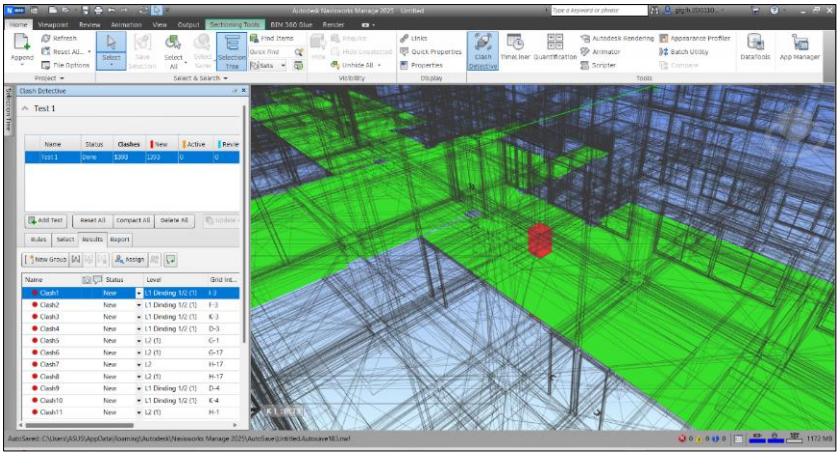

Figure 6. Architectural *Clash Detection*

Table 4 shows the average difference comparison between Manual, Revit, and Clash Detection methods for structural and architectural elements.

Table 4. Average Difference Comparison Between Manual, Revit, and Clash Detection Methods

Elemen	Manual - Revit (%)	Manual - *Clash Detection* (%)	Revit - *Clash Detection* (%)
Structural	35.76%	33.09%	1.51%
Architectural	43.14%	42.41%	3.98%

Figure 7 displays a graph illustrating the average difference comparison between the Manual, Revit, and Clash Detection methods for structural and architectural elements. This graph provides a visual representation of the differences among the three methods in calculating QTO and highlights the high level of consistency between Revit and Clash Detection for both analyzed elements.

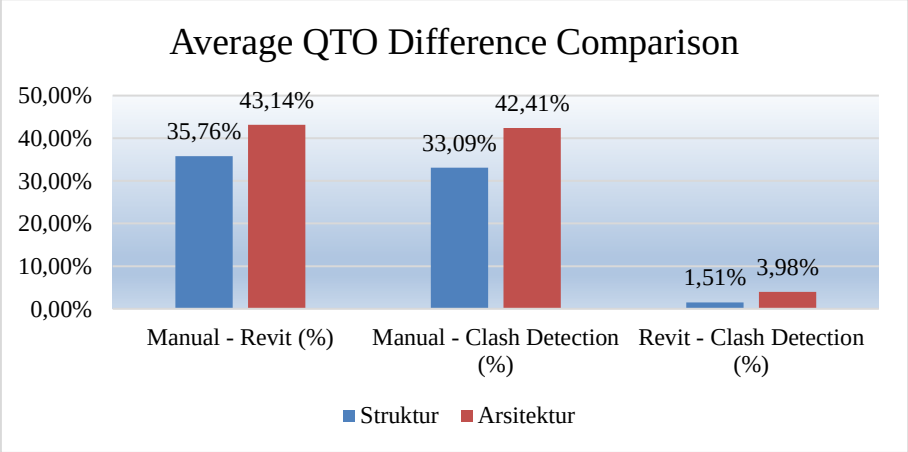

Figure 7. Quantitative Comparison of QTO Results

- For structural elements, the difference between Manual and Revit is 35.76%, while the difference between Manual and Clash Detection is smaller at 33.09%. The difference between Revit and Clash Detection is very small, at just 1.51%, indicating a high level of consistency between the two BIM-based methods.

- For architectural elements, the difference between Manual and Revit is 43.14%, and between Manual and Clash Detection is 42.41%. However, the difference between Revit and Clash Detection is much smaller at 3.98%, indicating a very high level of consistency between the two BIM-based methods.

11. Conclusion

This study compares three methods for performing Quantity Take-Off (QTO) in the General Lecture Building D project at Malikussaleh University: the manual method, Revit, and Clash Detection integrated with Navisworks. Based on quantitative analysis, the research findings reveal significant differences in accuracy and consistency among the three methods:

- The manual method shows greater differences compared to the two BIM-based methods. The average difference between Manual and Revit is 35.76% for structural elements and 43.14% for architectural elements, while the average difference between Manual and Clash Detection is 33.09% for structural elements and 42.41% for architectural elements.
- Revit and Clash Detection show very consistent results, with an average difference of only 1.51% for structural elements and 3.98% for architectural elements, indicating that both BIM methods produce nearly identical QTO results.
- *Clash Detection* has proven to provide additional benefits, including design validation, reducing clashes between elements, and improving design coordination between structural and architectural components—benefits that cannot be achieved by the manual method.

12. Suggestions

- Based on the research findings, it is recommended to enhance the use of BIM, particularly by integrating Revit and Navisworks (Clash Detection) in construction projects. Both BIM-based methods provide more consistent and efficient QTO results compared to traditional manual methods. Additionally, Clash Detection offers added benefits, including design validation that can minimize the risk of clashes between elements and implementation errors in the field.
- Although Revit and Clash Detection show good consistency in structural elements, architectural elements still exhibit greater variation, particularly in volume and area calculations. Therefore, further development in BIM-based architectural modeling is highly recommended to improve QTO accuracy, especially for more complex designs.
- Considering the importance of using BIM in construction projects, it is recommended to provide training to project teams to maximize the use of this technology. The training should include the use of Revit and Navisworks for automated QTO generation, as well as the application of Clash Detection for design validation.
- Penelitian Further research can focus on comparisons between various other BIM tools and their performance, as well as the implementation of Clash Detection in larger and more complex-scale projects. This could provide deeper insights into the effectiveness of BIM technology across different types of construction projects.

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STOCK PREDICTION OF SINGLE-USE MEDICINE USING AUTOREGRESSIVE INTEGRATED MOVING AVERAGE

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Stock Prediction of Single-Use Medicine Using Autoregressive Integrated Moving Average the(3, 1, 3) model, derived from the (p,q,d) model where p is the AR level, d is the process level that makes the data stationary, and q is the MA level. The (3, 1, 3) model used provides quite good results the ARIMA (3, 1, 3) model can be a good tool to predict the need for consumable drug stocks show that the ARIMA (3, 1, 3) model gives good results,log likelihood values and information criteria indicating that the model is reliable. Predictions for the demand for consumable drugs in 2025 show a downward trend, Requires further attention to understand the causes. health centres can plan drug procurement more precisely and efficiently meet patient needs without experiencing overstocks or shortages.

Keywords: predictions, ARIMA, single-use medicine.

1. Introduction

Medicines that can only be used once or within a certain period of time and cannot be stored for further use are called consumable medicine. Consumable medicine are usually used at Banda Sakti Health Centre in Lhokseumawe City in primary health care, where they are given to patients for the treatment of certain diseases or immunisation purposes. The purpose of using these consumables is to reduce the risk of contamination or inappropriate storage of drugs as well as ensuring that patients receive the correct dose.

Single-use medicine play an important role in the health system,especially in preventing infections and improving patient safety. The importance of single-use medicine lies in their ability to improve patient safety, operational efficiency, and compliance with evolving health standards. The management of consumable medicine stocks has an important role that not only affects patient satisfaction and public confidence in the health services provided.The According to the Regulation of the Minister of Health of the Republic of Indonesia No.30 of 2022 concerning Guidelines for Drug Management, every health facility is obliged to carry out good drug management, including accurate planning of drug needs [1]. However, many hospitals and health centress still face difficulties in forecasting grug needs, which often leads to excess or shortage of supplies. Overstocks can result in a waste of resources, while shortages can cause delays in treatment, potentially worsening the patient's condition.

Prediction is the use of statistical techniques in the form of a future picture based on the processing of historical figures [2], the use of appropriate prediction methods can help Puskesmas managers plan and manage drug supplies more efficiently. One method commonly used in time series analysis is Autoregressive Moving Average (ARIMA) [3]. The ARIMA method has the

ability to analyse historical data patterns and provide accurate predictions for the coming period [4]With the application of this method, it is hoped that the management of consumable medicine stocks at the Banda Sakti Community Health Centre in Lhokseumawe City will be improved, so that health services to the community will be better.

The ARIMA method is a forecasting method developed by George Box and Gwilym Jenkins which is often called the Box-Jenkins time series method [5]. The ARIMA model is a combined method of the Autoregressive (AR) and Moving Average (MA) methods. ARIMA models have been widely used in various fields, including finance, economics, and health, to predict future trends and patterns. In the contect of medicine stock management, the ARIMA Method can be used to predict the demand for medicines based on historical data, thus enabling health centres to make informed decisions about stock management.

The management policy of consumable medicine in the pharmaceutical installation of Banda Sakti Health Centre is very strict. Records must be made of all medicines administered to patients and distributed to the PUSTU in each kampong, including the type of medicine, dosage, and date of administration and date of distribution. This is very important to monitor the effectiveness of treatment and ensure that medicine are not wasted. In addition, the health centre conducts regular evaluations of consumable drugs to improve health services and ensure that all patients receive the best care.

Banda sakti Health Centre also strives to increase community awareness about the importance of using the right medicine and according to their needs. Through health education programmes, the community is educated on the correct use of medicines, including knowledge of consumable drugs and the risks associated with inappropriate drug use. Therefore, is it expected that the community will use medicines more wisely, which in turn will improve overall health.

So far, Banda Sakti Health Centre in Lhokseumawe City still uses a manual method to predict the stock of consumable drugs by looking at previous data. Based on the data, the amount of consumable medicine stock that will be prepared is estimated manually. However, this approach is not always accurate because today's sales results are not necessarily the same as the following year's data. This method often leads to errrors in the provision of consumable drug stocks, which results in waste and triggers the occurrence of insufficient medicine stocks.

2. Methods

2.1 Time Series

Times series data is a type of data that is collected in accordance with the time sequence within a certain time span. The basic idea in time series is that the current observation (Zt) is influenced by one or more previous obseervations (Zt-k) (Wulandari R.A & Gernowo R, 2019). The type of data that consists of variables collected in is a new development in economic forecasting methods, does not aim to form a structural model (single equation or simultaneous equation) based on economic theory and logic, but by analysing probabilistic or stochastic time series data by holding the philosophy of 'let the data speak for themselves'.

The ARIMA (Autoregressive Integrated Moving Average) method is a method used for short-term forecasting. The use of the ARIMA method in short-term forecasting is very appropriate because the ARIMA method has very accurate accuracy. And also determines a good statistical relationship between the variables to be forecasted and the value used for forecasting. As for long-term forecasting, the forecasting accuracy is not good. Usually the forecasting value will tend to be constant for a fairly long period [6]. ARIMA uses past and present values of the

dependent variable to produce accurate short-term forecasts. ARIMA is suitable if the observations from the time series are statistically related to each other [7].

time order within a certain time span is also known as a time series. In the discrete case, the frequency can be for example seconds,minutes,hours,days,weeks,months or years and [8].

2.2 ARIMA (Autoregressive Integrated Moving Average)

The Autoregressive Moving Average (ARIMA) method or also referred to as the Box-Jenkins method is a method that was intensively developed by George Box and Gwilym Jenkins(1976), which is a new development in economic forecasting methods, does not aim to form a structural model (single equation or simultaneous equation) based on economic theory and logic, but by analysing probabilistic or stochastic time series data by holding the philosophy of 'let the data speak for themselves'.

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Examination of the plots of the autocorrelation function (ACF) and partial autocorrelation or commonly classed (PACF). The purpose of the ACF and PACF examination is to determine the configuration of the ARIMA model that is suitable for getting the number of autogressive processes (AR) to affect the time series variable data, the total moving average (MA) and the number of times the number to make the data stationary (d) is the purpose of the ACF and PACF examination [11].

ARIMA is a suitable forecasting method for non-stationary data. The ARIMA model is usually denoted by three parameters [12]. ARIMA (p,d,q), and the following is the general formula of ARIMA Autoregressive Moving Average:

$Xt = \mu + (1 + \emptyset 1\ )Xt{-}1 + \cdots + (\emptyset p - \emptyset p{-}1)Xt{-}p - \emptyset pXt{-}p{-}1 + et\ {-}\theta 1et{-}1{-}\cdots{-}\theta qet{-}q$

Description:

et = time error value at time t

Xtt = time series data at time t 19

μ = constant value

$\emptyset p$ = autoregressive parameter to p = 1,2,3, ..., n

θq = autoregressive parameter to q = 1,2,3, ..., n

2.3 Stationer Data

Stationary data refers to a state where time series data tends to fluctuate around an average value. When graphed against time, stationary data often crosses the horizontal axis. Generally, stationary data will show a horizontal pattern along the time axis. In other words, the time-

dependent variation revolves around a stable mean value, while the variance remains relatively constant [13]

2.4 Python

Python is an interpretive programming language that is known for being easy to learn and has a focus on code readability. In general, Python uses object-oriented, imperative and functional programming paradigms [14].

Python supports various programming paradigms, especially object-oriented, imperative, and functional programming, without any particular limitation. One of Python's features is that it is a dynamic programming language that comes with automatic memory management. Like other dynamic programming languages, Python is usually used as a script language, although in practice, its use is broader and includes contexts that are not usually done with script languages [15]

3. Research Methods

Quantitative research methods are used in this research, where numerical data is involved in the process of measuring and analysing the variables.

3.1 Techniques for Collecting Data

In this study the authors used the following techniques to collect data:

1. Sample Data

Sample data in this study in the form of information related to the study case is collected for research on consumable drug stock data and this data information will be used as input when the data is processed.

2. Observation

The Banda Sakti Health Centre of Lhokseumawe City was directly observed as part of the observation process for this research. In addition, an analysis of the problems encountered in monitoring the process of recapitulating consumable medicine stock data at the Banda Sakti Health Centre was carried out Lhokseumawe City. In addition, an evaluation of the needs of the current problems is also carried out to facilitate calculations.

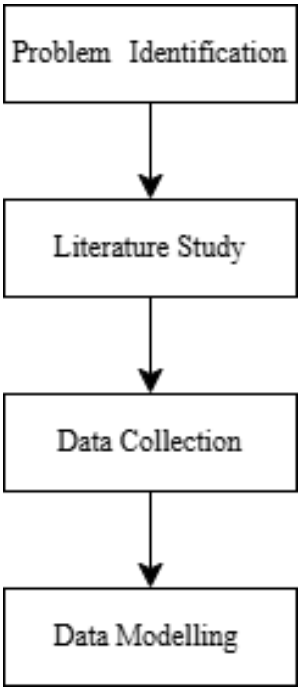
3. Interview

Furthermore, interviews were conducted with the Head of the pharmacy / drug warehouse of the Banda Sakti Health Centre, Lhokseumawe City and staff who had a hand in the process of recapitulating consumable drug stock data and determining the most needed drugs each year and interviewing these parties and asking what the obstacles were in the process of stocking consumable drug data so far. Puskesmas Banda Sakti Lhokseumawe City provides primary and secondary data for this research in the form of files.

4. Literacy Study

This research uses journals that have been reviewed by the author, books from official institutions and websites related to the research title as a reference source.

Table 1. Stages of research



3.1.1 Problem Identification

At this stage, a problem search is carried out, then continued by finding a solution to the problem that has been obtained. This research aims to implement the ARIMA method in forecasting consumable drug stocks.

3.1.2 Literature Study

Before being able to determine what contributions can be made by this research, it is necessary to find references from previous relevant research as well as several other objects such as books, internet, academics, and essays to get useful information in this research.

3.1.3 Data Collection

In order to collect the information required for the research, data collection is carried out. In this study, two data collection methods were used:

1. Primary Data Source

Primary data is obtained from interviews conducted with the staff of the Banda Sakti Health Centre, Lhokseumawe City.

2. Secondary Data Sources

Secondary data is obtained from books, internet, journals, which have relevance to the object of this research.

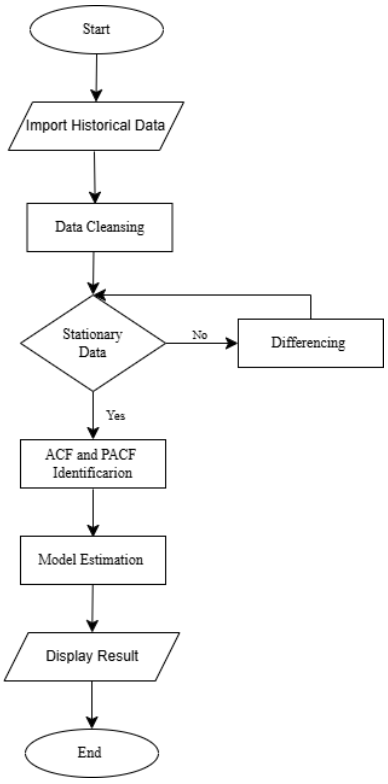
3.1.4 Data Modelling

At this stage, forecasting of consumable drug stocks is modelled using the ARIMA (Autoregressive Integrated Moving Average) method.

3.2 Schematic of the System

The schematic of the system for forecasting consumable medicine stocks at the Banda Sakti Health Centre in Lhokseumawe City is shown in the figure below :

Table 2. Schematic of the System



The following system flow description process will be explained through the following points:

1. Import Historical Data that will be used.
2. Perform Data Cleaning or Data Cleaning
3. Differencing will be performed if the data is not stationary.

4. Perform model estimation by selecting the most acceptable and suitable model type at this time.Next, select the model to be used provisionally and estimate its parameters.
5. Display the prediction results.

4. Problem Analysis

At Banda Sakti Health Centre in Lhokseumawe City, stock prediction of consumable drugs is an important challenge that must be faced to ensure adequate drug availability for patients. The fluctuating demand for drugs, influenced by various factors such as epidemics, seasonality, and health policies, makes stock management complex. Delays in drug procurement can have a direct impact on health services, potentially disrupting the treatment process and patient safety. Therefore, an effective method is needed to predict drug stock requirements, one of which is by using the Autoregressive Integrated Moving Average (ARIMA) model.

The ARIMA method offers a statistical approach that can help analyse historical drug usage data to identify patterns and trends. By applying this model, Banda Sakti Health Centre is expected to be able to obtain more accurate predictions of future consumable medicine stock requirements. However, challenges such as data limitations, sudden changes in demand patterns, and potential overfitting must be considered to keep the prediction results relevant and reliable. Therefore, collaboration between the health team and data analysis is essential to improve prediction accuracy and ensure efficient stock management.

5. Data Presentation

In the stage of data analysis of consumable drugs obtained by puskesmas banda sakti lhokseumawe city, the following are the top 5 data that the author obtained. then the following data presentation is as follows:

	NO	NAMA OBAT	Satuan	Sisa Stok Per 31 Des 2021	Pemakaian Rata Rata per bulan	Jumlah Kebutuhan Tahun	Rencana Kebutuhan Tahun	Harga	jumlah	Pengadaan Dana JKN	Jumlah2	Tahun
0	1	Antigen A-Glory	Kotak	0.0	0.40	7.20	7.20	201818	1453089.6	1.0	201818.0	2022
1	2	Antigen B-Glory	Kotak	0.0	0.40	7.20	7.20	181636	1307779.2	1.0	181636.0	2022
2	3	Antigen D-Glory	Kotak	0.0	0.40	7.20	7.20	201818	1453089.6	1.0	201818.0	2022
3	4	Aquadest	Botol	0.0	1.00	18.00	18.00	62370	1122660.0	NaN	0.0	2022
4	5	Asam Asetat 6% 1 Liter	Botol	0.0	0.11	1.98	1.98	132000	261360.0	NaN	0.0	2022

Figure 1 Data Presentation

This table contains data on the supply of consumable drugs at Banda Sakti Health Centre, covering various important aspects of drug management.

The table shows the remaining stock of drugs from January 2021, providing an overview of the current inventory. This information is important to know whether the stock of drugs is sufficient or if immediate procurement is needed.

The table also displays the average usage data per month, which is used to calculate the annual requirement. With this information, the health centre can plan its drug requirements for the coming year. The annual needs plan is also included, showing the target number of drugs to be

fulfilled. Drug prices and quantities required are also recorded, making it easier to calculate the total cost of procurement.

The table includes information on the source of procurement funds, which is the JKN Fund. By knowing the source of funds and the amount available, the health centre can plan drug procurement more precisely. The quantity and year data shows the number of drugs ordered and the year of procurement, which helps in tracking the history of drug procurement.

5.1 The Number of Years of Need Over Time

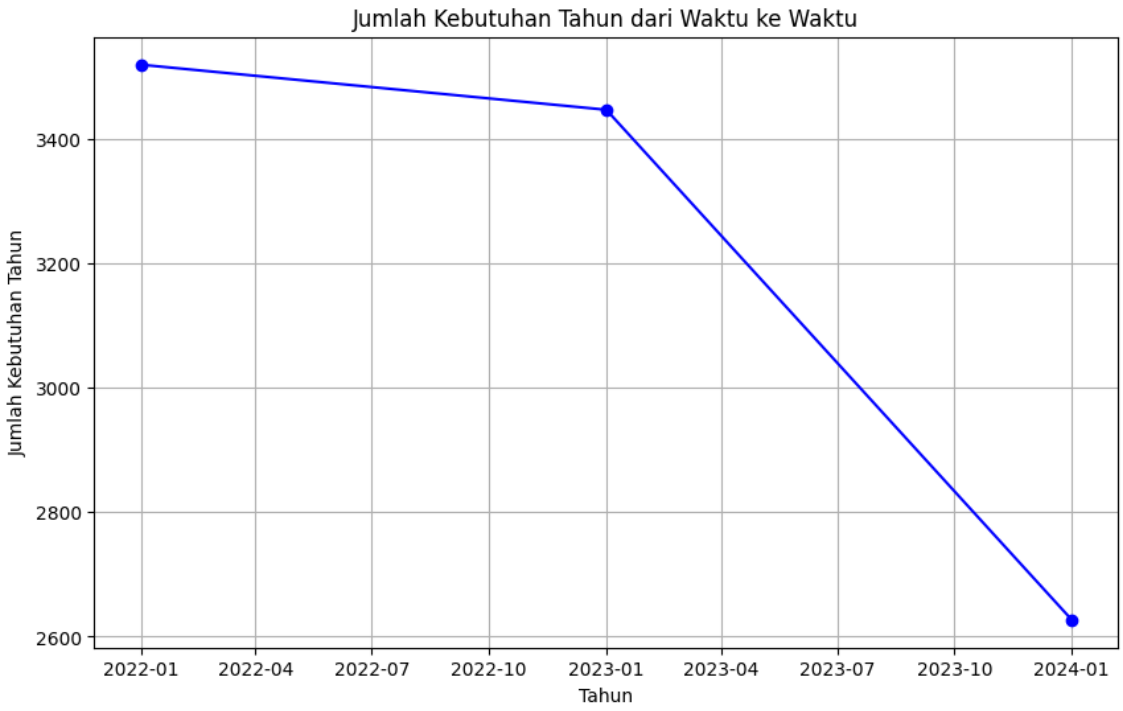


Fig 2 Total Demand per Year

This figure shows the trend of the number of demand years over time. The horizontal axis shows years, while the vertical axis shows the number of years demanded. The blue line shows the number of years demanded each year.

It can be seen that the number of demand years is decreasing year by year. In 2022-01, the number of demand years was around 3500. Then, there is a decrease in 2023-01, where the number of demand years is around 3450. Finally, there is a significant decrease in 2024-01, where the number of year requirements is around 2600.

The decrease in the number of demand years is likely due to various factors, such as changes in health policies, changes in people's lifestyles, and increased effectiveness of disease prevention programmes. To find out the exact cause of this decline, further analysis is required.

5.2 Total Demand per Year

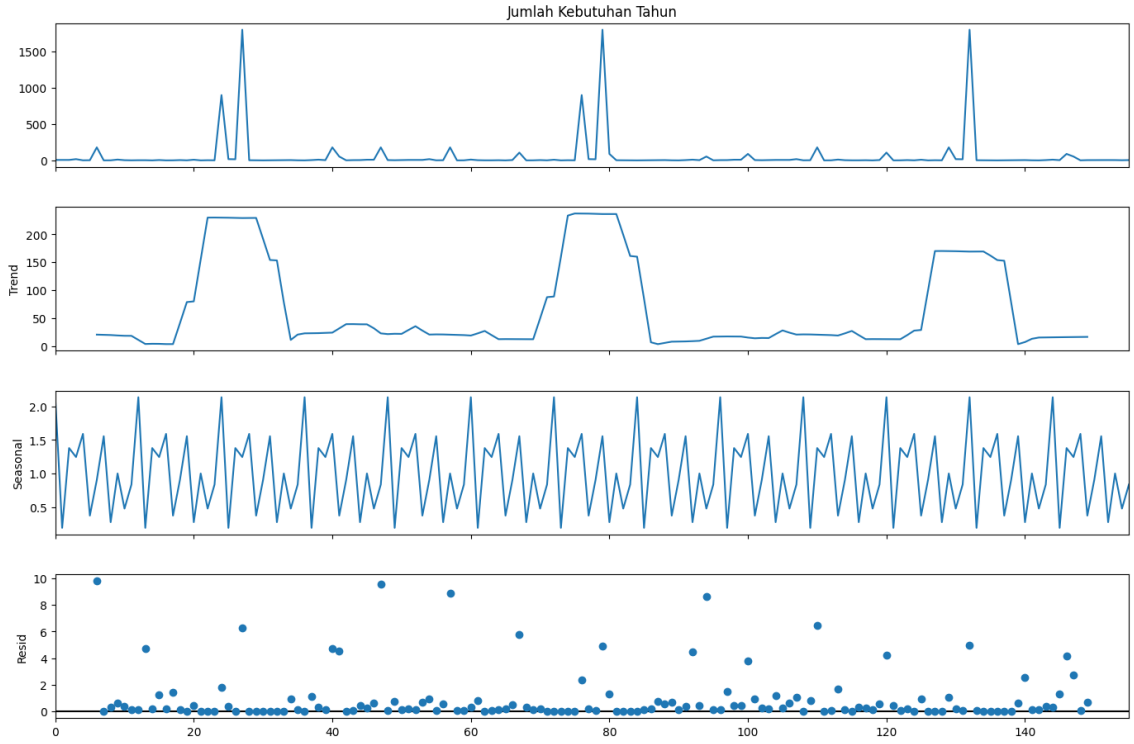


Fig 3 Total Demand per Year

The figure shows the data decomposition to predict the need for consumable drugs at Banda Sakti Health Centre, Lhokseumawe City. Data decomposition is the process of separating time series data into its components, namely trend, seasonality, and residual.

The trend component shows the general trend of the data over time. In the figure, the trend component shows that the demand for consumable drugs at Banda Sakti Health Centre tends to rise and fall periodically. This may be due to factors such as seasonality, health campaigns, and an increase or decrease in the number of patients.

The seasonal component shows a recurring pattern in the data that occurs within a certain period of time. In the figure, the seasonal component shows that the demand for consumable drugs tends to increase at certain periods of the year. This may be due to factors such as disease seasons, public holidays, and certain health events.

The residual component is the remainder of the data after the trend and seasonal components have been removed. The residual component reflects the random variation in the data. In the figure, the residual component shows that the random variation in the consumable drug demand tends to be small. This indicates that the data decomposition model is able to explain most of the variation in the data.

Based on the data decomposition, it can be concluded that the demand for consumable drugs at Banda Sakti Health Centre is influenced by trend, seasonal, and residual factors. By understanding these components, prediction of consumable drug needs can be done more accurately. Accurate predictions are essential to ensure that Banda Sakti Health Centre always has sufficient drug supplies to meet patient needs.

5.3 Autocorrelation plot

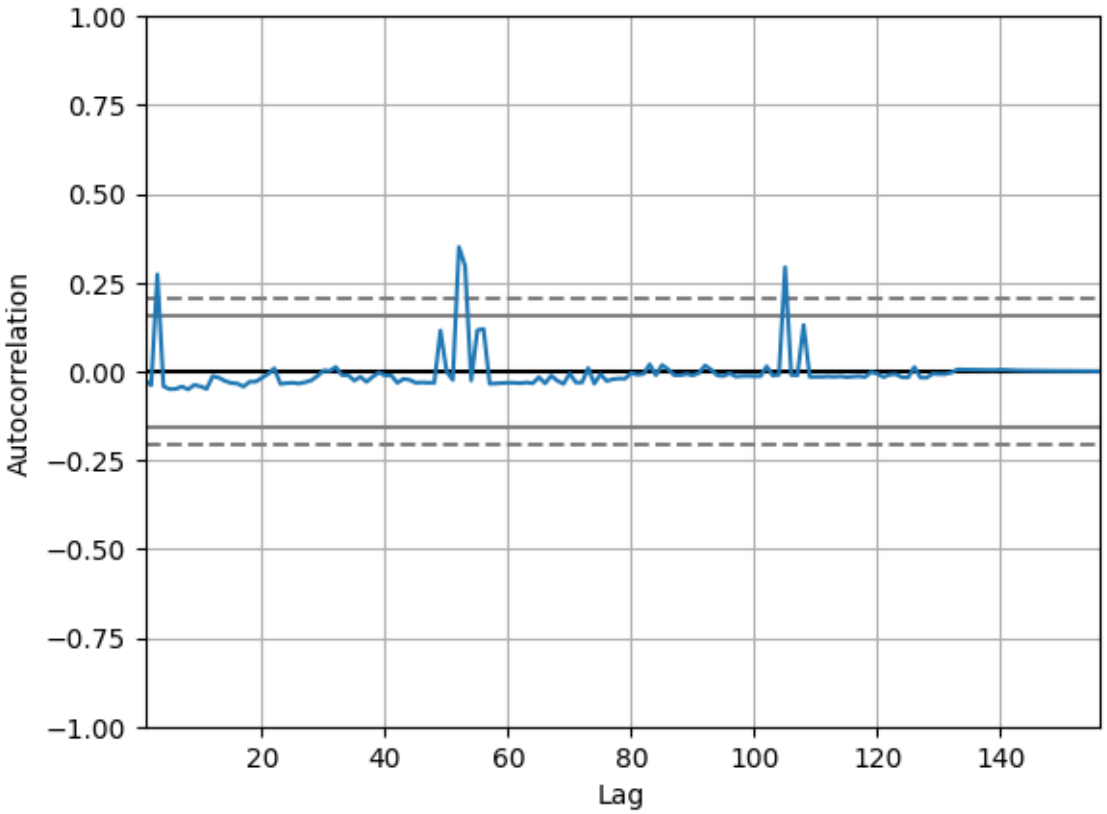


Fig 4 Autocorrelation plot

The figure shows an autocorrelation plot, which is a statistical tool used to measure the correlation of a time series with itself at various time lags. This plot shows that the data has significant autocorrelation at a certain time delay, which indicates that the data may be stationary.

In the context of predicting drug stocks using the ARIMA method at the Banda Sakti Health Centre in Lhokseumawe City, autocorrelation plots can be used to help determine the appropriate order of the ARIMA model for the data. The ARIMA model uses autoregressive (AR), integrated (I), and moving average (MA) components to model and predict time series.

The order of the AR, I, and MA components is determined based on the autocorrelation plot and partial autocorrelation plot (PACF) of the data. The autocorrelation plot shows the correlation between the data value at a particular time and the data value at the previous time delay. The PACF plot shows the correlation between the data value at a given time and the data value at the previous time delay, after the correlation from the previous time delay has been removed.

By analysing the autocorrelation and PACF plots, we can identify the autocorrelation pattern in the data and determine the appropriate order of the ARIMA model. This information can then be used to create a more accurate drug stock prediction model and help the Banda Sakti Community Health Centre of Lhokseumawe City manage drug inventory more effectively.

5.4 Prediction for The Total Demand in 2025

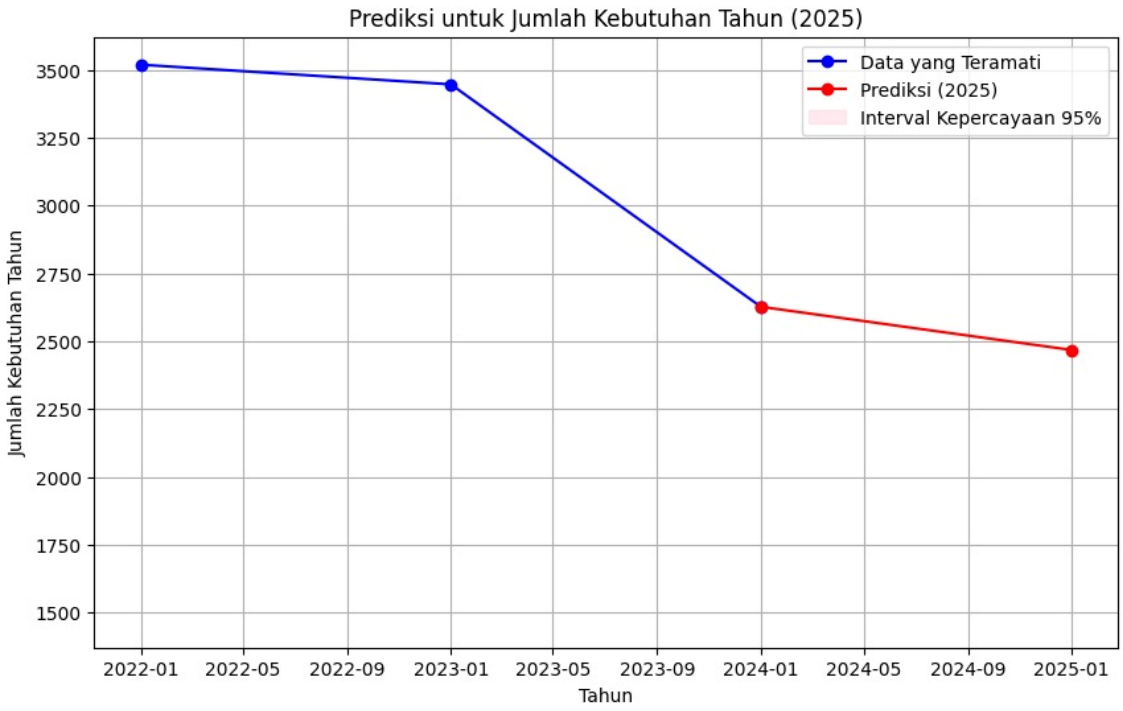


Fig 5 Prediction for The Total Demand in 2025

The figure shows the prediction of the amount of consumable drug needs at the Banda Sakti Health Centre in Lhokseumawe City using the ARIMA method. The horizontal axis shows time, starting from January 2022 to January 2025. The vertical axis shows the amount of consumable medicine demand, with unspecified units.

There are two lines in the graph: the blue line that shows the observed data, and the red line that shows the prediction of consumable medicine demand based on the ARIMA model. The blue line shows a downward trend in the quantity of consumables, while the red line predicts that the trend will continue, but at a slower rate of decline.

There is also a pink area that represents the 95% confidence interval of the ARIMA prediction. This means that with a 95% confidence level, the future demand for consumable drugs will fall within the pink area. The 95% confidence in the ARIMA model is the standard, because it compensates for the possibility of error, the interval is neither too wide nor too narrow, and it is easily understood by many people.

The ARIMA model, which stands for Autoregressive Integrated Moving Average, is a statistical method used to predict future values of a series of data based on past values of the data. In this case, the ARIMA model is used to predict future consumable drug requirements based on past consumable drug requirements data.

The results of this prediction can be used by the Banda Sakti Health Centre of Lhokseumawe City to plan for future consumable drug needs. By estimating the need for consumable drugs more precisely, Puskesmas can ensure that they have sufficient drug supplies to meet the needs of patients.

5.4 ARIMA Results

SARIMAX Results

Dep. Variable:	Jumlah Kebutuhan Tahun	No. Observations:	3
Model:	ARIMA(3, 1, 3)	Log Likelihood	-14.131
Date:	Mon, 18 Nov 2024	AIC	42.262
Time:	09:33:51	BIC	33.114
Sample:	01-01-2022	HQIC	23.131
	- 01-01-2024		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-1.0105	120.805	-0.008	0.993	-237.785	235.764
ar.L2	-1.0597	143.417	-0.007	0.994	-282.153	280.033
ar.L3	-0.9459	32.096	-0.029	0.976	-63.854	61.962
ma.L1	1.5318	13.421	0.114	0.909	-24.774	27.837
ma.L2	1.3641	97.467	0.014	0.989	-189.668	192.396
ma.L3	0.7964	50.614	0.016	0.987	-98.406	99.999
sigma2	1014.1523	0.178	5704.942	0.000	1013.804	1014.501

Ljung-Box (L1) (Q):	2.00	Jarque-Bera (JB):	0.33
Prob(Q):	0.16	Prob(JB):	0.85
Heteroskedasticity (H):	nan	Skew:	0.00
Prob(H) (two-sided):	nan	Kurtosis:	1.00

Fig 5 ARIMA Results

The figure shows the results of a prediction model of consumable drug stocks using the ARIMA (Autoregressive Integrated Moving Average) method at Banda Sakti Health Centre, Lhokseumawe City.

From the prediction results, it can be seen that the ARIMA (3, 1, 3) model, which is derived from the (p,q,d) model where p is the AR level, d is the process level that makes the data stationary, and q is the MA level. The ARIMA (3, 1, 3) model used provides quite good results, with a Log Likelihood value of -14.131, AIC of 42.262, BIC of 33.114, and HQIC of 23.131. The selected ARIMA model has three autoregressive (AR) components, one integrated (I) component, and three moving average (MA) components.

In addition, the prediction results also show that the ARIMA model can predict the stock of consumable drugs well, as seen from the coefficient values and standard errors produced, as well as the p-value which shows that the model does not reject the null hypothesis. Thus, the ARIMA (3, 1, 3) model can be a good tool to predict the need for consumable drug stocks at Banda Sakti Health Centre, Lhokseumawe City.

4. Conclusions

Stock prediction of consumable drugs at Banda Sakti Health Centre, Lhokseumawe, is an important aspect in ensuring adequate drug availability for patients. Consumable drugs, which are only used once or within a certain period, have a crucial role in maintaining patient safety

and preventing infections. By using appropriate prediction methods, such as ARIMA, drug stock management can be done more efficiently, thereby reducing the risk of overstocks or shortages that can negatively impact health services. In this context, the application of the ARIMA method is expected to provide a better solution to the challenges faced in drug stock management.

The ARIMA (Autoregressive Integrated Moving Average) method has proven to be effective in time series data analysis and drug demand prediction. With the ability to analyse historical data patterns, ARIMA allows health centres to make more accurate predictions of future drug demand. This is particularly important, given the many factors that can affect drug demand, including seasonality, epidemics, and health policies. The application of ARIMA not only helps in planning drug needs but also in optimising the use of existing resources.

Although the application of the ARIMA method offers many benefits, there are challenges that must be faced, such as data limitations and sudden changes in demand patterns. Fluctuations in medicine demand that are influenced by various factors make stock management complex. Therefore, collaboration between the healthcare team and data analysts is key to improving prediction accuracy and ensuring efficient stock management. With a solid team in place, data analysis can be conducted in greater depth, making the prediction results more relevant and reliable.

In this study, data was collected through observations, interviews, and literature studies to obtain relevant information regarding drug stocks. The analysis process was conducted by utilising Python software to apply the ARIMA model. By utilising historical data, analysis was conducted to determine existing patterns and trends, which were then used to predict future drug requirements. This process involves not only data collection, but also a deep understanding of how the data can be processed to produce useful information.

The prediction results show that the ARIMA (3, 1, 3) model gives good results, with log likelihood values and information criteria indicating that the model is reliable. Predictions for the demand for consumable drugs in 2025 show a downward trend, which requires further attention to understand the causes. With this information, health centres can plan drug procurement more precisely and efficiently, so as to meet patient needs without experiencing overstocks or shortages.

By applying the ARIMA method in drug stock prediction, Banda Sakti Community Health Centre can improve effectiveness in drug management. This not only has an impact on the timely availability of drugs, but also on increasing patient satisfaction and public trust in the health services provided. Good management will support efforts to improve the overall quality of health services, so that people feel safer and more secure in getting the care they need.

For future research, it is recommended to conduct a more in-depth analysis of the factors that influence fluctuations in demand for consumer drugs. In addition, it is also necessary to develop more complex prediction models by considering external variables such as health policies and demographic changes. Thus, the prediction of medicine demand can be more accurate and relevant to the existing conditions, and can make a positive contribution to public health management in the future.

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Science Process Skills Through The Read, Answer, Discuss, Explain And Create (Radec) Learning Model On Science Materials In High School

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Abstract. Natural Sciences (IPA) is a science related to nature that is systematically arranged through an investigation. The RADEC model as one of the solutions in the learning process that accommodates students to exchange information obtained and solve a problem. The purpose of this study is to implement the role of RADEC syntax in triggering student expertise in science process abilities (KPS). Increasing KPS requires the application of the RADEC Model to see the significance of increasing the use of the model, the measuring instrument used to measure KPS is a data collection instrument in the form of an observation sheet that has been prepared and then validated constructively (material experts). Sampling was carried out using convenience sampling, class sampling was carried out using a non-random technique which was then tested statistically as a basis for determining classes with the same abilities. The type of research conducted in this study is Pre-Experimental Design research. The posttest score of students' science process skills in the experimental class had the highest score of 96 and the lowest score of 78. While the posttest score in the control class had the highest score of 89 and the lowest score of 72. The average score of students' science process skills in the experimental class was 86 with a high category and in the control class was 80 with a very moderate category. The average score of students' science process skills in the experimental class was 81.66% with a moderate category. Students' science process skills in the Experimental class obtained the highest percentage on the observing indicator of 93.18% and the lowest percentage on the making a hypothesis indicator of 75.00%. Students' science process skills in the Control class obtained the highest percentage on the observing indicator of 86.36% and the lowest percentage on the making a hypothesis indicator of 61.36%.
Keywords: Science Process Skills, RADEC, Pre-Experimental Design

1. Introduction

The era of the industrial revolution 4.0 towards 5.0 has an impact on the development of human resources, one of which is in supporting the world of education (Dito & Pujiastuti, 2021). The world of education today, 21st century skills can help students to make it easier to understand science learning. Natural Sciences (IPA) is a science related to nature which is systematically arranged through an investigation of the concluded problems (Suharyat et al., 2022). The indicator components in IPA will be easy to understand conceptually in the learning

process, if there is a match between theory and practice. The use of the right learning model will affect student knowledge.

Read, Answer, Discuss, Explain and Create (RADEC) learning model is a student-centered learning model with a series of activities to improve reading skills, collaboration, problem solving and producing ideas/works (Pratama et al., 2019). This learning model aims to be a solution in the learning process that accommodates students to exchange information obtained and solve problems given by the teacher. This learning model is in accordance with the Indonesian education system which currently uses the independent curriculum, where students must understand many lessons in a short time, both in the form of understanding concepts, practicums and creative thinking skills (Sri Wahyuni, Khaerudin, 2022).

One of the syntaxes of the RADEC learning model that can implement aspects of science process skills indicators is create (creating) where at this stage, students are encouraged to create the creativity they get based on the knowledge they have acquired. Research conducted by (Agriyana & Sopandi, 2022) shows that the RADEC learning model has a positive effect on students' science process skills compared to the Inquiry model.

Science process skills are activities carried out to encourage skills in acquiring knowledge (Mellyzar et al., 2022). The current reality is that students' science process skills are still low and students also assume that science lessons are difficult, teach a lot of theory and are boring (Setiya Rini et al., 2022). The purpose of science process skills is to develop students' creativity in the learning process. Students can actively develop and apply their abilities, which means that students not only get results but will learn about the process of obtaining results. Thus, this will be a provision for students to form competent personalities and will be able to compete with the people around them (Suryaningsih & Ainun Nisa, 2021). Science process skills are the most important thing for students to have, where science process skills will support students' understanding of science literacy (Mellyzar et al., 2022). One thing that must be considered in applying scientific knowledge in life is a sustainability-oriented application.

2. Methodology

2.1. Location and Subject of Research

The research was conducted at SMA Negeri 2 Bireuen. The research was conducted in the odd semester of the 2024/2025 academic year.

2.2. Population and sample

In this study, the students who were the research samples came from SMA Negeri 2 Bireuen. The population in this study were grade X students of the 2024/2025 Academic Year. The research sample consisted of 2 classes, namely the experimental class and the control class. The sample selection technique in this study used the convenience sampling technique. The convenience sampling technique was carried out because the research was conducted in a class that had been provided by the school.

2.3. Type and Design of Research

The type of research conducted in this study is Pre-Experimental Design research, namely a research method used by researchers to be able to control all external variables that influence the course of the experiment (Sugiyono, 2016). In this design there are two groups of subjects, one group received treatment as an experimental class and one group as a control class. Sampling was not done randomly because it used classes that already existed in the school. The research design pattern is the Intact-Group Comparison type.

Table 3.1 Intact-Group Comparison Type Research Design

Class	Treatment	Posttest
Experiment	X	O1
Control	-	O2

Information :
X : Treatment
O_1 : Posttest to see the ability after treatment KPS/Experimental Class
O_2 : Posttest to see the ability after treatment KPS/Control Class

This study measures science process skills. The type of measuring instrument used in this study is a non-test in the form of an observation sheet used to measure science process skills. Data collection techniques can be seen in Table 3.2.

Tabel 3.2 Data Collection Instruments and Techniques

No	Target	Metode	Instrumen
1.	Science Process Skills	Observation Sheet	Observation Sheet to review aspects of KPS (Observation, Interpretation, Prediction, Communication, Hypothesis, Planning Concepts, and Asking Questions)
2.	Student practical activities	Practice	Student Worksheet (LKPD)
3.	Valid research instruments	Validation	Validation sheet (validation of observation sheets and LKPD)

2.4 Data analysis

In this study, two data analyses were conducted, namely improving students' science process skills by implementing the RADEC learning model. Improving students' abilities by comparing students' posttest achievements in science process skills.
Data analysis Students' science process skills were analyzed with categories of very high, high, medium, low, and very low. Values and criteria based on Azwar's theory (Azwar, 2010) are presented in Table 3.3.

Table 3.3 Student KPS Level Intervals

No	Cognitive Ability Interval	Category
1	M + 1,5 SD < X	Very high
2	M + 0,5 SD < X ≤ M + 1,5 SD	High
3	M - 0,5 SD < X ≤ M + 0,5 SD	Currently

4	M - 1,5 SD < X ≤ M - 0,5 SD	Low
5	X ≤ M - 1,5 SD	Very Low

3. Result and Discussion

The posttest scores of students in the experimental class can be seen in the following diagram:

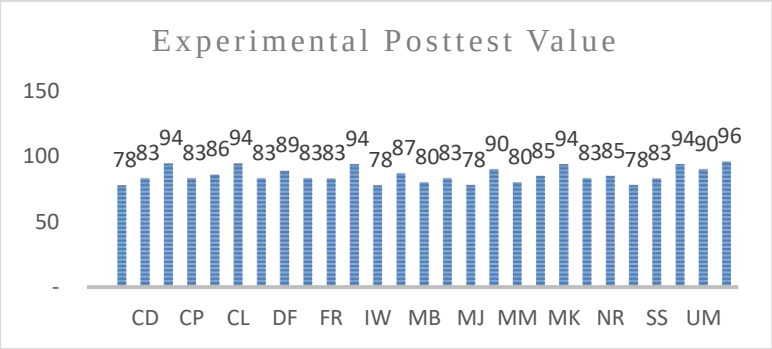

Figure 4.1 Posttest scores of experimental class students

Based on Figure 4.1 above, the posttest scores of students' science process skills in the experimental class, there is a highest score of 96 and the lowest score of 78. The posttest scores of students in the control class can be seen in the following diagram:

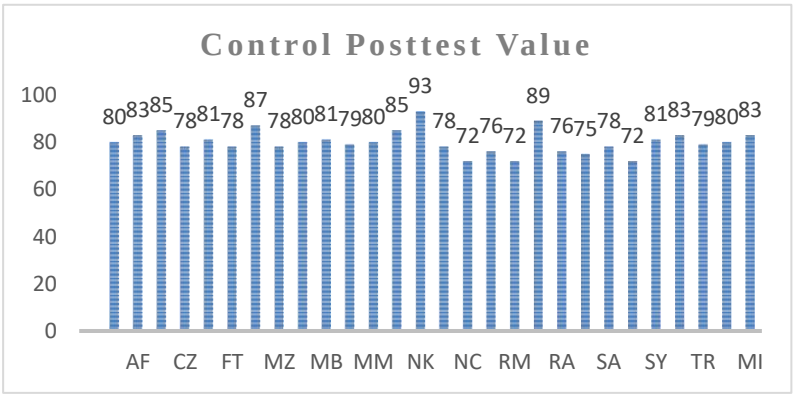

Figure 4.2 Posttest scores of control class students

Based on Figure 4.2 above, the posttest scores of students' science process skills in the control class, there is a highest score of 89 and the lowest score of 72. Based on the posttest scores of students in the experimental class and the control class, the calculation of the average posttest scores of students can be made in the following diagram:

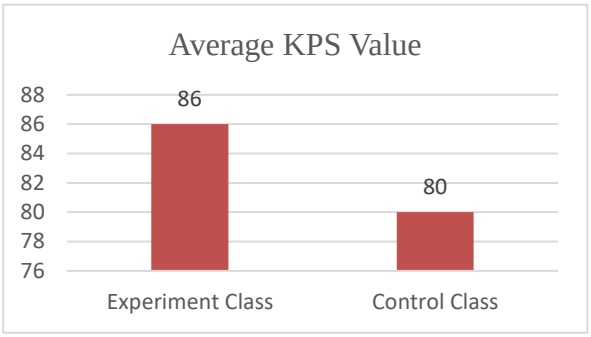

Figure 4.3 Average Score of Students' Science Process Skills

Based on Figure 4.3 above, the average value of the students' science process skills test, there is an average value of the experimental class of 86 with a high category and the control class of 80 with a very moderate category. It can be concluded that the average value of the science process skills test of the experimental class students is higher than the average value of the science process skills test of the control class students.

The observation sheet of the science process skills indicator is arranged based on the aspects of observing, predicting, making hypotheses, conducting experiments, interpreting data, concluding, and communicating, through the RADEC learning model in science practicums to students in the form of making soap on Colloid material that has been carried out at SMAN 2 Bireuen class X and is divided into Experimental class and Control class.

Table 4.2. Percentage of process skills of the Experimental class

Indikator	Percentage
Observing	93,18
Predicting	77,273
Making a Hypothesis	75,000
Conducting an Experiment	88,636
Data Interpretation	77,273
Conclude	81,818
Communicating	78,409

Based on table 4.2, it is obtained that the average value of the science process skills of students in the experimental class is 81.66% in the moderate category. According to (Ningsi & Nasih, 2020), science process skills are important skills for every student to have. Based on table 4.2, the science process skills of students in the Experimental class obtained the highest percentage in the observation indicator of 93.18% and the lowest percentage in the hypothesis making indicator of 75.00%. Based on table 4.3, the science process skills of students in the Control class obtained the highest percentage in the observation indicator of 86.36% and the lowest percentage in the hypothesis making indicator of 61.36%.

Table 4.3. Percentage of science process skills of students in the Control class

Indicator	Percentage
Observing	86,364

Predicting	72,727
Making a Hypothesis	61,364
Conducting an Experiment	77,273
Data Interpretation	68,182
Conclude	71,591
Communicating	76,136

The highest indicator of observing means that students use several senses in describing the objects observed in the form of seeing the tools and materials for the practicum, listening to instructions on the working mechanism of the practicum, being skilled in holding directly, this is in accordance with what was said by Sitompul et al (2018), that good education can be seen from the independence and enthusiasm of students in the learning process. As stated by (Ningsi & Nasih, 2020) that students tend to be active and skilled in carrying out practicum activities. One example in the practicum of making soap, students are already familiar with the tools used in making soap, students are already familiar with the materials being tested.

The lowest indicator makes a meaningful hypothesis, students make hypotheses based on observation data and existing theories. This is because it is difficult for students to describe estimates from the results of the practicum that are in accordance with the theory that has been obtained. One example in the soap-making practicum, the lack of students' cognitive knowledge of the names of compounds in soap solutions.

This RADEC model places students at the center of learning and allows them to become more active students. In Stage I (Read), students are encouraged to seek information from various sources including textbooks, the internet, and so on. At this stage, students are able to stimulate their skills regarding new knowledge obtained through reading activities related to colloid material before receiving an explanation from the teacher. Teachers play a role in students' reading literacy learning and have succeeded in increasing students' interest in reading by asking students to answer the teacher's questions before learning (Safitri & Dafit, 2021).

Stage II (Answer) students are trained to use their own reading comprehension skills to answer pre-learning questions based on information that has been read previously. This stage increases students' independence in answering pre-learning questions. Therefore, each student tries to answer the questions asked before learning, as evidenced by the student's worksheet. In this way, the teacher plays an active role in determining students' understanding of the material discussed based on information obtained through reading activities (Pohan et al., 2020).

Stage III (Discuss) discussion groups are formed according to teacher instructions, and function as a place for students to exchange information and discuss pre-learning questions and questions listed on student worksheets. In this discussion stage, students who have understood the material help students who do not understand. The teacher plays a role in encouraging students to think critically and express opinions, as well as instilling mental courage to express opinions (Sholihah & Amaliyah, 2022). So collaboration between students who do not understand the material and train collaboration between students in their groups, so that initially group members can understand the questions given by the teacher.

Stage IV (Explain), after group discussion, students present the results of their discussion to other groups. At this stage, students' oral communication skills improve, teachers also play an active role in helping students deliver material and correcting any misunderstandings in students' concepts (Rambe et al., 2023). Stage V (Create), students from other groups create new ideas in the form of questions about what was discussed and ask questions to the group that presented the results. Students who present the material then answer questions so that good communication is created between them which will continue continuously (Sa'baniyah & Riyandari, 2022). At this stage, students can conclude the material they have learned that day. The practicum of making soap itself was created by students using materials found in everyday life and practiced directly in front of the class.

4. Conclusion

A series of research stages have been carried out including pre-research stages including surveys of research implementation locations, LKPD, and validation of observation sheets. The research has been carried out at SMA N 2 Bireun, the sample of this study was students of class X.

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Analysis of Students' Scientific Literacy Abilities on Science Learning in High School

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Abstract. The world of education plays an important role in civilization and the mobility of future generations. However, there are still weaknesses in the learning process, especially in methods that are monotonous and rely on memorization, which results in students having difficulty relating learning to real contexts. Science learning in schools emphasizes results, while the process is often neglected. Scientific literacy, which includes content, context, competencies and attitudes, is the focus of this research to improve students' scientific literacy abilities at the high school level. Data from the Program for International Students Assessment (PISA) shows that scientific literacy in Indonesia is still low. This research aims to analyze students' scientific literacy profiles. Data collection was carried out through scientific literacy questions that were validated constructively and empirically. The scientific literacy indicators measured include 1) Identifying valid scientific opinions; 2) Understanding of research design elements and their influence on findings; 3) Ability to complete tests or questions related to scientific phenomena; 4) Understanding and interpreting basic statistics; 5) Ability to draw conclusions, observe and make decisions based on data. Students' scientific literacy abilities are divided into very good, good, sufficient and poor categories. Based on the research results, it was found that the percentage of students in the very good category was 27.08%, in the good category was 31.25%, in the fair category was 36.45%, and in the low category was 5.20%. Based on these results, it can be concluded that the highest percentage describing students' scientific literacy abilities is at sufficient criteria. Therefore, it is important to increase students' scientific literacy.

Keywords: literacy ability, science literacy, science

INTRODUCTION

The transition period from the industrial revolution 4.0 to 5.0 has an important impact on the progress of human resources, especially in supporting the education sector. Today, in the world of education, 21st century skills play an important role in facilitating students' understanding of science materials. Science learning itself includes aspects of products, attitudes, processes, and applications (Fatimah et al., 2021). In applying scientific knowledge to daily life, the orientation of sustainability is something that needs to be emphasized.

To achieve the desired learning outcomes, science learning requires students to have good science literacy skills. Science literacy has a very important role in the world of education, as evidenced by the assessment of science literacy as an indicator of student learning outcomes (Rita Zahara et al., 2022). However, the reality is that the science literacy ability of Indonesian students is still low, as evidenced by the results of the PISA survey from 2000 to 2018 which shows that the achievement of science literacy of Indonesian students is still at a low

level. Science literacy, according to the Programme for International Student Assessment (PISA), consists of four interrelated aspects, namely content aspects, context, competence, and science attitudes. The results of the 2018 Program for International Student Assessment (PISA) show that the science literacy of Indonesian students is still ranked 73rd with a score of 371, while the average science literacy ability of OECD countries is 487 out of a total of 78 participating countries. This fact shows that the science literacy ability of Indonesian students is below average. Thus, the ability of Indonesian students to understand the concepts and processes of science is still relatively low, and they are not fully able to apply the scientific knowledge that has been learned in daily life, according to reports from the OECD in 2016 and 2019.

Science literacy is also included in science learning. In schools, students still do not fully have good literacy skills. Science learning in schools is expected to be able to apply or implement science literacy in learning. Science is essentially a product, process, attitude and technology. So that in science learning, it is impossible for students to only acquire knowledge (products) but students must be actively involved in learning such as finding knowledge, proving that knowledge through a practicum or experiment and concluding it and ultimately being able to create a tool or technology that can later solve problems faced by the community (Suparya, et al., 2022).

Seeing the importance of scientific literacy in science learning, it is necessary to carry out an analysis to see students' literacy abilities. By knowing their situation, we as educators can look for and implement several alternative solutions as an effort to improve the learning process which prioritizes the development of students' scientific literacy abilities.

IMPLEMENTATION METHOD

This research was conducted at SMA Negeri 2 Bireuen in the odd semester of the 2024/2025 academic year, with 96 students from class XI as a sample. The sample selection used the convenience sampling method, which was chosen because the research was carried out in classes determined by the school. Thus, researchers conducted research in classes that were already available. This research is experimental research, where researchers give treatment to the sample to measure scientific literacy abilities after the treatment. The treatment given is the presentation of questions that are in accordance with scientific literacy indicators. The type of experimental research used is quasi-experiment with a quantitative approach. Data was obtained through a scientific literacy ability test instrument, which consisted of questions related to science learning at the high school level. These questions are designed to measure aspects of students' scientific literacy as a whole.

RESULTS AND DISCUSSION

The results of this study refer to the science literacy ability scores of students that have been calculated. From these calculations, the data was included in the criteria for science literacy ability. There are several criteria for science literacy as seen in table 1.

Table 1. Science literacy criteria

Score	Criterion
86 – 100	Excellent
72 – 85	Good
58 – 71	Enough
43 – 57	Low
≤ 43	Very Low

The research results obtained are presented in the form of percentages based on categories in table 1. The results are presented in table 2.

Table 2. Percentage of science literacy criteria

Category	Number of students	Percentage
Excellent	26	27,08%
Good	30	31,25%
Enough	35	36,45%
Low	5	5,20%

From the presentation in table 2 regarding the science literacy criteria, it can be seen that there are 26 students in the very good category, with a percentage of 27.08%, then in the good category as many as 30 students with a percentage of 31.25%, the category is enough to be filled by 35 students with a percentage of 36.45%, and then in the low category consists of 5 students with a percentage of 5.20%.

Based on the results of the mapping of science literacy criteria, the category that appears the most is the sufficient criterion, with a percentage of 36.45%, this is in line with research conducted by (Pratama et al., 2024), this shows that students are still on the sufficient criteria in their science literacy, so that there are several students who are also included in the very good criteria, good, and low.

Based on the results of the research reviewed from each indicator, it can be seen in figure 1.

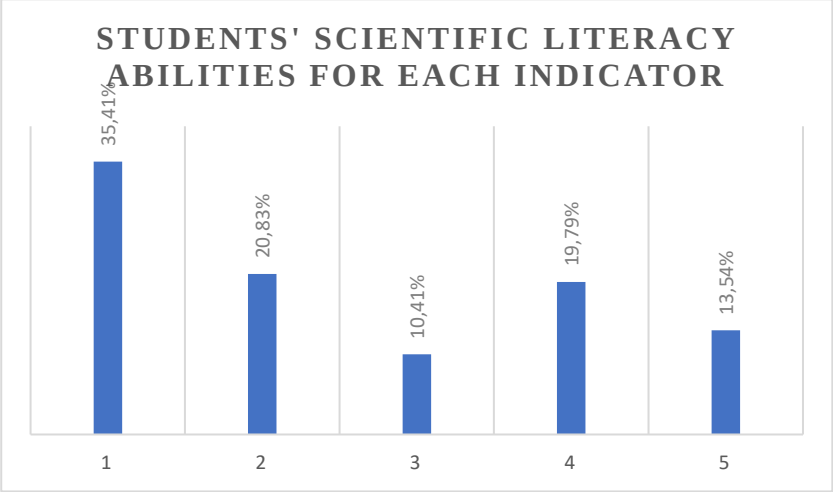

Figure 1. Results of Analysis of Students' Scientific Literacy for Each Indicator

The information in figure 1 includes: 1) Identifying valid scientific opinions; 2) An understanding of the design elements of the research and their influence on the findings; 3) Ability to complete tests or questions related to scientific phenomena; 4) Basic statistical understanding and interpretation; 5) Ability to draw conclusions, observe, and make decisions based on data.

Based on the graph in figure 1, the indicator that shows the ability to identify valid scientific opinions has a percentage of 35.41%, making it the highest achievement. This high percentage is likely due to the efforts of teachers who emphasize the importance of literacy in the learning process, thereby encouraging student engagement. This research is in line with (Inggrid Ayu Amala & Yushardi, 2022) showing that science literacy skills, especially in identifying valid scientific opinions, tend to be poor because students are late in understanding the concepts taught by teachers or other learning resources when answering questions.

The next indicator was an understanding of the design elements of the study and their influence on the findings, which showed a percentage of 20.83%. Therefore, students need guidance from teachers to be able to practice this ability by understanding data from reliable sources, which will help improve their literacy and deepen their understanding.

The next indicator regarding the ability to complete tests or questions related to scientific phenomena showed a percentage of 10.41%. This percentage reflects the lack of practice that students do to improve their understanding of science materials or concepts related to natural phenomena of everyday occurrences.
The next indicator, namely basic statistical understanding and interpretation, showed a percentage of 19.79%. This number shows the need for students to practice in understanding and interpreting the data provided by the teacher. Therefore, teachers must guide students in mapping their understanding and assist in interpreting the data, which can ultimately improve students' science literacy skills.

The last indicator is the ability to draw conclusions, observe, and make decisions based on data with a percentage of 13.54%. Science literacy includes the ability to make decisions that are expected to be based on students based on the science or concepts they have, the form of high thinking of students is through reasoning.

CONCLUSION

Based on the results and discussion above, it can be concluded that most students' scientific literacy abilities are in the sufficient category, namely 36.45%, with the highest indicator being the ability to identify valid scientific opinions, which reached 35.41%. Therefore, it is important to improve students' scientific literacy skills by prioritizing learning that uses scientific literacy-based questions.

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The Understanding Of Higher-Order Thinking Skills (Hots) Among Middle School Science Teachers in Lhokseumawe, Indonesia

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Abstract. This study aims to evaluate the understanding of Higher-Order Thinking Skills (HOTS) among middle school science teachers in public schools in Lhokseumawe. Employing a quantitative descriptive design, data were collected from 15 teachers selected through purposive sampling. A 15-item multiple-choice test was administered, with each question targeting specific HOTS indicators, such as Bloom's Taxonomy, project-based assessment, and analytical skills. The results revealed that while teachers demonstrated strong foundational knowledge of HOTS, with 93% showing proficiency in basic concepts and 87% understanding Bloom's Taxonomy, significant gaps were observed in the practical application of HOTS. Only 60% of teachers showed proficiency in project-based assessment, and just 53% demonstrated strong analytical skills. Furthermore, while 73% of teachers recognized the importance of HOTS in education, only 60% understood its long-term benefits for student growth. These findings highlight the need for targeted professional development, resource provision, and mentorship programs to enhance teachers' ability to implement HOTS effectively in their teaching practices. Addressing these gaps will better equip educators to foster critical thinking and problem-solving skills among students.

Keyword: HOTS, Science Teachers, Bloom's Taxonomy, Project-Based Assessment, Teacher Development, Education

1. Introduction

Higher-Order Thinking Skills (HOTS) are indispensable in contemporary education, as they foster students' ability to analyze, evaluate, and create knowledge rather than simply memorize or recall information. Rooted in Bloom's Taxonomy, HOTS encompass the upper levels of cognitive processes, including application, analysis, synthesis, and evaluation (Anderson & Krathwohl, 2001). These skills are critical in equipping students with the intellectual tools necessary to navigate an increasingly complex and dynamic global environment (Amali et al., 2022; Ms Sanchana Srivastava, 2023). In the context of science education, HOTS enable students to move beyond rote learning and engage in deeper, inquiry-based learning experiences that mirror the practices of real-world scientific exploration (Aryal, 2023; Suyidno et al., 2017)). The incorporation of HOTS into the learning process has been widely recognized as essential for preparing students to address challenges in academic, professional, and societal contexts (Brookhart, 2010).

A basic understanding of HOTS serves as the foundation for teachers to integrate these skills effectively into their teaching (Safirah et al., 2024). Teachers who grasp the core concepts of HOTS can design instructional strategies that challenge students to think critically, solve problems creatively, and apply knowledge in novel contexts (Ertmer & Newby, 2013; Kim et al.,

2019). Bloom's Taxonomy, which categorizes cognitive learning objectives, is central to understanding HOTS. It helps educators differentiate between lower-order skills, such as remembering and understanding, and higher-order skills, such as analyzing and creating (Chinedu et al., 2015; Seman et al., 2017). This framework provides a structured approach for teachers to design learning activities that progressively build students' cognitive abilities (Krathwohl, 2002). Research suggests that teachers' mastery of Bloom's Taxonomy significantly impacts their ability to implement HOTS in classroom practices effectively (Presseisen, 2001)

HOTS-based learning, particularly in science education, emphasizes active student engagement through methods such as problem-based learning, inquiry-based experiments, and real-world application of scientific principles (Harlen, 2010; Jailani et al., 2017). For example, HOTS-based science learning encourages students to formulate hypotheses, analyze data, synthesize findings, and draw evidence-based conclusions (Alanazi et al., 2024; Usman et al., 2024). These activities cultivate deeper understanding and critical thinking, preparing students for advanced studies and professional challenges (Andriani, 2018). However, the success of HOTS-based learning hinges on teachers' ability to synthesize information effectively (Deshpande & Metkewar, 2020; Moyo et al., 2022; Ulgari et al., 2024). Synthesis, a core component of HOTS, involves combining disparate pieces of information into cohesive and innovative ideas, a skill essential for fostering creativity and innovation in students (Binkley et al., 2012).

Assessment also plays a vital role in promoting HOTS. Project-based assessment is a powerful tool for evaluating students' higher-order skills, as it requires them to apply their knowledge to solve real-world problems. By engaging in projects, students demonstrate their ability to synthesize information, analyze complex issues, and create viable solutions. However, the effectiveness of project-based assessment depends on teachers' understanding of how to design and implement such evaluations to align with HOTS principles (Thomas, 2000). Research by Widiati et al (2020) highlights the importance of integrating project-based learning with HOTS to enhance students' cognitive and problem-solving abilities, particularly in science education.

The importance of HOTS in education extends beyond academic achievement. HOTS empowers students to approach challenges with confidence, think independently, and adapt to diverse contexts. In an era of rapid technological advancement and information overload, these skills are essential for lifelong learning and active participation in society (Voogt & Roblin, 2012). Teachers' ability to evaluate students' application of HOTS is crucial, as effective evaluation ensures that instructional strategies meet learning objectives. Evaluation in HOTS requires teachers to assess students' analytical and critical thinking processes, providing feedback that encourages further cognitive development (Brookhart, 2010).

Developing strategies for HOTS implementation is an integral aspect of teacher preparation. Educators must be equipped with practical tools and methodologies to foster HOTS effectively in their classrooms. For instance, integrating Bloom's Taxonomy with innovative teaching approaches, such as project-based learning or technology-enhanced instruction, can make HOTS more accessible and impactful (Mellyzar et al., 2024). Teachers also need to understand the characteristics of HOTS, such as problem-solving, critical thinking, and

creativity, to tailor their instruction to meet these objectives (Riza Andriani et al., 2023; Trilling & Fadel, 2009)

Moreover, understanding the benefits of implementing HOTS highlights its transformative potential. Beyond academic success, students who develop HOTS are better prepared for the workforce and life challenges, as they can think critically, collaborate effectively, and innovate solutions to complex problems. Teachers must recognize these benefits to remain motivated in incorporating HOTS into their instruction, even when faced with challenges such as limited resources or time constraints (OECD, 2018). Research further suggests that teacher training and continuous professional development are key to equipping educators with the skills and confidence to foster HOTS in their students (Darling-Hammond et al., 2017).

The understanding and application of HOTS among middle school science teachers are crucial for fostering a learning environment that prepares students for future challenges. From mastering basic concepts to implementing advanced strategies like project-based assessment, teachers' proficiency in HOTS directly influences students' ability to develop critical and creative thinking skills. This study seeks to evaluate the current level of HOTS understanding among teachers in Lhokseumawe, focusing on key aspects such as Bloom's Taxonomy, synthesis, evaluation, and the benefits of HOTS-based learning. By identifying strengths and gaps, this research aims to provide actionable recommendations for enhancing teachers' instructional practices, ultimately benefiting students and contributing to the broader goals of educational excellence.

2. Methodology

The methodology for this study employed a quantitative descriptive design to assess the understanding of Higher-Order Thinking Skills (HOTS) among middle school science teachers in public schools in Lhokseumawe. The population for this study consisted of 15 science teachers selected using a purposive sampling technique, targeting individuals actively teaching science in middle schools who are relevant to the study's objectives. Data were collected through a structured multiple-choice test containing 15 questions, each designed to measure a specific aspect of HOTS, such as Bloom's Taxonomy, project-based assessment, and analytical skills. Each question corresponded to an individual indicator, with teachers' responses providing quantitative data on their level of proficiency in each aspect.

The data collection process involved administering the test under controlled conditions to ensure accuracy and consistency in responses. For data analysis, the percentage of correct answers for each question was calculated to evaluate the overall performance and understanding level of HOTS indicators among the participants. Descriptive statistics, such as frequency distributions and percentages, were used to summarize and interpret the results, allowing for a clear representation of the strengths and weaknesses in teachers' understanding of HOTS. The findings were then analyzed to identify specific areas where teachers demonstrated high proficiency as well as areas requiring further professional development. This methodological approach ensured a structured, objective evaluation of HOTS

understanding among the sample group, providing insights into their instructional capabilities and areas for improvement.

3. Result and Discussion

This study aimed to assess teachers' performance in applying *Higher-Order Thinking Skills* (HOTS) in science teaching at the secondary school level. Data collected from 15 science teachers in Lhokseumawe revealed that most teachers had a strong basic understanding of HOTS concepts, but there was significant variation in how they applied HOTS in their teaching practices. Figure 1 presents the teachers' performance on each HOTS indicator, with further discussion on strengths and areas needing further development.

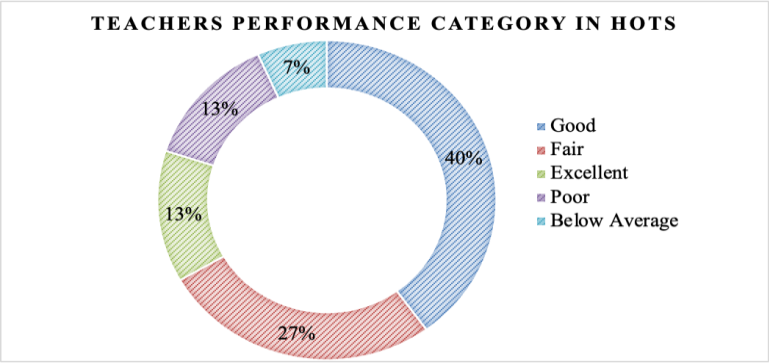

Figure 1. Science Teachers' Performance Category in HOTS

Figure 1 provides a breakdown of the performance categories of middle school science teachers in Lhokseumawe in their understanding of Higher-Order Thinking Skills (HOTS). According to the data, 40% of the teachers fall under the "Good" category, indicating that a significant portion of the educators has a relatively strong grasp of HOTS. The "Fair" category follows with 27%, suggesting that many teachers are competent but may still have room for improvement. Notably, only 13% of teachers are rated as "Excellent," while an equal percentage (13%) falls into the "Poor" category. The "Below Average" category accounts for the remaining 7%.

This distribution reveals several critical insights into the professional development needs and instructional capabilities of science teachers in Lhokseumawe. While a combined 67% of teachers fall within "Good" and "Fair" categories, the low percentage of teachers in the "Excellent" category highlights a gap in exceptional proficiency. This could suggest that while the majority of teachers have a functional understanding of HOTS, only a few demonstrate advanced or exemplary skills necessary for deepening student engagement and fostering critical thinking skills effectively in the classroom.

The presence of teachers in the "Poor" (13%) and "Below Average" (7%) categories raises concerns about the quality of science education provided to students who may be exposed to inadequate instructional methods. HOTS are critical for preparing students for complex problem-solving and analytical tasks; thus, these findings indicate an area that may require urgent intervention. Teachers with limited understanding of HOTS may struggle to implement teaching strategies that challenge students to apply, analyze, evaluate, and create new ideas—skills central to scientific literacy.

The moderate percentage of teachers in the "Good" category implies a foundation that can be built upon through targeted professional development initiatives. However, the scarcity of "Excellent" teachers could also point to systemic issues, such as limited access to resources or training opportunities focused on HOTS. To address these disparities, Lhokseumawe's educational authorities might consider implementing specific workshops, mentorship programs, or continuing education courses tailored to developing HOTS competencies. While the data indicate a fair level of understanding of HOTS among the majority of science teachers, the lack of excellence and presence of lower-performing teachers underscore a need for structured and sustainable professional development. By elevating teachers' proficiency in HOTS, Lhokseumawe's educational system can better equip students with the critical thinking and problem-solving skills essential in today's knowledge-driven world (Kimani, 2024; Mansell, 2002; Rati et al., 2023).

A more detailed analysis of the teachers' achievements across the 15 aspects of HOTS can be found in Table 1. This table provides a comprehensive breakdown of the teachers' understanding and application of each specific HOTS indicator, offering valuable insights into areas of strength as well as those that may require further development and improvement.

Table 1. Evaluation of HOTS Knowledge Among Middle School Science Teachers in Lhokseumawe

Question Number	Indicator	Percentage Correct	Comments
1	Basic Understanding of HOTS (Q1)	93%	Strong understanding of HOTS basics
2	Higher-Order Thinking Skills (Q2)	67%	Moderate understanding; needs improvement
3	Bloom's Taxonomy Levels (Q3)	87%	Good understanding of Bloom's Taxonomy
4	HOTS-Based Learning (Q4)	87%	Good understanding of HOTS-based learning
5	HOTS-Based Science Learning (Q5)	73%	Fair understanding of HOTS-based science
6	Synthesis of Information in HOTS (Q6)	67%	Needs improvement in synthesis skills
7	Project-Based Assessment (Q7)	60%	Requires further clarity on project-based assessment
8	Importance of HOTS in Education (Q8)	73%	Awareness of HOTS importance is adequate
9	Evaluation in HOTS (Q9)	67%	Evaluation process needs better comprehension
10	Bloom's Taxonomy - New Ideas (Q10)	80%	Understanding of idea generation is fair
11	Characteristics of HOTS (Q11)	53%	Requires clarity on HOTS characteristics
12	Analysis in HOTS (Q12)	53%	Limited understanding of analysis in HOTS
13	Strategies for Developing HOTS (Q13)	80%	Fair knowledge of HOTS development strategies

14	Project-Based Assessment for HOTS (Q14)	80%	Fair comprehension of project-based assessment
15	Benefits of Implementing HOTS (Q15)	60%	Requires improvement in understanding benefits

The data on middle school science teachers' understanding of Higher-Order Thinking Skills (HOTS) in Lhokseumawe provides a detailed insight into the strengths and challenges faced by educators in incorporating these essential skills into their teaching practices. HOTS, which encompasses skills such as critical thinking, analysis, synthesis, and evaluation, is crucial for developing students' ability to tackle complex problems and adapt to various academic and real-life situations. The overall results indicate that while a foundational understanding of HOTS is prevalent (with 93% scoring well in basic HOTS understanding), there are clear discrepancies in more specialized and practical applications. For instance, a good grasp of Bloom's Taxonomy (87%) and HOTS-based learning (87%) suggests that teachers understand the theoretical structure of HOTS and its general application. However, the lower scores in HOTS-based science learning (73%) and synthesis (67%) point to difficulties in contextualizing these skills within specific subject areas like science, which requires a specialized approach to foster critical thinking and problem-solving.

One relevant aspect for further analysis is the teachers' ability to apply HOTS through various pedagogical strategies. The moderate scores in project-based assessment (60%) and strategies for developing HOTS (80%) reveal that while teachers may be aware of these strategies, they might lack the practical tools or confidence to integrate them effectively into their teaching routines. Project-based learning (PBL) and other experiential methods are proven to foster deeper learning and engagement, especially in science subjects (Almulla, 2020; Lavado-Anguera et al., 2024; Yu, 2024). However, the low score in general project-based assessment indicates a need for more intensive training on how to design, implement, and assess projects that require students to apply HOTS. This gap suggests that while teachers might conceptually understand PBL, they may not feel equipped to apply it in their classrooms effectively, thus limiting students' opportunities to engage in hands-on, real-world problem-solving activities.

Additionally, the relatively low scores in understanding the *Characteristics of HOTS* (53%) and *Analysis in HOTS*(53%) point to a fundamental gap in recognizing the unique elements that define HOTS. This could affect how teachers interpret and implement HOTS-based approaches, potentially leading to surface-level rather than deep applications. If teachers lack clarity on what distinguishes HOTS from basic learning skills, they may inadvertently deliver lessons that do not fully challenge students' cognitive capacities. Therefore, training should include a focus on defining and recognizing HOTS elements across different scenarios, which could be supported by case studies and real-world examples to deepen teachers' understanding (King & Ritchie, 2012; Lloyd, 2017; Sølvik & Glenna, 2022).

The scores also suggest that while teachers acknowledge the importance of HOTS (73%) and have a fair understanding of generating new ideas based on Bloom's Taxonomy (80%), there is a limited awareness of the broader benefits of implementing HOTS in the classroom (60%). This finding indicates a need for educational programs that emphasize the long-term advantages of HOTS, not only in academic success but also in preparing students for life skills

such as adaptability, critical thinking, and resilience (Carvalho et al., 2008; De Souza et al., 2015; Folke et al., 2010). By understanding the transformative potential of HOTS, teachers might be more motivated to invest in these methods and seek creative ways to incorporate them into their teaching practices.

Another factor to consider is the role of institutional support in enhancing teachers' HOTS proficiency. The data shows that only a small percentage of teachers excel in applying HOTS effectively, suggesting that the educational system may lack adequate resources or support structures (Hamzah et al., 2022). Effective HOTS implementation requires not only individual effort from teachers but also institutional backing in the form of curriculum support, access to resources, and a collaborative environment that encourages innovation (Bakah et al., 2019; Osborne, 2016; Zitha et al., 2023). School administrations in Lhokseumawe could support teachers by offering structured professional development opportunities, encouraging collaboration among teachers to share best practices, and providing access to teaching aids designed to facilitate HOTS-oriented lessons (Rati et al., 2023; Suhadi et al., 2023).

In light of this analysis, a comprehensive approach to address these gaps is recommended. First, workshops focusing on practical applications of HOTS within specific subjects like science could help teachers translate theoretical knowledge into actionable strategies. Second, ongoing mentoring programs that pair less experienced teachers with those who demonstrate higher proficiency in HOTS can foster a culture of continuous improvement. Third, providing teachers with access to resources—such as digital tools, lesson plans, and assessment models tailored to HOTS—can ease the transition from theory to practice. Finally, enhancing teachers' understanding of the long-term benefits of HOTS through seminars or discussions on educational psychology may inspire them to prioritize HOTS in their classrooms.

The data analysis reveals a foundational understanding of HOTS among middle school science teachers in Lhokseumawe, yet highlights significant areas for improvement, particularly in practical applications, project-based assessment, and a deeper conceptual grasp of HOTS characteristics. By addressing these gaps through targeted professional development, resource provision, and institutional support, Lhokseumawe's educational system can enhance teachers' capacity to deliver high-quality, HOTS-focused instruction. This improvement will ultimately benefit students, equipping them with critical thinking, problem-solving, and adaptive skills necessary for success in an increasingly complex world.

4. Conclusion

This study demonstrates that middle school science teachers in Lhokseumawe possess a strong foundational understanding of Higher-Order Thinking Skills (HOTS), with 93% demonstrating basic HOTS knowledge and 87% understanding Bloom's Taxonomy. However, they face challenges in practical application, particularly in areas such as project-based assessment, where only 60% show proficiency, and analytical skills, where just 53% demonstrate a strong grasp. These gaps in specialized skills limit teachers' ability to fully implement HOTS in the classroom, potentially restricting students' development of critical thinking and problem-solving abilities. Although 73% of teachers recognize the importance of

HOTS, only 60% understand its long-term benefits for student growth, which may impact their motivation to consistently integrate HOTS into their teaching practices. To bridge these gaps, the study recommends targeted professional development focusing on practical application of HOTS in science, provision of resources specifically designed to support HOTS-oriented teaching, and mentorship programs that encourage skill-sharing among educators. In summary, while teachers' foundational knowledge of HOTS is solid, enhancing their practical skills through institutional support, access to resources, and comprehensive training can better equip them to foster a classroom environment that promotes critical thinking, preparing students to navigate complex challenges in the future.References

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The Understanding Of Higher-Order Thinking Skills (Hots) Among Middle School Science Teachers in Lhokseumawe, Indonesia

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Abstract. This study aims to evaluate the understanding of Higher-Order Thinking Skills (HOTS) among middle school science teachers in public schools in Lhokseumawe. Employing a quantitative descriptive design, data were collected from 15 teachers selected through purposive sampling. A 15-item multiple-choice test was administered, with each question targeting specific HOTS indicators, such as Bloom's Taxonomy, project-based assessment, and analytical skills. The results revealed that while teachers demonstrated strong foundational knowledge of HOTS, with 93% showing proficiency in basic concepts and 87% understanding Bloom's Taxonomy, significant gaps were observed in the practical application of HOTS. Only 60% of teachers showed proficiency in project-based assessment, and just 53% demonstrated strong analytical skills. Furthermore, while 73% of teachers recognized the importance of HOTS in education, only 60% understood its long-term benefits for student growth. These findings highlight the need for targeted professional development, resource provision, and mentorship programs to enhance teachers' ability to implement HOTS effectively in their teaching practices. Addressing these gaps will better equip educators to foster critical thinking and problem-solving skills among students.

Keyword: HOTS, Science Teachers, Bloom's Taxonomy, Project-Based Assessment, Teacher Development, Education

1. Introduction

Higher-Order Thinking Skills (HOTS) are indispensable in contemporary education, as they foster students' ability to analyze, evaluate, and create knowledge rather than simply memorize or recall information. Rooted in Bloom's Taxonomy, HOTS encompass the upper levels of cognitive processes, including application, analysis, synthesis, and evaluation (Anderson & Krathwohl, 2001). These skills are critical in equipping students with the intellectual tools necessary to navigate an increasingly complex and dynamic global environment (Amali et al., 2022; Ms Sanchana Srivastava, 2023). In the context of science education, HOTS enable students to move beyond rote learning and engage in deeper, inquiry-based learning experiences that mirror the practices of real-world scientific exploration (Aryal, 2023; Suyidno et al., 2017)). The incorporation of HOTS into the learning process has been widely recognized as essential for preparing students to address challenges in academic, professional, and societal contexts (Brookhart, 2010).

A basic understanding of HOTS serves as the foundation for teachers to integrate these skills effectively into their teaching (Safirah et al., 2024). Teachers who grasp the core concepts of HOTS can design instructional strategies that challenge students to think critically, solve problems creatively, and apply knowledge in novel contexts (Ertmer & Newby, 2013; Kim et al.,

2019). Bloom's Taxonomy, which categorizes cognitive learning objectives, is central to understanding HOTS. It helps educators differentiate between lower-order skills, such as remembering and understanding, and higher-order skills, such as analyzing and creating (Chinedu et al., 2015; Seman et al., 2017). This framework provides a structured approach for teachers to design learning activities that progressively build students' cognitive abilities (Krathwohl, 2002). Research suggests that teachers' mastery of Bloom's Taxonomy significantly impacts their ability to implement HOTS in classroom practices effectively (Presseisen, 2001)

HOTS-based learning, particularly in science education, emphasizes active student engagement through methods such as problem-based learning, inquiry-based experiments, and real-world application of scientific principles (Harlen, 2010; Jailani et al., 2017). For example, HOTS-based science learning encourages students to formulate hypotheses, analyze data, synthesize findings, and draw evidence-based conclusions (Alanazi et al., 2024; Usman et al., 2024). These activities cultivate deeper understanding and critical thinking, preparing students for advanced studies and professional challenges (Andriani, 2018). However, the success of HOTS-based learning hinges on teachers' ability to synthesize information effectively (Deshpande & Metkewar, 2020; Moyo et al., 2022; Ulgari et al., 2024). Synthesis, a core component of HOTS, involves combining disparate pieces of information into cohesive and innovative ideas, a skill essential for fostering creativity and innovation in students (Binkley et al., 2012).

Assessment also plays a vital role in promoting HOTS. Project-based assessment is a powerful tool for evaluating students' higher-order skills, as it requires them to apply their knowledge to solve real-world problems. By engaging in projects, students demonstrate their ability to synthesize information, analyze complex issues, and create viable solutions. However, the effectiveness of project-based assessment depends on teachers' understanding of how to design and implement such evaluations to align with HOTS principles (Thomas, 2000). Research by Widiati et al (2020) highlights the importance of integrating project-based learning with HOTS to enhance students' cognitive and problem-solving abilities, particularly in science education.

The importance of HOTS in education extends beyond academic achievement. HOTS empowers students to approach challenges with confidence, think independently, and adapt to diverse contexts. In an era of rapid technological advancement and information overload, these skills are essential for lifelong learning and active participation in society (Voogt & Roblin, 2012). Teachers' ability to evaluate students' application of HOTS is crucial, as effective evaluation ensures that instructional strategies meet learning objectives. Evaluation in HOTS requires teachers to assess students' analytical and critical thinking processes, providing feedback that encourages further cognitive development (Brookhart, 2010).

Developing strategies for HOTS implementation is an integral aspect of teacher preparation. Educators must be equipped with practical tools and methodologies to foster HOTS effectively in their classrooms. For instance, integrating Bloom's Taxonomy with innovative teaching approaches, such as project-based learning or technology-enhanced instruction, can make HOTS more accessible and impactful (Mellyzar et al., 2024). Teachers also need to understand the characteristics of HOTS, such as problem-solving, critical thinking, and

creativity, to tailor their instruction to meet these objectives (Riza Andriani et al., 2023; Trilling & Fadel, 2009)

Moreover, understanding the benefits of implementing HOTS highlights its transformative potential. Beyond academic success, students who develop HOTS are better prepared for the workforce and life challenges, as they can think critically, collaborate effectively, and innovate solutions to complex problems. Teachers must recognize these benefits to remain motivated in incorporating HOTS into their instruction, even when faced with challenges such as limited resources or time constraints (OECD, 2018). Research further suggests that teacher training and continuous professional development are key to equipping educators with the skills and confidence to foster HOTS in their students (Darling-Hammond et al., 2017).

The understanding and application of HOTS among middle school science teachers are crucial for fostering a learning environment that prepares students for future challenges. From mastering basic concepts to implementing advanced strategies like project-based assessment, teachers' proficiency in HOTS directly influences students' ability to develop critical and creative thinking skills. This study seeks to evaluate the current level of HOTS understanding among teachers in Lhokseumawe, focusing on key aspects such as Bloom's Taxonomy, synthesis, evaluation, and the benefits of HOTS-based learning. By identifying strengths and gaps, this research aims to provide actionable recommendations for enhancing teachers' instructional practices, ultimately benefiting students and contributing to the broader goals of educational excellence.

2. Methodology

The methodology for this study employed a quantitative descriptive design to assess the understanding of Higher-Order Thinking Skills (HOTS) among middle school science teachers in public schools in Lhokseumawe. The population for this study consisted of 15 science teachers selected using a purposive sampling technique, targeting individuals actively teaching science in middle schools who are relevant to the study's objectives. Data were collected through a structured multiple-choice test containing 15 questions, each designed to measure a specific aspect of HOTS, such as Bloom's Taxonomy, project-based assessment, and analytical skills. Each question corresponded to an individual indicator, with teachers' responses providing quantitative data on their level of proficiency in each aspect.

The data collection process involved administering the test under controlled conditions to ensure accuracy and consistency in responses. For data analysis, the percentage of correct answers for each question was calculated to evaluate the overall performance and understanding level of HOTS indicators among the participants. Descriptive statistics, such as frequency distributions and percentages, were used to summarize and interpret the results, allowing for a clear representation of the strengths and weaknesses in teachers' understanding of HOTS. The findings were then analyzed to identify specific areas where teachers demonstrated high proficiency as well as areas requiring further professional development. This methodological approach ensured a structured, objective evaluation of HOTS

understanding among the sample group, providing insights into their instructional capabilities and areas for improvement.

3. Result and Discussion

This study aimed to assess teachers' performance in applying *Higher-Order Thinking Skills* (HOTS) in science teaching at the secondary school level. Data collected from 15 science teachers in Lhokseumawe revealed that most teachers had a strong basic understanding of HOTS concepts, but there was significant variation in how they applied HOTS in their teaching practices. Figure 1 presents the teachers' performance on each HOTS indicator, with further discussion on strengths and areas needing further development.

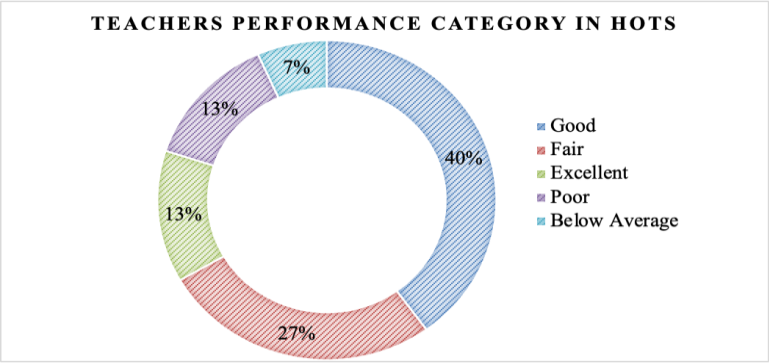

Figure 1. Science Teachers' Performance Category in HOTS

Figure 1 provides a breakdown of the performance categories of middle school science teachers in Lhokseumawe in their understanding of Higher-Order Thinking Skills (HOTS). According to the data, 40% of the teachers fall under the "Good" category, indicating that a significant portion of the educators has a relatively strong grasp of HOTS. The "Fair" category follows with 27%, suggesting that many teachers are competent but may still have room for improvement. Notably, only 13% of teachers are rated as "Excellent," while an equal percentage (13%) falls into the "Poor" category. The "Below Average" category accounts for the remaining 7%.

This distribution reveals several critical insights into the professional development needs and instructional capabilities of science teachers in Lhokseumawe. While a combined 67% of teachers fall within "Good" and "Fair" categories, the low percentage of teachers in the "Excellent" category highlights a gap in exceptional proficiency. This could suggest that while the majority of teachers have a functional understanding of HOTS, only a few demonstrate advanced or exemplary skills necessary for deepening student engagement and fostering critical thinking skills effectively in the classroom.

The presence of teachers in the "Poor" (13%) and "Below Average" (7%) categories raises concerns about the quality of science education provided to students who may be exposed to inadequate instructional methods. HOTS are critical for preparing students for complex problem-solving and analytical tasks; thus, these findings indicate an area that may require urgent intervention. Teachers with limited understanding of HOTS may struggle to implement teaching strategies that challenge students to apply, analyze, evaluate, and create new ideas—skills central to scientific literacy.

The moderate percentage of teachers in the "Good" category implies a foundation that can be built upon through targeted professional development initiatives. However, the scarcity of "Excellent" teachers could also point to systemic issues, such as limited access to resources or training opportunities focused on HOTS. To address these disparities, Lhokseumawe's educational authorities might consider implementing specific workshops, mentorship programs, or continuing education courses tailored to developing HOTS competencies. While the data indicate a fair level of understanding of HOTS among the majority of science teachers, the lack of excellence and presence of lower-performing teachers underscore a need for structured and sustainable professional development. By elevating teachers' proficiency in HOTS, Lhokseumawe's educational system can better equip students with the critical thinking and problem-solving skills essential in today's knowledge-driven world (Kimani, 2024; Mansell, 2002; Rati et al., 2023).

A more detailed analysis of the teachers' achievements across the 15 aspects of HOTS can be found in Table 1. This table provides a comprehensive breakdown of the teachers' understanding and application of each specific HOTS indicator, offering valuable insights into areas of strength as well as those that may require further development and improvement.

Table 1. Evaluation of HOTS Knowledge Among Middle School Science Teachers in Lhokseumawe

Question Number	Indicator	Percentage Correct	Comments
1	Basic Understanding of HOTS (Q1)	93%	Strong understanding of HOTS basics
2	Higher-Order Thinking Skills (Q2)	67%	Moderate understanding; needs improvement
3	Bloom's Taxonomy Levels (Q3)	87%	Good understanding of Bloom's Taxonomy
4	HOTS-Based Learning (Q4)	87%	Good understanding of HOTS-based learning
5	HOTS-Based Science Learning (Q5)	73%	Fair understanding of HOTS-based science
6	Synthesis of Information in HOTS (Q6)	67%	Needs improvement in synthesis skills
7	Project-Based Assessment (Q7)	60%	Requires further clarity on project-based assessment
8	Importance of HOTS in Education (Q8)	73%	Awareness of HOTS importance is adequate
9	Evaluation in HOTS (Q9)	67%	Evaluation process needs better comprehension
10	Bloom's Taxonomy - New Ideas (Q10)	80%	Understanding of idea generation is fair
11	Characteristics of HOTS (Q11)	53%	Requires clarity on HOTS characteristics
12	Analysis in HOTS (Q12)	53%	Limited understanding of analysis in HOTS
13	Strategies for Developing HOTS (Q13)	80%	Fair knowledge of HOTS development strategies

14	Project-Based Assessment for HOTS (Q14)	80%	Fair comprehension of project-based assessment
15	Benefits of Implementing HOTS (Q15)	60%	Requires improvement in understanding benefits

The data on middle school science teachers' understanding of Higher-Order Thinking Skills (HOTS) in Lhokseumawe provides a detailed insight into the strengths and challenges faced by educators in incorporating these essential skills into their teaching practices. HOTS, which encompasses skills such as critical thinking, analysis, synthesis, and evaluation, is crucial for developing students' ability to tackle complex problems and adapt to various academic and real-life situations. The overall results indicate that while a foundational understanding of HOTS is prevalent (with 93% scoring well in basic HOTS understanding), there are clear discrepancies in more specialized and practical applications. For instance, a good grasp of Bloom's Taxonomy (87%) and HOTS-based learning (87%) suggests that teachers understand the theoretical structure of HOTS and its general application. However, the lower scores in HOTS-based science learning (73%) and synthesis (67%) point to difficulties in contextualizing these skills within specific subject areas like science, which requires a specialized approach to foster critical thinking and problem-solving.

One relevant aspect for further analysis is the teachers' ability to apply HOTS through various pedagogical strategies. The moderate scores in project-based assessment (60%) and strategies for developing HOTS (80%) reveal that while teachers may be aware of these strategies, they might lack the practical tools or confidence to integrate them effectively into their teaching routines. Project-based learning (PBL) and other experiential methods are proven to foster deeper learning and engagement, especially in science subjects (Almulla, 2020; Lavado-Anguera et al., 2024; Yu, 2024). However, the low score in general project-based assessment indicates a need for more intensive training on how to design, implement, and assess projects that require students to apply HOTS. This gap suggests that while teachers might conceptually understand PBL, they may not feel equipped to apply it in their classrooms effectively, thus limiting students' opportunities to engage in hands-on, real-world problem-solving activities.

Additionally, the relatively low scores in understanding the *Characteristics of HOTS* (53%) and *Analysis in HOTS*(53%) point to a fundamental gap in recognizing the unique elements that define HOTS. This could affect how teachers interpret and implement HOTS-based approaches, potentially leading to surface-level rather than deep applications. If teachers lack clarity on what distinguishes HOTS from basic learning skills, they may inadvertently deliver lessons that do not fully challenge students' cognitive capacities. Therefore, training should include a focus on defining and recognizing HOTS elements across different scenarios, which could be supported by case studies and real-world examples to deepen teachers' understanding (King & Ritchie, 2012; Lloyd, 2017; Sølvik & Glenna, 2022).

The scores also suggest that while teachers acknowledge the importance of HOTS (73%) and have a fair understanding of generating new ideas based on Bloom's Taxonomy (80%), there is a limited awareness of the broader benefits of implementing HOTS in the classroom (60%). This finding indicates a need for educational programs that emphasize the long-term advantages of HOTS, not only in academic success but also in preparing students for life skills

such as adaptability, critical thinking, and resilience (Carvalho et al., 2008; De Souza et al., 2015; Folke et al., 2010). By understanding the transformative potential of HOTS, teachers might be more motivated to invest in these methods and seek creative ways to incorporate them into their teaching practices.

Another factor to consider is the role of institutional support in enhancing teachers' HOTS proficiency. The data shows that only a small percentage of teachers excel in applying HOTS effectively, suggesting that the educational system may lack adequate resources or support structures (Hamzah et al., 2022). Effective HOTS implementation requires not only individual effort from teachers but also institutional backing in the form of curriculum support, access to resources, and a collaborative environment that encourages innovation (Bakah et al., 2019; Osborne, 2016; Zitha et al., 2023). School administrations in Lhokseumawe could support teachers by offering structured professional development opportunities, encouraging collaboration among teachers to share best practices, and providing access to teaching aids designed to facilitate HOTS-oriented lessons (Rati et al., 2023; Suhadi et al., 2023).

In light of this analysis, a comprehensive approach to address these gaps is recommended. First, workshops focusing on practical applications of HOTS within specific subjects like science could help teachers translate theoretical knowledge into actionable strategies. Second, ongoing mentoring programs that pair less experienced teachers with those who demonstrate higher proficiency in HOTS can foster a culture of continuous improvement. Third, providing teachers with access to resources—such as digital tools, lesson plans, and assessment models tailored to HOTS—can ease the transition from theory to practice. Finally, enhancing teachers' understanding of the long-term benefits of HOTS through seminars or discussions on educational psychology may inspire them to prioritize HOTS in their classrooms.

The data analysis reveals a foundational understanding of HOTS among middle school science teachers in Lhokseumawe, yet highlights significant areas for improvement, particularly in practical applications, project-based assessment, and a deeper conceptual grasp of HOTS characteristics. By addressing these gaps through targeted professional development, resource provision, and institutional support, Lhokseumawe's educational system can enhance teachers' capacity to deliver high-quality, HOTS-focused instruction. This improvement will ultimately benefit students, equipping them with critical thinking, problem-solving, and adaptive skills necessary for success in an increasingly complex world.

4. Conclusion

This study demonstrates that middle school science teachers in Lhokseumawe possess a strong foundational understanding of Higher-Order Thinking Skills (HOTS), with 93% demonstrating basic HOTS knowledge and 87% understanding Bloom's Taxonomy. However, they face challenges in practical application, particularly in areas such as project-based assessment, where only 60% show proficiency, and analytical skills, where just 53% demonstrate a strong grasp. These gaps in specialized skills limit teachers' ability to fully implement HOTS in the classroom, potentially restricting students' development of critical thinking and problem-solving abilities. Although 73% of teachers recognize the importance of

HOTS, only 60% understand its long-term benefits for student growth, which may impact their motivation to consistently integrate HOTS into their teaching practices. To bridge these gaps, the study recommends targeted professional development focusing on practical application of HOTS in science, provision of resources specifically designed to support HOTS-oriented teaching, and mentorship programs that encourage skill-sharing among educators. In summary, while teachers' foundational knowledge of HOTS is solid, enhancing their practical skills through institutional support, access to resources, and comprehensive training can better equip them to foster a classroom environment that promotes critical thinking, preparing students to navigate complex challenges in the future.References

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Study of the effect of variations in fiber orientation on the tensile strength properties of polyester composites reinforced abaca fiber

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Abstract. A composite is a material formed from a combination of two or more constituent materials using a heterogeneous mixing process, whose mechanical properties vary. The aim of this research is to compare the tensile strength values of abaca banana stem fiber polyester composites with variations in fiber orientation. The fiber orientation used is parallel, random and woven. The method used is a hand lay-up press with a fiber volume fraction of 30% and the resin itself uses BQTN 157 EX polyester resin with a hand lay-up method using a glass mold. The test was carried out by tensile testing using the ASTM D3039 measurement standard and macro photos. The results of research on tensile testing show that composites with variations in parallel fiber orientations reinforced with abaca banana stem fibers have an average tensile strength of 39.63 MPa, variations in random fiber orientation have an average tensile strength of 32.87 MPa and variations in fiber orientation woven has an average tensile strength of 25.90 MPa. From the results of macro photo fracture observations, it was found that the type of fracture is a brittle fracture on an uneven fracture surface which causes fiber pull-out where the fibers appear to be coming out of the specimen because the matrix and fibers are not strongly bonded and the fracture is also caused by voids near the fibers.

Keywords: Composite, Abaca Fiber, Fiber Orientation, Tensile Strength, Macro Photo

1. Introduction

The development and application of composite materials has grown and in various sectors, including in this region. Composites are used in household products and industrial applications, spanning small-scale enterprises to large-scale manufacturing industries. Their increasing popularity is attributed to their superior properties compared to conventional engineering materials. Composites are recognized for their high strength, excellent corrosion resistance, cost-efficiency, and other advantageous characteristics. Polymer-based composites comprise a polymer resin matrix (either thermoset or thermoplastic) reinforced with fibers, which can be natural or synthetic. The fibers are available in different forms, like continuous long fibers, short fibers, and woven configurations. Each form has unique mechanical properties that depend on how the fibers are arranged within the composite [1].

Composites are defined as engineered materials formed by combining two or more distinct constituents to achieve superior performance compared to individual components. These materials comprise two primary elements: a reinforcement material, which provides strength and rigidity, and a matrix material, which binds the reinforcement and protects it from environmental and mechanical stresses. Reinforcements, such as fibers, are strong, rigid, and brittle, while matrix materials, often polymers, are ductile, flexible, and chemically resistant [6]. The matrix plays a crucial role in transferring loads to the reinforcements, ensuring their efficient mechanical performance under stress.

Abaca fiber *(Musa textilis),* derived from the banana plant, is a natural fiber with considerable potential as reinforce composite materials. This fiber is renowned for its high tensile strength, exceptional resistance to seawater, and natural durability against microbial degradation. Incorporating abaca fiber into polyester composites has shown the potential to enhance their mechanical properties, encompassing tensile strength, stiffness, and wear resistance. However, to improve the interfacial bonding between abaca fibers and the polyester matrix, alkali treatment with sodium hydroxide (NaOH) is employed. This process removes impurities, changes the fiber's surface characteristics, and enhances its compatibility with the matrix, resulting in improved overall composite performance [11].

The mechanical properties of fiber-reinforced composites are influenced by the orientation of the fibers. Different fiber orientations produce varying mechanical characteristics. Common fiber orientation patterns include unidirectional (parallel), pseudo-isotropic (random), and bidirectional (woven). In fiber-reinforced composites, fibers function as the primary load-bearing component, with the composite's strength dependent on the inherent strength and arrangement of the reinforcing fibers. Smaller, well-arranged fiber components yield higher material strength because of reduced material discontinuities. Fiber orientation, which encompasses variations in angle and layout, is a critical factor in determining the tensile strength and overall mechanical performance of composite materials [7].

Zulfan et al. (2021) conducted a study to examine the tensile strength of polyester composites reinforced with abaca fibers under different fiber orientations, including random, longitudinal (parallel), and woven configurations. Tensile tests were performed on composites fabricated using the hand lay-up method. Composites with woven fiber orientation had a tensile strength of 13.46 kgf/mm^2, those with random orientation had a strength of 1.64 kgf/mm^2, and those with longitudinal orientation achieved 14.64 kgf/mm^2.

This study aims to further explore and compare the tensile strength of abaca fiber-reinforced polyester composites under three distinct fiber orientations—parallel,

random, and woven. Additionally, it investigates the fracture patterns observed during tensile testing through macro-photographic analysis, providing valuable insights into the mechanical behavior and failure mechanisms of such composites.

2. Method

2.1 Fiber Processing

Abaca fibers were got from the village of Paloh Mampree, in Peusangan Siblah Krueng District, Bireuen Regency, Aceh Province, Indonesia. The abaca variety used was the red variety, with banana stalks aged between 9 and 24 months. The processing steps were: Abaca banana stalks were harvested (cut) from plantations or forests into pieces 50 cm, and their outer layers (sheaths) were separated. The sheaths were soaked in water using the water retting method for 14 days. Once the fibers were formed, they were washed with water and combed to remove impurities. The combed fibers were then dried under sunlight.

2.2 Composite Fabrication

Using the hand lay-up method, we performed the composite fabrication process. The specimen design and preparation followed the standards for tensile testing, ASTM D-3039. The steps were as follows: Abaca fibers were immersed in a 5% NaOH solution for 2 hours, then dried in sunlight. Once it is dried, the fibers were cut to match the mold dimensions, with the fiber orientations arranged as parallel, random, or woven.

A glass mold with dimensions of 20 cm in length, 10 cm in width, and 0.5 cm in thickness was prepared. Mirror glaze applied to the mold to facilitate the removal of the composite specimen after drying. Polyester resin was mixed with a catalyst to accelerate the drying process, with the catalyst amounting to 1% of the total resin weight. The liquid resin, serving as the matrix, was poured into the mold, ensuring an even distribution.

The mold was then covered with a glass sheet, and pressure was applied by placing weights on top of the mold as a pressing tool. The drying process was conducted for 5–10 hours or longer if the composite was not cured. After curing, the composite was removed from the mold using a knife or cutter and cut into specimens for tensile testing.

2.3 Research Procedure Flowchart

The research procedure is illustrated in Figure 1.

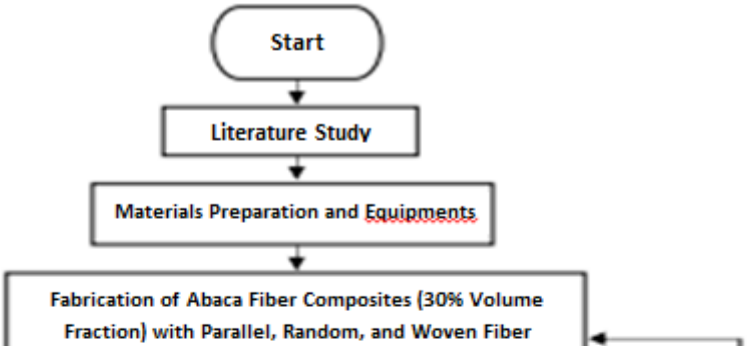

Figure 1 Research Flowchart

3. Result and Discussion

3.1 Tensile Test Specimens

The tensile test specimens consisted of 15 samples, with 5 specimens for each variation of fiber orientation, following the ASTM D-3039 standard. The specimens are shown in Figure 2.

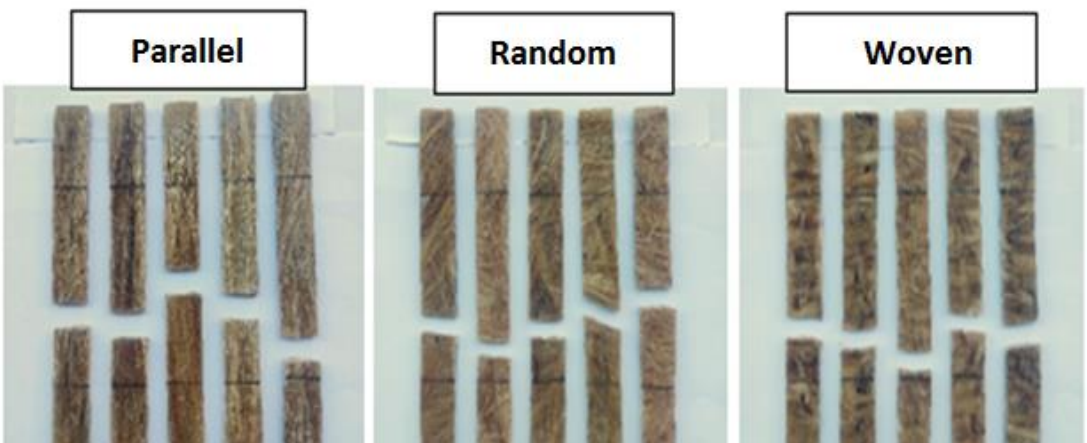

Figure 2 Tensile Test Specimens

The tensile tests based on ASTM D-3039 were conducted on abaca fiber-reinforced polyester composites treated with an alkali solution (5% NaOH) and a fiber volume fraction of 30%, using three different fiber orientations: parallel, random, and woven. To facilitate data analysis, the results are presented in tabular form, as shown in Table 1.

No. of Specimens	cross-sectional area	Elongation	Maximum Load	Tensile strength	Modulus of Elasticity
	(mm^2)	(mm)	(N)	(Mpa)	(Gpa)
1	100	2,21	3972,9	39,73	1,8117
2	100	2,37	3591,9	35,92	1,5269
3	100	2,95	4859,7	48,60	1,6581
4	100	2,39	4393,2	43,93	1,8517
5	100	1,93	2996,2	29,96	1,5493
Rata-rata		2,37	3962,8	39,63	1,6795

For the parallel fiber orientation, the results indicated that the minimum tensile strength was 29,96 MPa, shown by the fifth specimen with corresponding maximum load and modulus of elasticity of 2996,2 N and 1,5493 GPa, respectively. The highest tensile strength was 48,60 MPa shown by the third specimen with corresponding maximum load and modulus of elasticity of 4859,7 N and 1,6581 GPa, respectively. Table 2 provides the tensile test results for the random fiber orientation.

No. of Specimens	cross-sectional area	Elongation	Maximum Load	Tensile strength	Modulus of Elasticity
	(mm^2)	(mm)	(N)	(Mpa)	(Gpa)
1	100	2,09	3274,2	32,74	1,5641
2	100	2,37	2603,4	26,03	1,097
3	100	2,03	3193,3	31,93	1,5702
4	100	2,17	3475,4	34,75	1,5993
5	100	2,39	3888,3	38,88	1,6252
Rata-rata		2,21	3286,9	32,87	1,4912

For the random fiber orientation, the tensile strength indicated the lowest point at specimen 2 with 26,03 MPa and the maximum load was 2603,4 N. The highest level was 38,88 MPa, shown by specimen 5, with maximum loads of 3888,3 N. The modulus of elasticity ranged from 1,097 GPa to 1,6252 GPa, respectively. Table 3 presents the tensile test results for the woven fiber orientation.

No. of Specimens	cross-sectional area	Elongation	Maximum Load	Tensile strength	Modulus of
	(mm^2)	(mm)	(N)	(Mpa)	(Gpa)
1	100	1,75	2997,6	29,98	1,7086
2	100	1,58	2281,7	22,82	1,4487
3	100	1,73	1998,4	19,98	1,1522
4	100	2,13	3395,2	33,95	1,5916
5	100	2,09	2278,3	22,78	1,0884
Rata-rata		1,86	2590,2	25,90	1,3979

For the woven fiber orientation, the tensile strength ranged from 19,98 MPa (specimen 3) to 33,95 MPa (specimen 4), with maximum loads of 1998,4 N and 3395,2 N, respectively. The modulus of elasticity varied between 1,1522 GPa and 1,5916 GPa.

3.2 Comparison of Average Tensile Strength Based on Fiber Orientation

The differences in tensile strength can be attributed to factors such as fiber orientation, fiber volume fraction, and the bonding capability of the matrix. A comparison of the average tensile strength for the three fiber orientations (parallel, random, and woven) is shown in Figure 3.

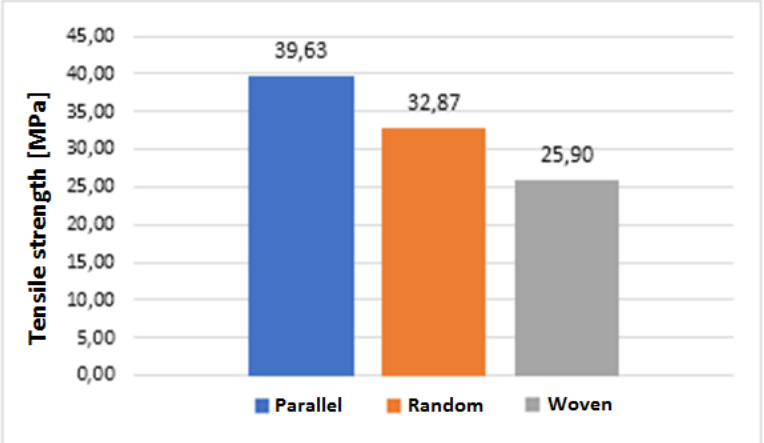

Figure 3 Comparison Diagram of Average Tensile Strength

The results indicate that the parallel fiber orientation exhibited the highest average tensile strength of 39,63 MPa. The random fiber orientation showed an average tensile strength of 32,87 MPa, while the woven orientation yielded the lowest average tensile strength of 25,90 MPa. A comparison of the average elongation values for the different fiber orientations is shown in Figure 4.

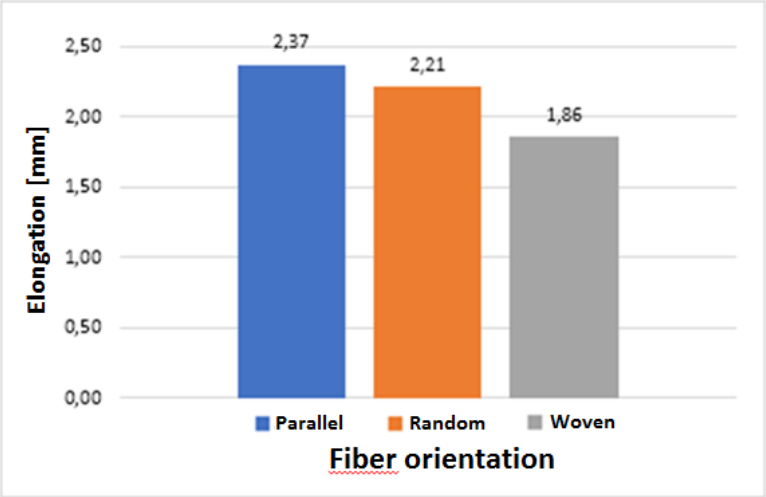

Figure 4 Comparison Diagram of Average Elongation Values

The figure 4 indicated that the parallel fiber orientation had the highest average elongation at 2,37 mm, followed by the random orientation at 2,21 mm, and the woven orientation at 1,86 mm. A comparison of the average Modulus of Elasticity for the three fiber orientations (parallel, random, and woven) is shown in Figure 5.

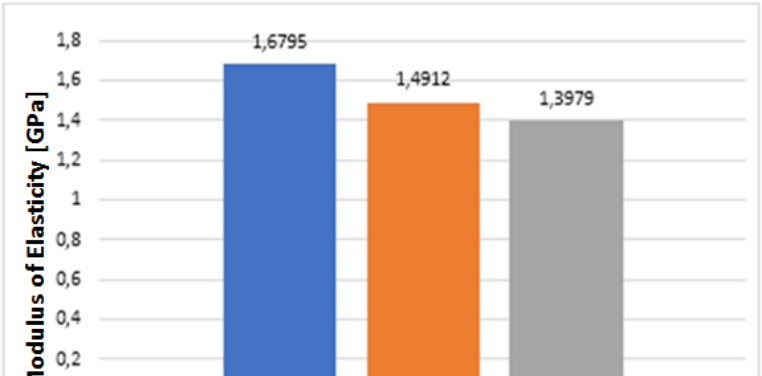

Figure 5 Comparison Diagram of Average Modulus of Elasticity Values

Figure 5 presents the comparison of the average modulus of elasticity for the three fiber orientations. The parallel orientation showed the highest modulus of elasticity at 1,6795 GPa, followed by the random orientation at 1,4912 GPa, and the woven orientation at 1,3979 GPa.

3.3 Macrography Analysis

Macrography analysis was conducted to examine the fracture surfaces of the tested specimens. The macro images, captured using a digital camera with up to 50× magnification at a resolution of 1280 × 960 pixels, were used to identify the type of fracture. For the parallel fiber orientation (Figure 6), the dominant fracture mode was brittle, with significant fiber pull-out observed. This indicates weak bonding between the fibers and the matrix, and the presence of voids around the fibers further contributed to the fractures.

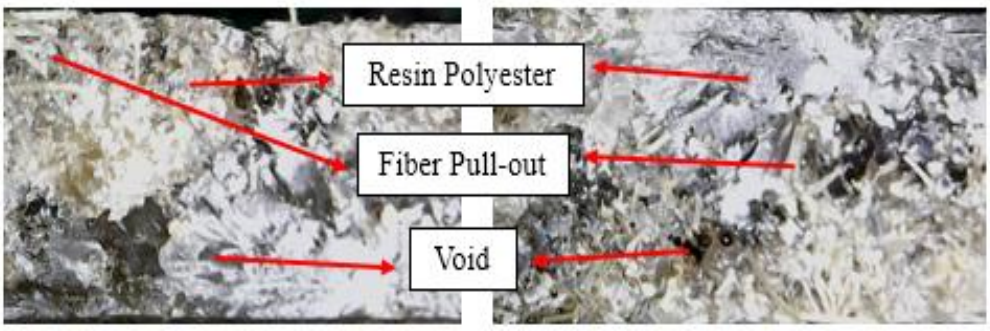

Figure 6 Macrography Analysis for the parallel fiber orientation

For the random fiber orientation (Figure 7), the fractures were primarily due to the brittle nature of the matrix. Additionally, voids trapped within the hardened resin caused weaknesses that made the specimens more susceptible to failure.

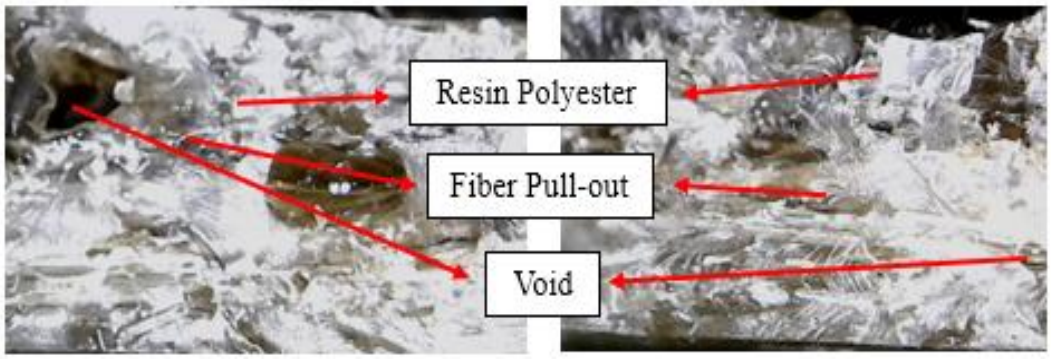

Figure 7 Macrography Analysis for the random fiber orientation

For the woven fiber orientation (Figure 8), the fractures observed were also brittle. Unlike the other orientations, there was minimal fiber pull-out, suggesting that the fibers played a limited role in resisting sudden loads.

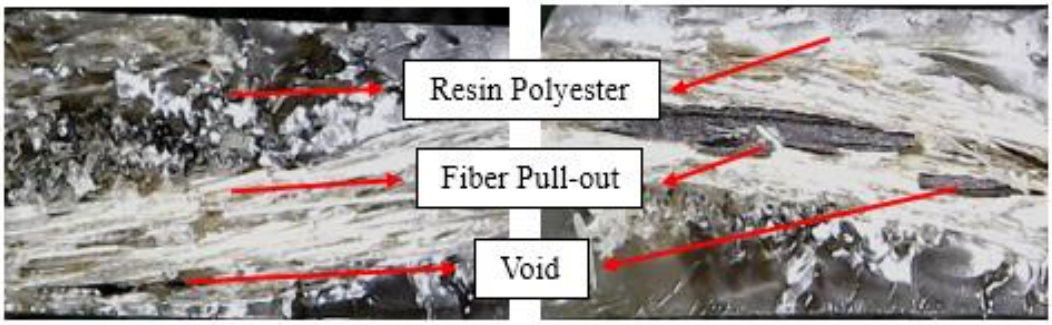

Figure 8 Macrography Analysis for the woven fiber orientation

These results emphasize the influence of fiber orientation on the mechanical properties of abaca fiber-reinforced composites. The parallel orientation provided superior tensile strength and modulus of elasticity, whereas the woven orientation showed the lowest performance.

4. Conclusion

Based on the results of the research, the following conclusions can be drawn: 1. This study found that fiber orientation affects the tensile strength of abaca fiber-reinforced polyester composites. Composites with parallel fiber orientation exhibited the highest tensile strength, followed by those with random and woven orientations. The tensile strength varied with fiber orientation. Parallel fibers showed the highest strength at 39,63 MPa, followed by random fibers at 32,87 MPa, and lastly woven fibers at 25,90 MPa.

2. Macrography analysis revealed that the fracture types observed were brittle fractures, with uneven fracture surfaces. Fiber pull-out was clear, showing that the fibers detached from the specimen because of weak bonding between the matrix and fibers. The fractures were also attributed to voids near the fibers.

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Social and Economic Impact of Measurable Fishing Policies on Fishermen in North Aceh Regency

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Abstract: The measured fishing policy, or catch share, aims to manage marine resources sustainably by providing special quotas to fishermen, but its implementation in North Aceh Regency shows complex social and economic impacts. While these policies can reduce overfishing and improve planning for fishers' activities, potential inequalities in quota distribution can exacerbate economic inequality, with large fishers better able to control quotas than small or traditional fishers. This can affect the social structure within the fishing community and create tension. While there is potential to strengthen cooperation between fishers and increase incomes, the success of these policies relies heavily on fair and inclusive planning to ensure optimal economic and social benefits and sustainability of marine resources. Theoretical perspective on the impact of socio-economic change. Data collection was carried out through Live in, observation, in-depth interviews and the use of documents. The data analysis process is carried out interactively through stages; Data collection, data verification, data patterns, data coding, data thematic networks, meaning and conclusion drawn. The results of this study show that the measured fishing policy in North Aceh aims to preserve marine resources through the regulation of catch quotas. Despite the impact on fishermen's income and society, this policy has the potential to provide long-term benefits if managed properly, through increased fish stocks, stable incomes, and fisher participation.

Keywords: Socio-Economic Impact 1; Policy 2; Fishing 3; Measurable 4; Fisherman 5;

1. Introduction

Fisheries are one of the important economic sectors for many countries, especially in coastal areas that depend on the sea for their livelihoods. However, overexploitation and unsustainable fishing practices have threatened the existence of fish stocks and marine ecosystems. In an effort to overcome this problem, various fisheries management policies have been introduced, one of which is the measured fishing policy. This policy aims to regulate and limit the number of fish that can be caught by each fisherman through a quota system that is determined measurably [1].

Measured fishing policies, or often referred to as "*catch shares*" offer a rights-based approach to fisheries management. This system gives fishermen specific rights or quotas, which allows them to catch a certain number of fish in a certain period of time [2] With this approach, it is hoped that there will be a reduction *in overfishing* and recovery of fish stocks, as well as an increase in efficiency in the use of marine resources. However, the implementation of this policy also has various social and economic impacts that need to be considered in depth.

From a social perspective, measured fishing policies can significantly affect the structure of fishing communities. Large fishermen who have the resources are more likely to buy or control larger quotas, while small or traditional fishermen may have difficulty competing. This can cause tension and injustice in the distribution of quotas, which has an impact on social relations in

coastal communities. However, there is also the potential to strengthen cooperation between fishermen and improve community welfare if this policy is implemented fairly and effectively.

Based on an interview with the commander of North Aceh Laot Tgk Hamdani (2024) economically, the measured fishing policy can affect the income and economic stability of fishermen. With clear quotas, fishermen can plan their activities better, which in turn can increase income and reduce the risk of losses due to fluctuations in fish stocks. However, there is also a risk that these policies could exacerbate economic inequality if access to quotas is not managed fairly. It is important to ensure that these policies are designed with various economic and social aspects in mind to achieve sustainability goals.

Overall, a measured fishing policy is an important step in sustainable fisheries management. However, the success of its implementation relies heavily on careful planning and attention to the social and economic impacts that may arise. Understanding the background and implications of these policies will help in formulating better strategies to support the sustainability of marine resources as well as the well-being of coastal communities.

This reality is interesting to study, the main objective of which is to find out how the implementation of measured fishing policies affects the social and economic conditions of fishermen in North Aceh Regency, with a focus on small and traditional fishers. It includes an analysis of how changes in the distribution of fish quotas affect the income, social structure, and general well-being of fishers within coastal communities. The findings of this study focus on identifying challenges that may arise during the implementation of measured fishing policies and the opportunities that exist to improve the effectiveness of those policies. This includes considering various aspects such as inequities in the distribution of quotas, impacts on social relations between fishermen, as well as strategies to maximize economic benefits and sustainability of marine resources through improvements in policy implementation.

2. Research Methods

This research was conducted in North Aceh Regency. This location was chosen because it is a coastal area and caught by fishermen. Informants for qualitative research can be selected from people who are considered to understand the research problem being studied (Hignett and McDermott 2015). The informants of this study consisted of fishermen, bench toke, Panglima laot lhok and regional commander. The data of this study includes visual *data (observations*), spoken *data*, and written data *(documents)* [3]–[5] These various data were collected by means of non-participant observations, in-depth interviews, and the use of documents [6] Documents consisting of qanuns, memos, announcements, instructions, meeting reports, leadership decisions, journals, newspapers, newsletters and other notes relevant to the research theme are used as secondary data [7] These documents are critically reviewed to understand and become additional data and reinforcement to the primary data. This is done through the process of deconstruction, reconstruction and meaning.

3. Results and Discussion

Social and Economic Impact of Measured Fishing Policies on Fishermen in North Aceh Regency

The measured fishing policy implemented by the Indonesian government, including in North Aceh Regency, aims to manage fish resources in a sustainable manner. This policy establishes a certain quota for fishermen to catch fish in certain waters. This aims to prevent overfishing that can threaten the sustainability of fish resources. While this policy has good long-term goals, its impact on fishermen in areas like North Aceh can be complexs [8], [9].

From an economic perspective, this policy has a direct impact on fishermen's income. With the fishing quota, fishermen who usually catch as many fish as possible without restrictions now

have to adjust their activities to the allowed amount. For fishermen with large fleets, this may not have much of an impact, but for small fishers or traditional fishermen who rely on daily catches to make ends meet, these restrictions can reduce their income significantly [10], [11]. This affects the purchasing power of the fishing community and increases their economic burden.

In addition, restrictions on the number of fish catches can lead to tighter competition between fishermen to obtain fishing permits. In some cases, fishermen who are unable to meet the set quotas or do not have enough equipment to catch fish in accordance with this policy may be forced to find side jobs that are not directly related to the fisheries sector. This can lead to a reduction in the number of fishermen who focus on fisheries, leading to reduced employment in this sector.

However, measured fishing policies also have a long-term positive impact on the fisherman's economy. With more measured fish management, the sustainability of fish resources can be maintained, which means there will be more fish stocks to catch in the future. If this policy goes well, in the long run, fishermen in North Aceh can enjoy a more abundant and stable catch, which in turn can increase their income. This can also strengthen food security in the region.

From the social side, this policy has the potential to cause tension between fishermen. For some fishermen, limiting the number of catches can be seen as a threat to their livelihoods, leading to social discontent. In some cases, disunderstanding or disapproval of this policy can lead to protests or conflicts among fishing groups. Therefore, it is important for the government to conduct intensive socialization about the goals and benefits of this policy and provide training to fishermen so that they can make better use of this policy.

On the other hand, if this policy is accompanied by the active involvement of fishermen in the planning and supervision process, negative social impacts can be minimized. Through a participatory approach, fishers can be given a better understanding of the importance of sustainability of fishery resources and how these policies can benefit them in the long run. Cooperation between the government, fishermen, and local communities is key in creating fair and effective policies.

Overall, although measured fishing policies pose challenges for fishermen in North Aceh Regency, especially in the short term, the long-term impact can be very positive if managed properly. Education and training for fishermen, as well as close monitoring of policy implementation, will be crucial in ensuring that these policies provide maximum social and economic benefits to fishing communities. With proper management, this policy can support the sustainability of natural resources and improve the welfare of fishermen in the long term.

Challenges and Opportunities for Fishermen in the Implementation of Measured Fishing Policy in North Aceh

The implementation of the measured fishing policy in North Aceh Regency presents a number of challenges and opportunities for local fishermen. This policy is designed to preserve fish resources by regulating the number of catches allowed, as well as to keep marine ecosystems from being damaged by overfishing. Fishermen in North Aceh face various challenges in implementing measured fishing policies [12]. One of the main issues is the limited understanding of these policies, as many fishermen are unclear about catch quotas, fishing gear regulations, and the restrictions on fishing times and areas.

The lack of effective socialization or limited access to information makes it difficult for these policies to be properly implemented. Additionally, the new policies require fishermen to change their fishing habits and patterns. Previously accustomed to catching large amounts of fish without concern for quotas or sustainability, many fishermen now face resistance to adapting to the new restrictions. This process of adjustment requires time and support. Furthermore, the

region's infrastructure and technological limitations present further challenges. The lack of effective extension facilities and the inability to use technology to monitor and measure fish catches makes it difficult to supervise and enforce the policies, potentially reducing their effectiveness.

Another significant obstacle is the heavy reliance of fishermen in North Aceh on fish catches for their income. The imposition of catch quotas could adversely affect their livelihoods, especially if the policies are not accompanied by support measures like alternative livelihoods or economic assistance. This dependence on the fisheries sector complicates the implementation of the policies. Despite these challenges, the measured fishing policies present a valuable opportunity for the long-term sustainability of marine resources. Stricter regulations can help preserve the marine ecosystem in North Aceh, ultimately benefiting the fisheries industry. Fishermen who successfully adapt to these changes may experience more stable and increasing catches in the future.

Improving Fish Quality and Economic Value

With more measured management, the quality of fish caught in North Aceh can improve. Fish that are healthier and have a well-maintained ecosystem will be more valuable in the market, both locally and internationally . This opens up opportunities for fishermen to obtain better prices on their catch, as long as they can follow existing regulations and operate in accordance with sustainability principles. Government Support and Collaboration with Other Parties

Another opportunity is the support from the government and various related institutions in the implementation of this policy. Local governments, along with the private sector and non-governmental organizations, can work together to provide training, technology, and socio-economic assistance to fishermen. This collaboration will accelerate the adaptation of fishermen to the policy and increase the effectiveness of its implementation in the field.

Overall, despite significant challenges in the implementation of the measured fishing policy in North Aceh, it offers great opportunities in terms of marine ecosystem sustainability and economic improvement for fishermen who can adapt to the changes. Good assistance and supporting policies will be very important in maximizing the existing potential.

4. Conclusion

The measured fishing policy in North Aceh aims to conserve fish resources and marine ecosystems by regulating catch quotas. While it provides long-term benefits for fisheries sustainability and food security, it has an impact on the fisherman economy, especially smallholder fishers who depend on daily catches. Quota restrictions can lower revenue and create tighter competition. On the social side, this policy can cause tension if fishermen do not understand the impact. Socialization, fisherman participation, and government support are essential to reduce conflict. With good management, this policy can increase fish stocks and fishermen's welfare.

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The Role of Acehnese Women in Post-Conflict Local Economic Development in North Aceh Regency

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Abstract: This research focuses on the role of Acehnese women in post-conflict local economic development in North Aceh. Aceh is an area that has a long history of armed conflict, especially those related to the Free Aceh Movement (GAM) and the Indonesian government. This conflict lasted for more than three decades, which not only resulted in casualties, but also destroyed infrastructure, affected economic stability, and changed the social dynamics of Acehnese society. On this basis, this study seeks to identify what women experience, their strategies, structural and cultural barriers and their experiences in the local economy after conflict. Data collection is carried out through Live in, observation, in-depth interviews and the use of documents. The results of the study show that women in North Aceh play an important role in post-conflict economic development, driving the agriculture, micro enterprises, and handicraft sectors. They are active in the economic empowerment of families and communities, despite the challenges of accessing capital and education. Skills training programs help women increase their entrepreneurial capacity. In addition, they also play a role in post-conflict social reconciliation, improving intergroup relations, and fighting for women's rights in the peace process. Despite much progress, they still face difficulties in accessing education and gender equality in the job market.

Keywords: Women's Role 1; Economic Access 2; Structural-Cultural Barriers 3; Post-Conflict 4; Aceh 5;

1. Introduction

After the signing of the peace agreement in 2005, Aceh began to enter the reconstruction and reconstruction phase. However, the impact of prolonged conflict has left a major challenge in economic recovery efforts. One of the important aspects of this recovery process is the role of women, who are often the backbone of the family, especially in difficult times. However, the role of women in local economic development often does not receive adequate attention, both from the government and from various development programs launched after the conflict [1][2][3].

In North Aceh, which is one of the most conflict-affected areas, women have great potential to drive economic development. They not only play a role in the informal sector, but also begin to be involved in various micro, small, and medium enterprises (MSMEs) that can contribute to the recovery of the local economy. However, this role is still often hampered by factors such as lack of access to resources, education, and training, as well as traditional cultural norms that limit women's participation in the public economy [4].

In this context, this study attempts to understand more deeply how women in North Aceh play a role in post-conflict economic development. The study also aims to identify the challenges women face in their efforts to contribute to the local economy, as well as explore potential strategies that can be implemented to strengthen their roles. Thus, this research is not only academically relevant, but also practical in an effort to support sustainable development and women's empowerment in North Aceh.

In addition, it is important to note that post-conflict also brought significant changes in the social and economic structure in North Aceh [5]. Prolonged conflict not only leaves physical scars but also affects social relationships, power distribution, and gender roles in society [6]. Acehnese women, who during the conflict have lost many husbands, fathers, or sons, often become heads of families and are forced to take a more active role in supporting the family economy. This role, although often seen as an adaptation to emergencies, has opened up new spaces for women to be more deeply involved in economic activities [7].

However, women's involvement in post-conflict economic development is not without challenges. Many women in North Aceh still face social stigma, where they are expected to remain in traditional domestic roles. This stigma is often exacerbated by a lack of structural support such as access to capital, entrepreneurial training, and opportunities to develop business networks. In addition, low levels of education and limited access to information are also significant obstacles. Thus, despite efforts from various parties to support economic recovery, the role of women is often still marginalized [8][9][10].

This research will delve deeper into how North Acehnese women face and overcome these challenges, as well as how they take advantage of the opportunities available to contribute to the local economy. By exploring various successful local initiatives, such as micro-enterprises managed by women, this research is expected to provide new insights into effective strategies to support women's economic empowerment in post-conflict areas. Ultimately, this study aims to provide policy recommendations that can strengthen the role of women in economic development in North Aceh, which is not only important for post-conflict recovery but also for sustainable development in the future.

The formulation of the problem in this study focuses on a deep understanding of the role of Acehnese women in the post-conflict local economic development in North Aceh, as well as the challenges and obstacles they face in these efforts. Post-conflict in Aceh, many women have begun to take an important role in economic recovery efforts, both at the household and community levels. However, despite their significant contribution, women's roles are often still ignored or not adequately recognized in existing economic development policies and programs.

The main issue raised in this study is how Acehnese women, especially in North Aceh, can maximize their role in local economic development in the midst of various existing obstacles. An important question to be answered is: to what extent do women in North Aceh contribute to the local economy after the conflict, and what are the factors that support or hinder their contribution? In addition, the study also wanted to explore how women are overcoming these challenges and what kind of support they need to strengthen their role in the local economy.

Furthermore, the study will also explore how women's access to economic resources—such as capital, training, and business networks affects their participation in economic development. Given that these access is often limited due to the impact of conflict, it is important to understand how these barriers can be overcome and how better access can increase women's participation in economic activities [11]. In addition, this study will consider how cultural and social norms prevailing in Aceh affect the role of women in the economy and how changes in those norms can support or hinder women's economic empowerment.

Thus, the formulation of the problem in this study aims to identify and analyze the role of women in the development of the local economy after the conflict in North Aceh, evaluate the challenges they face, and develop recommendations that can increase women's participation and contribution in the local economy. This research is expected to provide useful insights for policymakers, community organizations, and other institutions working to promote inclusive and sustainable economic development in North Aceh.

2. Research Methods

The methodology of this study is designed to provide a comprehensive understanding of the role of Acehnese women in the development of the local economy after the conflict in North Aceh. This research uses a qualitative approach to explore the experiences, perceptions, and challenges faced by women in their efforts to contribute to the local economy. The qualitative approach was chosen because it allows researchers to gain deep and contextual insights into complex issues, which often cannot be fully explained through quantitative data [12][13]. This research will involve key informants consisting of women business actors, female heads of families, community leaders, and local government officials involved in economic development and women's empowerment programs.

Informants for qualitative research can be selected from people who are considered to understand the research problem being studied [14][15] The informants of this study consisted of women victims of conflict who have small and medium enterprises, local Geuchiek Gampong, the Social Service, representatives of the Aceh Reintegration Agency, as well as NGOs or assistance providers to increase women's participation in MSME businesses such as PGA and the surrounding community which were determined on a purposive basis. All informants in this study were placed as research subjects.

3. Results and Discussion

The Phenomenon of the Dual Role of North Aceh Women After Conflict

In Indonesia, the movement to fight for the position and role of women has been carried out for quite a long time. Kartini is a figure who has pioneered liberating women from darkness through education. Education is considered important because education is a solution in solving all problems and misery of nations [16]. One of the differences between women today and the Kartini era or the past is that women today want, are willing, can, and are even directed to be able to fill two roles, one in the household as a mother and wife, and the other role outside the home.

The definition of women's dual roles in the development era is women's participation which includes the domestic and public sectors, which is urgently needed to support the success of development. In rural communities, the dual role of women is not new. Besides being wives, mothers also have to work outside the home, for example: farming, gardening, trading, looking for timber, working as laborers and others. Because without work, the needs of life will not be met. It means that working is a must. In general, women who have a high level of education are a resource for development, so if they are not used, it is a waste of funds because of the high cost of education.

The shift in roles (division of labor) between men and women in the family and household occurs when a mother has a very important role in society and the state. Where the role of women is not only to lead but also to lead. It must be fought for positive and definite recognition. The division of domestic and public roles is irrelevant if applied in Javanese society. Because in this society, women are used to domestic and public roles. This is especially true in Javanese society

of farmers, traders, and fishermen, where women take care of households (domestic) and earn a living [17].

The same thing also happened to the dual role of North Aceh women. Conflicts are very significant in the process of recovery and reconstruction of society. After the end of the Aceh conflict in 2005, women in North Aceh not only returned to their traditional roles as housewives and educators, but also began to be actively involved in various aspects of social, economic, and political life. Post-conflict contexts give women the opportunity to play a broader role in rebuilding lives devastated by conflict, although they still face great challenges related to social and cultural norms.

As agents of social recovery, North Acehnese women play an important role in healing emotional and psychological wounds arising from conflict. They are often the liaison between family members and the community in the reconciliation process. Women also play a role in conveying the message of peace and tolerance at the local level, especially in fostering harmonious relationships between groups previously involved in conflict. They participate in community forums to strengthen peace and reduce social tensions that may arise post-conflict.

In addition, North Aceh women are taking part in economic recovery efforts in areas affected by the conflict. Many women are involved in informal economic activities, such as micro-enterprises, agriculture, and handicrafts, to improve the welfare of their families. The government and various non-governmental organizations (NGOs) provide skills training and business capital for women, with the aim of empowering them economically. This not only improves family welfare, but also strengthens the role of women in the local economy.

In the education sector, post-conflict North Aceh women also play an important role in advancing the younger generation. Many women return to continue their education after the conflict or become educators in schools to teach the values of peace and tolerance. They play a role in shaping the character of children and adolescents so that they can grow into individuals who are aware of the importance of a peaceful life, and are ready to face social and economic challenges in the future. Education is one of the main keys in ensuring the sustainability of peace and development in North Aceh.

Although North Acehnese women have demonstrated significant abilities and dual roles post-conflict, they still face various challenges. Limited access to resources, including education, health, and decent work, remains a major obstacle. In addition, cultural norms that limit women's role in public life often prevent them from fully participating in politics and decision-making. However, despite this, North Acehnese women have shown remarkable resilience and continue to play an important role in rebuilding a more peaceful and prosperous Aceh.

The Role of Women in Post-Conflict Local Economic Development in North Aceh

Women play a very important role in economic development, especially after the conflicts that hit North Aceh in the past. Post-conflict, the region experienced major challenges in social and economic recovery. Even so, women in North Aceh not only survive in difficult conditions, but also actively contribute to driving the local economy. They are involved in various sectors, from agriculture to small and medium enterprises, and play a key role in restoring post-conflict social and economic stability Interview with said that post-conflict Aceh women began to be directly involved in economic empowerment, unlike before because they were constrained by social constructions as if women could not play a role in the problem [18].

Women play a very important role in economic empowerment, both at the family and community levels. In many cases, women are the main pillars in managing household finances and creating family economic stability. With greater economic empowerment, women can increase their access to education, training, and employment opportunities, which in turn

strengthens their ability to contribute optimally to the economy. When women are given the opportunity to develop their skills and participate in the workforce, they not only improve their own well-being, but also improve the quality of life of their families and communities.

In addition, women's economic empowerment also has a positive impact on the country's overall economic growth. Studies show that increasing women's participation in the workforce can accelerate economic development and reduce poverty. Women who are financially independent tend to be better able to make wise decisions in terms of health, education, and the economy. Therefore, it is important to create policies that support gender equality and provide women with equal access to resources and economic opportunities. In this way, women's empowerment can create a domino effect that brings positive change in various aspects of life.

Women in North Aceh are not only housewives, but also the main drivers in the economic empowerment of families and communities. They are involved in various economic activities such as agriculture, handicrafts, trade, as well as the service sector. Post-conflict, many of them were involved in microeconomic activities, by establishing small businesses that provided jobs for the local community. They not only demand their rights, but also show initiative to improve economic well-being.

Education and Training for Women

Education and training are key to post-conflict women's empowerment in North Aceh. With limited access to education during times of conflict, many women started from scratch. However, with the skills training program, they acquire new skills that support economic activities. Training in entrepreneurship, technical skills, and business management gives women in North Aceh the confidence to develop their businesses and increase their family's economic capacity.

The micro business sector in North Aceh is mostly managed by women, who have succeeded in establishing small businesses such as stalls, handicrafts, and agricultural businesses. Thanks to their active role, many of these businesses are thriving and have a positive impact on the local economy. These micro-enterprises not only create jobs for women, but also encourage economic growth at the village and sub-district levels. They often use loan capital or government assistance to start a business, which then becomes a sustainable source of income.

One of the main challenges faced by women in North Aceh is limited access to capital and economic resources. Although they are highly productive in economic activities, they often face obstacles in obtaining credit or business loans. For this reason, various non-governmental organizations and local governments have played an important role in providing financial management training and access to microloans for women. This support allows them to enlarge their efforts and expand their market network.

Women's organizations in North Aceh play a strategic role in strengthening the role of women in the economy. Through various organizations, women are given space to share experiences, get information, and participate in trainings that can improve their entrepreneurial skills. These organizations also help women in building business networks and fighting for their economic rights. Thus, women are not only part of the family economy, but also play a role in broader economic development.

In the context of local economic development, women in North Aceh also play an important role in natural resource management. Many women are involved in the agriculture, fisheries, and forestry sectors. They contribute to preserving nature, as well as ensuring that the use of natural resources is carried out in a sustainable manner. Through their involvement in such management, women not only support the economy, but also help create an ecological balance that supports long-term sustainability.

Women as Agents of Peace and Reconciliation in Aceh

The prolonged conflict in Aceh has left deep wounds in society. Women play an important role in the process of social reconciliation and recovery. As figures close to family and community, women are often a bridge to rebuild relationships damaged by conflict. They help create an atmosphere of peace, reduce tensions, and strengthen social cohesion that is the foundation for local economic development. Women are also heavily involved in dialogue and post-conflict healing processes, which have a positive impact on economic recovery.

The role of women in the peace and reconciliation process in Aceh is crucial, especially after the decades-long conflict between the Free Aceh Movement (GAM) and the Indonesian government. Women are not only victims of conflict, but also play an important role as agents of peace and reconciliation after the Helsinki peace accords in 2005. Some important aspects of the role of women in this context Post-conflict, women in Aceh play the role of trauma healers. They are often the first to revive war-torn social and family networks. In addition, women are often the liaison in the reconciliation process at the community level, bringing together opposing parties and encouraging dialogue between groups involved in conflict.

Women in Aceh are active in facilitating the peace process, both at the local and national levels. They are involved in peace talks, provide input in policy formulation, and fight for women's rights in peace agreements. In many cases, women are pushing for peace treaties to recognize their rights that are often overlooked during conflict. Despite their great contribution, women in North Aceh still face a number of challenges in local economic development. One of them is the difficulty in accessing higher education, inequality in the job market, and gender-based violence that hinder them from developing. In addition, there are still social stereotypes that assume that women are only suitable for certain jobs, which limits their potential in broader sectors.

4. Conclusion

Overall, women in North Aceh have proven their vital role in post-conflict economic development. With the right empowerment, they are able to overcome various challenges and contribute significantly to the recovery of the local economy. Support from the government and various civil society organizations is essential to increase women's capacity, provide greater access to resources, and create equal opportunities in economic development. In the future, it is important for all elements of society to continue to support the role of women in the economy, so that sustainable and inclusive development can be realized.

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Development of Interactive Media Based On Quizzizz Paper Mode Science Education as an Effort to Improve the Character Profile of Pancasila Students

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Abstract: The digital era is one of the fields that influences the civilization of the 5.0 revolution on world mobility. Learning media as a tool that helps the learning process in presenting material in an interesting way so that the learning situation becomes effective, efficient, active and easy to understand by students. One of the innovations of learning media in the digital era is learning media based on Quizizz Paper - Mode which is a means to facilitate teachers in developing innovative media and for planning interesting learning and can accompany students in the learning process. The purpose of this study was to determine how the validity (by academic media and material experts), feasibility (by media and material expert teachers), and student responses through the implementation of interactive media design based on Quizizz Paper - Mode as an effort to create learning innovations in improving the character of Pancasila student profiles for students of SMAN 2 Biruen. The development of learning media based on Quizizz Paper - Mode Science education uses research and development methods. This study uses the ADDIE development model which is developed consisting of five stages: Analysis, Design, Development, Implementation and Evaluation. Data collection techniques and instruments with validation tests, feasibility tests, student responses through questionnaires. The results of the validity test from media experts obtained results of 85% with the category "Valid", and material experts 75% with the category "Valid". Based on the results of the feasibility test with teachers of SMAN 2 Bireun, the results were 87.50% with the category of feasible and the results of the student response assessment obtained a score of 87.30% with the category of interesting. For N-Gain percent, the average value obtained was 76.2407. This value is greater than 76.00. So it can be concluded that the questions given to students through quizzis paper mode can improve the character of Pancasila profile students. The design of the quizizz paper mode media and the questions chosen are very interesting in science education which aims to strengthen student character in the Pancasila student profile program.

Keywords: Quizizz Paper – Mode, research and development, Pancasila student profile

1. Introduction

The development of science and technology in the current era is very rapid, which requires a digital transformation of development through technology. This era is often also called the digital era, (Mulyani & Haliza, 2021: 101). The rapid development of technology today will continue to produce new patterns in learning and encourage rapid adaptation. In the learning process, the use and utilization of technology in the classroom has become a necessity as well as a demand in the global era (Susilowati, 2022). The use of learning media during the teaching and learning

process is important, both for educators and students (Soekanto et al., 2023). Learning media is a tool that can be used in the learning process with the aim of providing a deeper understanding of the subject matter (Nuranti et al., 2023; Ramadhan et al., 2023; Rezeki & Ishafit, 2017). Interactive learning media brings many benefits, including improving student learning outcomes (Pudjiati et al., 2024).

One concrete example that can be used in interactive technology-based learning evaluation activities in Science education activities can use the Quizz paper mode media. Quizizz paper mode is an interactive quiz that can be followed offline using Quizizz Paper - Mode sheets of paper (Abadi et al., 2023). For teachers, the paper model feature is very useful as a means of offline learning. In addition, the Quizizz paper printing mode eliminates the need for students to use smartphones or internet data. According to (Tarsono et al., 2024) QR codes in education are used so that the learning materials created can be used comfortably and effectively. The Quizizz feature with Paper Mode uses a QR code on a sheet of paper that can be used in offline learning, aiming to help teachers and students create creative face-to-face learning based on interactive, effective and efficient quizzes (Susilowati, 2022).

As a teacher who is one of the figures who has an important role in education, it requires teachers to have the ability to design learning, one of which is designing learning media that is in line with technology. Students who are in the exploration period, identification period, sensitive period and play period are golden periods that should not be missed. Therefore, an effective approach is taken to develop the profile of Pancasila students for students (Oktiningrum & Zuhroh, 2023). Efforts to realize the character of Pancasila Students through learning activities require the selection of appropriate learning media and learning instructions (Muhlisin et al., 2022).

Quizizz-based learning media can help teachers in integrating between online and face-to-face learning (Angelina et al., 2020). This also provides a new experience in learning for students so that the learning process can be more varied, interactive, and innovative which can improve student achievement (Kurniawan & Wijarnako, 2023) Learning innovation based on Quizizz Paper - Mode. By using Quizizz Paper - Mode, it will provide students with new additional media that are interesting and accompany students in learning because students in today's era cannot be forced to learn so this media becomes a companion for students.

2. Materials and Methods

2.1. Location and Subject of Research

Which will be implemented from April to August 2024.

2.2. Population and subjects

The subjects in this study were grade X students of SMAN 2 Bireuen, 2 media experts and 2 material experts and the object of this study was the development of interactive media based on Quizizz Paper - Mode.

2.3. Types and Design of Research

The type of research conducted in this study is a research on the development of learning media based on Quizizz Paper - Mode using research and development methods. This study uses the ADDIE development model which is developed consisting of five stages: Analysis, Design, Development, Implementation and Evaluation. In this study, the stages of ADDIE model development carried out by researchers up to 4 stages of analysis, design, development, and implementation. The selection of the ADDIE model is based on the consideration that this model is developed systematically and is based on the theoretical foundation of learning design (Tegeh et al., 2015). Visually, the stages of the ADDIE model can be seen in the following image:

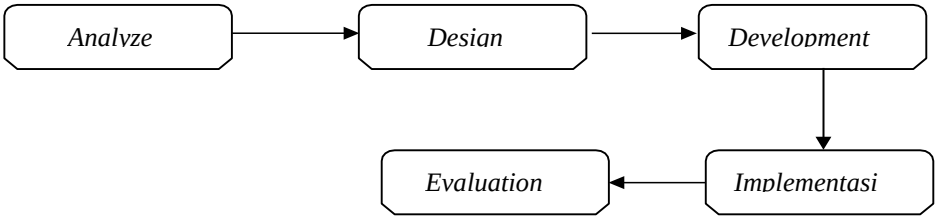

Figure 1. ADDIE model stages

2.4. Data Analysis

2.4.1. Validation Eligibility

The research data was processed using descriptive analysis with notice aspects related design multimedia interactive based on Quizizz Paper - Mode which reviewed from a number of aspect. According to Arikunto (2010) criteria evaluation on the feasibility of interactive multimedia based on Quizizz Paper - Mode is stated in presentation which is calculated using Pers (1).

$$\text{Percentage} = \frac{Jumlah\ skor\ hasil\ pengumpulan\ data}{Jumlah\ skor\ maksimal}\ x\ 100\% \quad (1)$$

Epinur et al., (2014) stated that the percentage score for assessing the feasibility of Bilingual Mobile Learning shown as in Table 1.

Table 1. Percentage of Feasibility Assessment of interactive media based on Quizizz Paper – Mode

No	Achievement Level (%)	Qualification
1	80-100	very worthy/very worthy interesting
2	61-80	worthy/interesting
3	41-60	Moderate/sufficient
4	21-40	No worthy/not interesting
5	0-20	very No worthy/very worthy No interesting

Source: Arikunto (2010)

2.4.2. Expert Validation Questionnaire

Interactive media based on Quizizz Paper – The developed mode is tested for validity by providing a validation sheet to experts consisting of media experts and material experts to clarify the level of validity of the learning device. The scores obtained from all aspects assessed are then converted into percentages using the following formula:

$$P = \frac{\text{Jumlah Skor Hasil Pengumpulan Data}}{\text{Skor Kriteria}}\ \text{x}\ 100\% \quad (2)$$

Table 2. Validity Clarification

Score (%)	Validity Level
81 – 100	Very Valid
61 – 80	Valid
41 – 60	Quite Valid
21 – 40	Less Valid

0 – 20	Invalid

Source: Gitnita, dictionary, & Gusnedi (2018)

2.4.3. Teacher Eligibility Questionnaire

Student and teacher response data were obtained from the results of filling out the response questionnaire sheet. Participant educate And Teacher. Epineur et al., (2014) state that for analyze data which obtained from questionnaire distribution so use formula like on Press (3).

$$\%\text{Score} = \frac{Jumlah\ skor\ hasil\ pengumpulan\ data}{Jumlah\ skor\ maksimal}\ x\ 100\% \quad (3)$$

The feasibility questionnaire used in this development was given to physics subject teachers. This questionnaire was used to see how feasible the multimedia was interactive based on Quizizz Paper – Fashion. The assessment used is a Likert scale. The scores obtained from all aspects assessed are then converted into percentages using the following formula:

$$P = \frac{\text{Jumlah Skor Hasil Pengumpulan Data}}{\text{Skor Kriteria}}\ \text{x}\ 100\% \quad (4)$$

Table 3. Criteria for assessing feasibility testing

Score (%)	**Validity Level**
81 – 100	Very worthy
61 – 80	worthy
41 – 60	Quite decent
21 – 40	Not worthy
0 – 20	Not feasible

2.4.4. Student Response Questionnaire

The response questionnaire sheet was given to students. Researchers gave a questionnaire to students with the aim of seeing the feasibility of multimedia interactive based on Quizizz Paper – Mode developed by researchers. The scores obtained from all aspects assessed are then changed into percentage form using the following formula (Sugiyino, 2016).

$$P = \frac{\text{Jumlah Skor Hasil Pengumpulan Data}}{\text{Skor Kriteria}}\ \text{x}\ 100\% \quad (5)$$

Table 4. Product Practicality Criteria

Score (%)	**Criteria**
81 – 100	Very interesting
61 – 80	interesting
41 – 60	Quite interesting
21 – 40	Less attractive
0 – 20	Not attractive

2.4.5. Student Response Questionnaire

According to Meltzer, the magnitude of the increase can be calculated using the following formula.

Table 5. N-Gain Score Equation

$$\text{N Gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}}$$

N-Gain score acquisition category can be determined based on the N-Gain value or N-Gain percentage (%). The N-Gain value categories are as follows:

Table 6. Gain Score Categories

***N-Gain* Value**	**Category**
$g > 0.7$	Tall
$0.3 \leq g \leq 0.7$	Currently
$g \leq 0.3$	Low

Source: (Meltzer, nd)

3. Results and Discussion

Media interactive based on Quizizz Paper Mode Science Education as an Effort to Improve Character profile Pancasila students. This study uses the ADDIE method. The development procedures carried out are analysis, design, development, implementation and evaluation. The following is a description of the research data conducted based on ADDIE, including the following

3.1. Analyze

This stage aims to determine the basic research problem which begins with conducting observations and interviews with school teachers in Bireun, namely SMAN 2. Through this stage, researchers get information from teachers that digital media can also be used to strengthen students' character in the Pancasila student profile. Therefore, researchers develop media interactive based on Quizizz Paper Mode Science Education as an Effort to Improve Character profile Pancasila students.

3.2. Design

This stage is carried out by creating an interactive media design based on Quizizz Paper Mode Science Education which is designed using the Quizizz application by entering questions that have been validated. The steps in creating Quizizz Paper Science Education Mode include preparing learning objectives in terms of material and questions, then the stage of creating a design visualization plan, cover display, account creation, format selection and initial design. Quizizz Paper Mode Science Education is as follows:

a. Download the Quizizz application on your cellphone and log in with your account (teacher).
b. Quizziz account login
c. Select a quiz with multiple choice questions (4 answer choices), then select start now, then select paper mode.
d. Print the QR cards and distribute them to students. These answer sheets can be reused for each quiz. The QR sheets can be laminated for durability.
e. You can assign QR cards to students by creating a new paper mode group or selecting one of the pre-created groups.
f. Start or host a quiz on your computer/laptop. Questions can be displayed on a projector screen. (Make sure the Quizizz account on your computer/laptop is the same as the account on the mobile app.

g. Scan the student's answers through the Quizizz application on the cellphone. Continue the steps until the question is finished.
h. If the questions are finished, see the quizziz report on the report menu. (Teachers can download the report).

3.3. Development

The development stage at the ADDIE stage carries out validation tests. In this study, validation was carried out by material experts and media experts. Each validator can fill out a questionnaire provided by the researcher to see the quality of the product that has been developed and the validator can provide suggestions for improvement. Product validation aims to see the validity of the Quizizz Paper Mode Science Education that has been developed. The results of the validation of media experts and material experts are as follows:

3.3.1. Media Expert Validation

Media validation aims to measure the validity of the media or design used in the quizizz paper mode media. The following are the results of the media expert validation data:

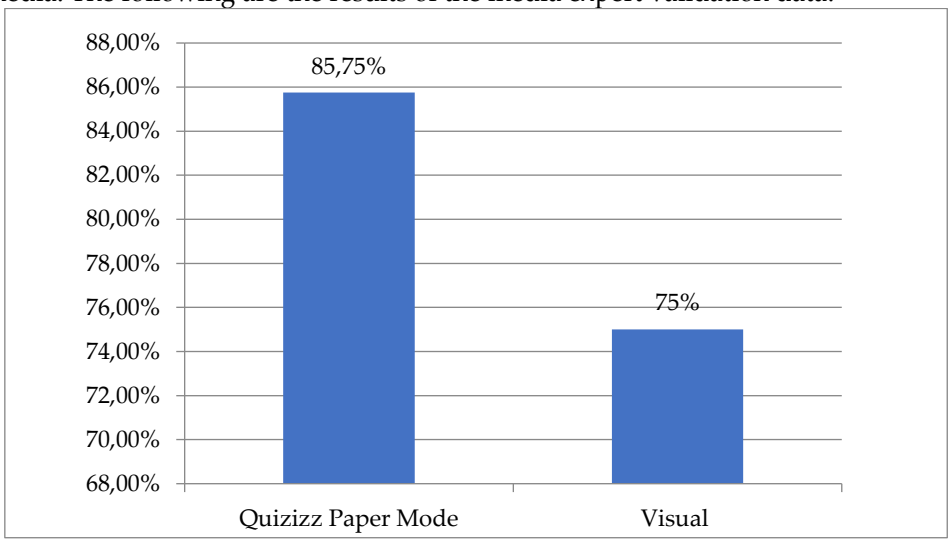

Figure 2. Media Validation Diagram

Based on the table above, the results of the media expert's validity show that the interactive media developed is included in the valid category. This category is seen from the average score of 85% and 75% with the valid category. Based on the assessment by the media expert validation, it shows that the media innovation developed can be declared valid to proceed to the next stage.

3.3.2.Validation of material experts

The validation of material experts aims to test the completeness of the material before the field test. The following are the results of the material validation data.

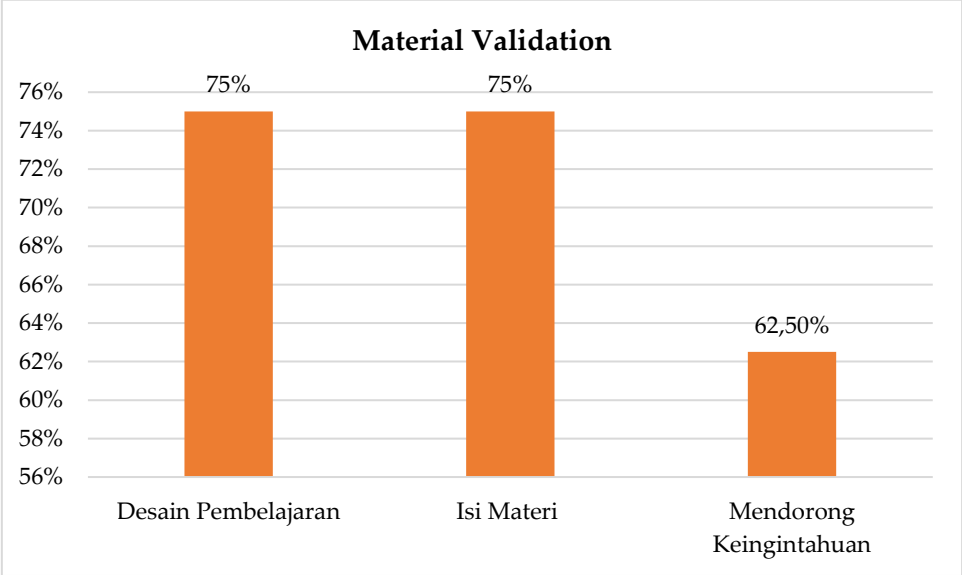

Figure 3. Validation by Material Experts

Based on the table above, the results of the material expert's validity show that the interactive media developed is included in the feasible category. This category is evident from the average score on the learning design aspect of 75%, the material content aspect of 75%, and curiosity of 62.50% with each aspect category being feasible. Based on the assessment by expert validation, it shows that the interactive science education media that supports strengthening the profile of Pancasila students that is developed can be stated Valid tested with several revisions.

3.4. Implementation

This stage is the field trial stage, namely by introducing the media to teachers to test its suitability and to students to find out the response to the learning media that has been created.

3.4.1. Teacher suitability test at SMAN 2 Bireun.

Media quality assessment by teachers at SMAN 2 Bireun. The results of the trial assessment of the feasibility of teachers can be seen in the following figure:

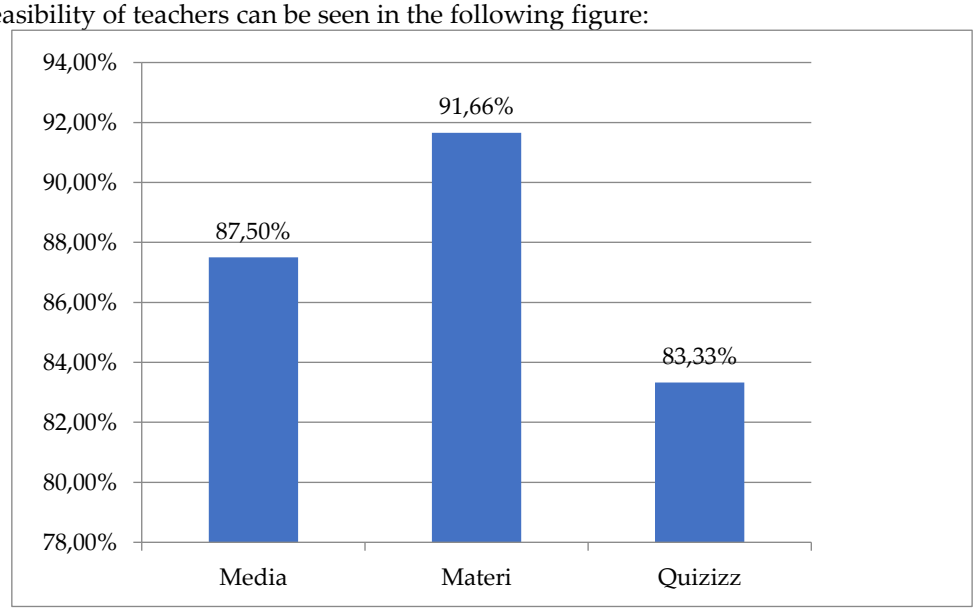

Figure 4. Diagram of teacher suitability test at SMAN 2 Bireun

Based on the picture above, the results of the teacher assessment at SMAN 2 Bireun obtained a percentage of each aspect, namely 87.50 %, 91.66% and 83.33% with the categories very feasible and feasible. Based on the results of the study, it shows that the interactive media quizizz paper mode is very feasible to be used as a science education effort to strengthen student character in the Pancasila student profile.

3.4.2. Student Response Results

The results of the assessment of student responses to interactive media created by students of SMAN 2 Bireun can be seen in the following image:

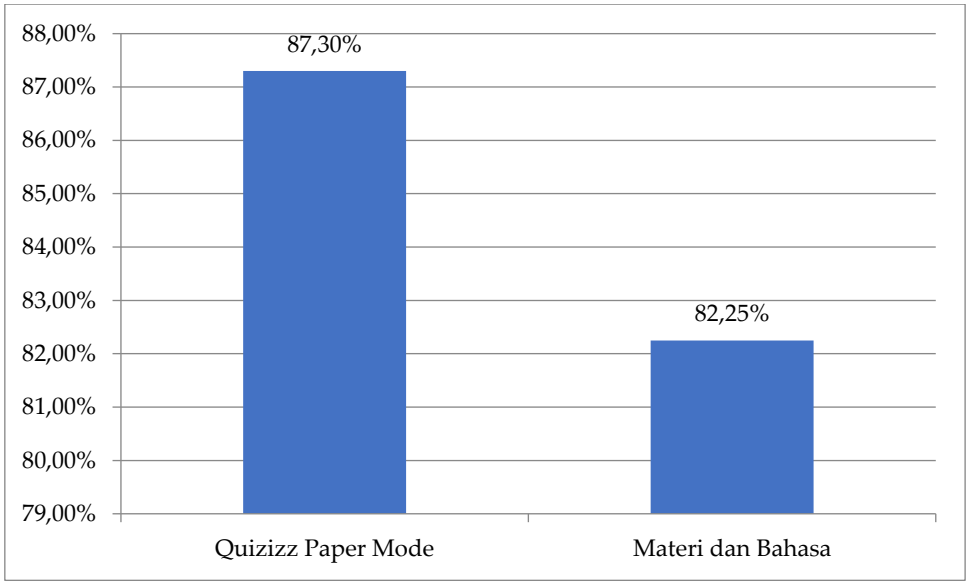

Figure 5. Student Response Results Diagram

The results of the student response trial on interactive science education media show that the media developed is included in the interesting category to use. This category is evident from the assessment results of 2 aspects. The media aspect is 87.30% in the interesting category. The material and language aspects are 82.25 % in the interesting category. This indicator shows that the Quizizz paper mode media used is easy for students to understand.

3.4.3. N-Gain test results

The results of the N-Gain test of the question instrument given to students showed the following N-Gain test results:

Table 7. Test Results N-Gain

Descriptive Statistics

	N	***Minimum***	***Maximum***	***Mean***	***Std. Deviation***
GAIN_SCORE	30	.25	1.00	.7624	.23091
GAIN_PERCENT	30	25.00	100.00	76.2407	23.09084
Valid N (listwise)	30				

N-Gain test in the table above, the average value of the N-Gain score found a result of 0.762. This value is greater than 0.7, so the category obtained is high and can be interpreted as high effectiveness. For N-Gain percent, the average value obtained is 76.2407. This value is greater than 76.00. So it can be concluded that the questions given to students can improve the character profile of Pancasila students.

4. Conclusions

Based on the results of research and development of innovative web-based science learning media for grade X science material as well as data analysis and discussion, the following conclusions can be drawn:

a. The Interactive Media Quizizz Paper Science Education Mode obtained validity from media experts of 85% with the category "Valid", and material experts 75% with the category "Valid".
b. The results of the feasibility test that was carried out with teachers at SMAN 2 Bireun obtained 87.50% in the feasible category.
c. The results of the student response assessment at SMA N 2 Bireun obtained 87.30% in the interesting category.
d. For N-Gain, the average value obtained is 76.2407. This value is greater than 76.00. So it can be concluded that the questions given to students through quizzis paper mode can improve the character of Pancasila profile students.
e. The design of the quizizz paper mode media and the questions chosen are very interesting in science education which aims to strengthen students' character in the Pancasila student profile program.

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