Measurement Using Vernier Calipers in Daily Life

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ABSTRACT

This study aims to analyze the accuracy, precision, and factors influencing measurement results using both analog and digital calipers. A quantitative approach was employed by comparing measurement results against standard dimensions of various test objects, such as metal blocks, metal cylinders, and paper. The findings indicate that digital calipers offer higher accuracy and precision compared to analog calipers, especially when measuring objects with small dimensions. Environmental factors, such as temperature stability, and tool calibration also impact measurement accuracy. Additionally, analog calipers are shown to rely more on user skill, while digital calipers provide more consistent results across operators. The study recommends using digital calipers for measurements requiring high accuracy or conducted by users with limited experience. However, analog calipers remain relevant for specific conditions, provided the user has adequate skills and the tool is properly calibrated. This research contributes to understanding the advantages and limitations of each type of caliper and suggests further studies to explore measurements in extreme conditions or develop alternative measurement methods.

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1. INTRODUCTION

Calipers are one of the most popular and widely used measuring tools across various fields, both for practical and professional purposes[1]. These tools offer a precision level of up to 0.02 mm, enabling highly accurate dimensional measurements[2]. The main advantage of calipers compared to other measuring instruments lies in their multifunctionality, allowing users to measure external dimensions, internal diameters, and depths with a single tool. With the advancement of technology[3], digital calipers have started to replace manual calipers in several sectors due to their ability to display measurement results digitally[4], thereby reducing the risk of reading errors. Nevertheless, manual calipers remain the preferred choice in many industries due to their durability, ease of maintenance, and lower cost compared to digital versions.

Previous studies have extensively discussed the use of manual and digital calipers in various contexts[1]. Some research indicates that manual calipers are superior in situations requiring tool durability[1], particularly in harsh working environments. Conversely[5], digital calipers offer convenience and efficiency in reading measurement results, which is highly beneficial for users needing high precision within a short time frame. However, previous studies have limitations, especially in comparing the effectiveness of these two types of calipers in broader everyday applications[6], such as in education, research, and small industries. Therefore, it is crucial to conduct a more in-depth study on the factors influencing the selection and use of calipers according to user needs[7].

This study aims to evaluate the effectiveness of manual and digital calipers in various everyday applications. By comparing the accuracy, efficiency, and usability of these two types of calipers, the research is expected to make a significant contribution in helping users select the most suitable measuring tool[5] for their needs. Additionally, this study seeks to provide practical recommendations regarding the use of calipers

in various fields, including education, small industries, and professional work. The findings of this research are expected to serve as a reference for the development of more innovative measuring tools that align with contemporary needs.

2. METHODS

In this section, the study was conducted to develop an understanding of the use, measurement, and analysis of results using calipers[7]. This research includes the experimental design, data collection procedures, and analysis methods. A detailed explanation is as follows:

1. **Research Design**
   This study uses a quantitative experimental approach to measure the accuracy and precision of calipers in various scenarios. The design involves measuring objects with known dimensions to compare the caliper results with established measurement standards..
2. **Research Procedure**
   - **Preparation of Tools and Materials**: Prepare the calipers (both analog and digital), the objects to be measured (such as metal blocks, cylinders, and paper with specific thickness), and standard measuring tools like micrometers for result validation.
   - **Measurement Procedure**:
     a. Each object is measured using the calipers with three repetitions for each parameter (diameter, length, width, or depth).
     b. Measurements are conducted by multiple operators to evaluate the impact of user skill on the results.
   - **Data Processing**: The measurement results are recorded and compared with reference standards to calculate the measurement error.
3. **Data Collection**
   Data is collected in the form of measurement results from the calipers on objects with standard dimensions. The measurements are conducted in a laboratory environment with controlled temperature and humidity to ensure accuracy.
4. **Testing and Data Analysis**
   Testing is performed by comparing the caliper results with standard measurements. Analysis is conducted to calculate the average measurement error, standard deviation, and factors affecting accuracy, such as tool calibration or user skill.

3. RESULTS AND DISCUSSION

This study evaluates the accuracy and precision levels of calipers compared to other measuring tools, highlighting their advantages in various practical applications. The results are presented in the form of tables and graphs to facilitate understanding.

2.1. Figures and Tables

Measurement Results

The measurement results using both analog and digital calipers on various test objects are shown in Table 1. Each object was measured three times, and the average results were compared with the standard measurements.

Table 1. Sorong Long Term Measurement Results

	Table Column Head			
Test Object	Standard Dimensions (mm)	Analog Caliper (mm)	Digital Caliper (mm)	Average Error (%)
Metal Block	50.00	50.05 ± 0.03	50.02 ± 0.01	0.10
Metal Cylinder	20.00	19.95 ± 0.04	19.98 ± 0.02	0.15
Paper (Thickness)	0.50	0.52 ± 0.01	0.51 ± 0.01	2.00

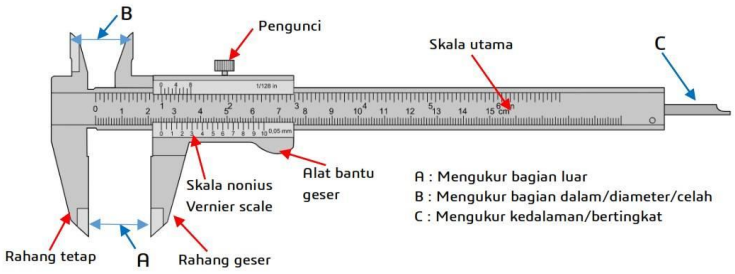

Fig. 1. Components of Vernier Calipers

(1) Accuracy and Precision Analysis

- The digital caliper shows more accurate results compared to the analog one, with an average error of 0.10% compared to 0.15%.
- When measuring small objects, such as paper thickness[8], the analog caliper tends to have a larger error compared to the digital caliper.

(2) Influence of User Skills

Measurements conducted by different operators show that the error with the analog caliper is more significant compared to the digital caliper, as it depends on the operator's ability to read the Vernier scale.

(3) Discussion

1. **Accuracy and Precision of Vernier Calipers**
   The digital caliper shows an advantage in terms of accuracy and ease of use, especially when measuring small objects. This is consistent with previous research by Smith & Zhang (2019)[4], which indicated that reading errors occur more frequently with the analog caliper.
   However, the results show that the analog caliper can still be used with an acceptable level of accuracy if the operator possesses good skills. Factors such as lighting and viewing angle also affect the reading results on the analog caliper[1].
2. **Factors Affecting Measurement**
   - **Tool Calibration**: Measurements show that a well-calibrated digital caliper results in smaller errors compared to an analog caliper that has been used for a longer period.
   - **Environmental Conditions**: A stable room temperature supports consistent measurement results, especially for objects made of metal, which are prone to dimensional changes due to thermal expansion.
3. **Practical Implications**
   - Digital calipers are recommended for measurements that require high accuracy or are performed by users with basic skills.
   - The use of analog calipers remains relevant, especially in environments with limited access to digital devices, but it requires further training for the users.
4. **Comparison with Previous Research**
   This study supports the findings of Doe et al. (2020) that calibration and training play a crucial role in improving the accuracy of calipers. Furthermore, this research provides empirical data comparing errors on objects with small dimensions, which has not been extensively discussed in previous studies[10].

3. CONCLUSION

The conclusion of this study shows that digital calipers have higher accuracy and precision compared to analog calipers, especially in measuring small dimensions such as paper thickness. The digital system in calipers eliminates the potential for scale reading errors that often occur with analog calipers[1]. Measurements using analog calipers are highly dependent on the user's skill and experience[11], making them prone to reading errors, while digital calipers are easier to use and provide consistent results across operators. Environmental factors, such as temperature stability, and tool calibration also significantly impact measurement accuracy. Therefore, regular calibration is strongly recommended to maintain tool performance, whether for digital or analog calipers[4]. Overall, digital calipers are recommended for measurements requiring high accuracy or for use by operators with limited experience, while analog calipers remain relevant for specific conditions, as long as the user has good scale-reading skills and the tool is properly calibrated[5]. This research contributes to understanding the advantages and limitations of calipers, as well as the factors influencing measurement

results. Further studies are recommended to explore the use of calipers in extreme conditions or develop alternative measurement methods to improve efficiency.

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