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# Cantilever Jaw Measuring Instruments As Microcontroller Learning Trainers

[1]Ulfah Mediaty Arief*, [2]Lazuardi Kahfi, [3]Indah Novi Yarman, [4]Sri Sukamta, [5]Riska Dami Ristanto, [6]Henry Ananta, [7]Rizal Anas Khasbullah, [8]Rembulan Almasya Choiri

**Abstract**
*The chewing process has a significant impact on the quality of human life. The condition of the teeth and jaw will affect self-confidence and nutritional intake. This research aims to develop and test a bite force measuring instrument using stainless steel material from car leaf springs for toughness and flexibility - in the form of cantilevers. The research was carried out by making a gnathodynamometer to measure the accuracy and accuracy of the readings. Testing is carried out by p[1]roviding a tool with a known mass and comparing the results with the weight of the mass as well as trialling the use of the tool to Electrical Engineering Education Students which is an educational implementation of Basic Electronics, Electronic Instrumentation, Microcontrollers, and other courses. So this tool is also designed to support students' psychomotor processes by acting as a trainer/learning medium. Development research method with waterfall and respondents 73 students. The device uses Arduino Nano to process bite-force data from the HX711 module. The test used a mass of 45,590; 96.648; and 144,952 Newtons. The results stated that the gnathodynamometer was effective enough to be used with an uncertainty of 0.192 and an RMSE value of 0.554. The study did not measure the maximum capacity of the device due to limitations of the test equipment, and more research is needed before testing on human subjects. The Psychomotor Learning Outcomes graph obtained the percentage of students who completed 83.87%, and the percentage of students who did not complete it was 16.13%. So, it can be concluded that this tool can be used as a learning medium in the form of a bite measuring trainer (gnathodynamometer) which can help students understand the process of using the tool until empirical measurements are recorded and become learning in the use of gnathodynamometer.*

***Keywords:*** *Testing, bite strength, measurement device, cantilever deformation***.**

## INTRODUCTION

Traffic management and accident management is Chewing is one of the necessary processes for everyone. But not everyone has good chewing skills. Several factors include decay, loose teeth, malocclusion, temporomandibular joint function, or jaw fracture (Brassard et al., 2020). In addition, malocclusion or imbalance between the upper and lower teeth can also affect how we chew food. Temporomandibular joint function (TMJ) or jaw fractures can also cause problems in chewing ability (Miró et al., 2023). Problems during the chewing process have a significant impact on the quality of life of humans. When a person has problems chewing food, it can affect his nutritional intake and make him feel uncomfortable eating (S. Kim et al., 2021). In addition, this problem can also cause embarrassment or lack of confidence in the individual who experiences it. In this case, it can be challenging for those with unhealthy mouths. 57.6% of the Indonesian population has oral problems. They have a vision of dental and conditional

[1,2,3,4,5,6,7,8]Department of Electrical Engineering, Faculty of Engineering, Semarang State University Building E8, UNNES Sekaran Campus, Gunungpati, Semarang, 50299, Indonesia
*corresponding author: ulfahmediatyarief@mail.unnes.ac.id[1]

health by measuring how strong the bite is. A jaw gauge (gnathodynamometer) is needed to measure bite force (Alunda & Lee, 2020).

A jaw gauge or gnathodynamometer is a device used to measure a person's bite force. This tool is commonly used by dentists and oral and maxillofacial surgery specialists to evaluate the health condition of a person's teeth and mouth(Ismail et al., 2022). The device can determine the pressure generated when a person bites into food. Critical because good chewing ability is also affected by the force of a person's bite(Miró et al., 2023). This force can be measured using a particular device called a bite force meter (Amon et al., 2022). The device is usually attached to the front of the patient's teeth and asked to bite the plate or sensor contained in the tool. Then, the bite force will be displayed in Newtons (N) or pounds-force (lb-f)(Sakamoto, 2022). The value of a person's bite force can be prejudiced by various factors such as age, gender, body size, dental and oral health conditions, and daily physical activity. For example, research shows that men have greater bite force than women. In addition, children generally have weaker bite forces than adults (Wittler et al., 2021).

Bite force measurement can be helpful in dentistry, such as orthodontics and restoration procedures on damaged teeth and treating TMD (temporomandibular disorders) because the value of the bite force can provide information about the function of the masticatory system and assist doctors in diagnosing and planning further medical actions (Journal of Zoology - 2022 - Deeming - Inter-relationships among Body Mass  Body Dimensions  Jaw Musculature and Bite Force.Pdf, n.d.).
A gnathodynamometer is placed in the patient's mouth, telling them to bite as hard as possible without hurting. However, biting strength differs between individuals, determined by age and sex (Saffari et al., 2020). The dominant side has greater bite force than the non-dominant side (Beli et al., 2019). But the biting force is not affected by the palatine torus (Brassard et al., 2020). Despite this, there are cases in which the palatine's torus can cause discomfort, such as difficulty speaking or eating. However, the torus palatine generally will not affect a person's ability to bite food firmly (Beli et al., 2019).

The gnathodynamometer tool can be a testing tool for students as a learning medium as a trainer. There is no trainer tool used in learning to check bite force which is very useful for health students in gnathodynamometer training. Meanwhile, to find out the gap in previous research, in a search with a web application, https://openknowledgemaps.org found research mapping as in Figure 1 below, which can be explained that the novelty value of this research is still high to be continued and has a good impact on improving the quality of education, especially in the health sector using technology.

**Figure 1.** Research Gap Related to Gnathodynamometer (Open Knowledge Maps, 2023)

This research was conducted by making a gnathodynamometer to measure the accuracy and precision of its readings. Testing is performed by giving the tool a known mass and comparing the result with the mass weight and trial of using tools to Electrical Engineering Education Students. The results can be calculated to determine if the device is effective enough to display measurement results (Y. Yang et al., 2019). Bite force can be measured using measuring devices with sensors such as Strain Gauge Transducer, piezoresistive transducer, pressure transducer, piezoelectric transducer, and pressure sensitive film. Another alternative is using gummy candy (D. S. Kim et al., 2020).

## METHODOLOGY

### Research Methods

The research method uses a waterfall with stages in Figure 2; Phase I: a feasibility study. The goal of the first step is to build a tool to check the bite strength of the teeth and determine what to design and what functions (Li et al., 2021). The software's specifications must be met are outlined and listed at this point (Placeholder1) (Şengül Ayçiçek et al., 2021). This stage begins the software development process, where an analysis of the needs or requirements of the system to be developed is carried out. Phase II: The project's hardware requirements are determined during this stage. Packaging and component requirements stage developers begin to design the interface's appearance and the overall system architecture to determine how the application works (Event Horizon Telescope Collaboration et al., 2022).

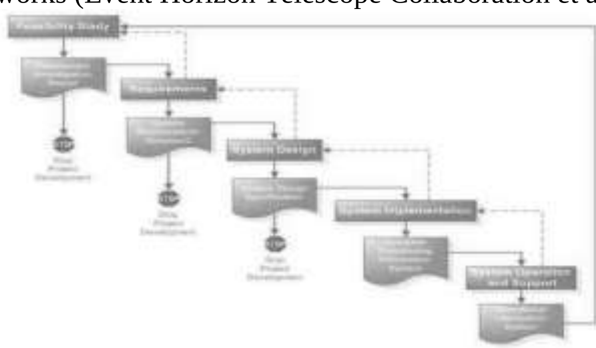


**Figure 2.** Waterfall Method (McCormick, 2012)

Phase III of the system design process will be implemented by assembling a prototype bite force check device using a barbell. In the next installation, the implementation of this installation design is fully completed (Brassard et al., 2020). Furthermore, implement or create programs based on the design results in the previous stage. Testing is carried out by providing a tool with a known mass and comparing the results with the weight of the mass as well as trialling the use of the tool to Electrical Engineering Education Students which is an educational implementation of Basic Electronics, Electronic Instrumentation, Microcontrollers, and other courses. So this tool is also designed to support students' psychomotor processes by acting as a trainer/learning medium. The evaluation phase is looked at, and the design phase utilizes new components (Kiran et al., 2021). This gnathodynamometer will use strain gauge sensors on the cantilever based on the reference, then 2 strain gauges on the cantilever in the Wheatstone bridge half-bridge configuration as Figure 3:

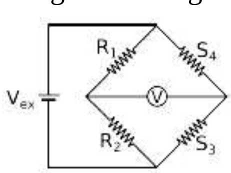


**Figure 3.** Wheatstone Bridge Half-Bridge Configuration (Anderson Langone Silva et al.)

When the cantilever is deformed, the voltage that crosses the Wheatstone bridge is then amplified and converted into a digital signal using the HX711 module and processed by Arduino Nano so that the results can be seen on the LCD screen (Meng, 2022). This configuration consists of two strain gauges connected in series and mounted on a test specimen such as a beam, plate, or cylinder. In each strain gauge, there is a change in resistance that occurs when the specimen is distorted or strained due to loading. A Wheatstone bridge then amplifies the change in resistance to produce an output signal in the form of electric voltage (Rochman & Yunianto, 2019). In the Wheatstone half-bridge configuration, only two-gauge strains of the same type and identical resistance values are used. These two gauge strains are connected in series so electric current can pass through them simultaneously (Şengül Ayçiçek et al., 2021).

The output signal of the two-gauge strains will be the difference between their output voltages when given a specific load on the specimen. The difference can be calculated and converted to units of force or pressure according to the sensitivity of the strain gauge sensor (Anderson et al., 2021). The advantages of the Wheatstone half-bridge configuration are more cost-effective than the entire bridge configuration because it only requires 2 sensors. However, the sensitivity is not as good as in the complete bridge configuration because it only gets half the resistance change information on the Wheatstone bridge circuit (Hildebrandt et al., 2021).
Phase IV: The idea and application flowchart are now realized, and the equipment is ready. Test the system after it has been implemented to ensure the quality and functionality of the application before the public uses it. The gnathodynamometer will be tested against high loads so that it uses a cantilever form (Şengül Ayçiçek et al., 2021). The cantilever is made of stainless steel leaf springs from Toyota Kijang Cars. Steel was chosen for its outstanding resistance to high loads without permanent deformation (Mikalef & Gupta, 2021). Phase V: Equipment testing. After going through the trial process and being declared passed, it only enters the operationalization stage or direct use by the user. Testing will be conducted using 3 known weights from 45,590 N, 96,648 N, and 144,952 N. These weights were chosen to represent the biting style of children aged 8-12 years [9]. Then compare the readings. The collected data is then calculated to determine the average reading value, standard deviation, standard error, and RMSE (Root Mean Square Error). An RMSE value of less than 1 indicates that the tool is practical. This study did not measure the maximum load capacity due to the limitations of the test equipment (Lamatenggo et al., 2020).

**Electronoc Circuit**

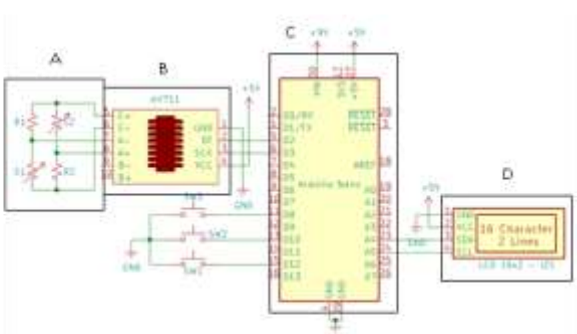


**Figure 4** Electronic Circuit

In the Figure 4 above, box A is the input section where bite pressure will affect Strain Gauge S1 and S2. Resistance changes will affect the Wheatstone Bridge's balance, resulting in tension. Wheatstone Bridge is one type of electrical measuring device used to measure an object's resistance value (resistance) using the principle of comparison (Concas et al., 2021). This tool was first invented by Samuel Hunter Christie in 1833 and then further developed by Sir Charles Wheatstone in 1843. The working principle of the Wheatstone bridge is to compare the resistance values of four resistors in an electrical circuit. The circuit consists of three fixed resistors and one variable resistor, usually called a galvanometer or microammeter (Yoga Widiana et al., 2019). When the resistance value between the two sides of the bridge is the same, then there will be no net current flowing through the galvanometer (Oliver, 2021). One example is to measure the voltage of a strain gauge sensor or load sensor on a digital scale (Saniman et al., 2020). The voltage will be amplified by the HX711 module in box B, part of the signal amplifier. The digital signal generated by the HX711 module will be sent to the Arduino Nano in box C, after which the measurement results can be displayed on the LCD screen in box D.

**Analysis Cantilever - Von Mises Strain**

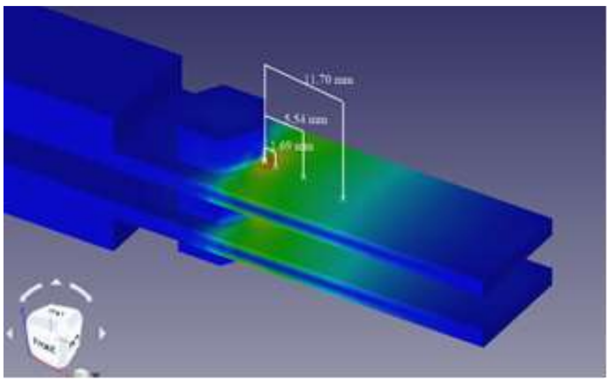

**Figure 5** Simulation with 600 N Load

Cantilever analysis is one technique for measuring materials' strength using cantilever structures. The cantilever structure consists of beams or rods placed at a fixed point, and the other end is free to move as Figure 5 (S. Yang et al., 2021). In cantilever analysis, a unique tool in the form of a micro spring is used as a pressure sensor at the free end of the rod. By attaching the material sample to the tension side of the rod and providing a specific tensile force, there will be a change in deformation or bending in the material sample (Siregar et al., 2023).
At the time of this deformation, the micro spring will record data about how much attraction is enerated and how much change in shape occurs. These data will later be processed to calculate the modulus of elasticity and maximum strength of the material sample (Sihombing & Listiari, 2020). Simulations are conducted to determine the best Strain Gauge installation position to get accurate readings. From the simulation results above, it is known that strain occurs in indigo-colored areas until maximum strain occurs in red areas. The strain gauge is attached to the green part (Myles et al., 2021).

**Research Parameters**

The parameters of this study are tool manufacturing, calibration, and testing of measuring instruments.

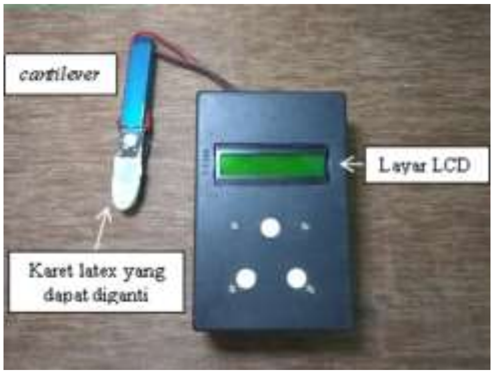


**Figure 6.** Gnathodynamometer with LCD

Figure 6 above shows the cantilever coated with disposable latex rubber to prevent transmission of bacteria between patients when tested on humans. The LCD screen displays the results; 3 buttons are used to start the measurement, tare the results are displayed, and calibration (Guo & Xiao, 2021). Data retrieval begins with giving the cantilever a known weight. The weight must be measured with a digital scale. Digital scales were chosen because they have the same working principle as gnathodynamometers. Digital scales have an uncertainty of 1 gram or 0.0098 N. The position of the scale on the measuring instrument is shown:


**Figure 7** Data Retrieval Process

Figure 7 above shows the data retrieval process. The barbell was measured on a digital scale, then attach the barbell to the gnathodynamometer, recording the reading value (Basu et al., 2019). To reduce random error, repeat the measurement (in this case, each weight is measured 10 times) and then statistically analyze as the difference in weight position affects the reading value (Zhong et al., 2021).

The collected data is calculated using this formula:

$$\bar{x} = \frac{\sum x}{n} \quad (1)$$

Where is the average value of x, and n is the amount of data. Calculate the standard deviation using this formula:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}} \quad (2)$$

From the formula, s is the standard deviation of the square root of the array x minus If we add the uncertainty of the weights used with the standard division of the measured data, we get total uncertainty. The RMSE value can be calculated using this formula:

$$RMSE = \sqrt{\frac{\sum (x - y)^2}{n}} \quad (3)$$

Somewhere RMSE is the Root Mean Square Error, y is the predicted value. The precision is calculated using this formula:

$$\%rsd = \frac{s}{\bar{x}} \times 100 \quad (4)$$

s is the standard deviation and is the mean value. When the device was tested on humans, a cantilever was placed on the posterior tooth because it had maximum biting power.

**Data Analysis Techniques**

1. Expert Validation Analysis

Expert validation analysis is carried out by gathering experts to assess the media to determine media shortcomings. The values of the Likert Scale range used are 1-4, with 4 as the largest value.

$$\text{Validation Percentage (\%)} = \frac{jumlah\ skor\ total}{skor\ kriterium} \times 100\% \quad (5)$$

Information:
Criterion score = Max score of each item x ∑ item score x ∑validator (6)
(Riduwan, 2015:21)

**Table 1** Expert Validation Score Interpretation

| **Assessment Percentage** | **Interlent** |
|---|---|
| 0 – 20% | Invalid |
| 21 – 40% | Less Valid |
| 41 – 60% | Quite Valid |
| 61 – 80% | Valid |
| 81 – 100% | VeryValid |

(Riduwan, 2015: 22)

2. Student Response Analysis

After the CANTILEVER JAW Tool was applied, student responses were measured using response questionnaires. Interpretation of student response questionnaire scores according to the following Table 2:

**Table 2** student responses Interpretation

| Table | Category |
|---|---|
| 85% ≤ Response | Very Positive |
| 70% ≤ Response < 85% | Positive |
| 50% ≤ Response < 70% | Less positive |
| Response < 50% | Not positive |

(Yamasari, 2010:4)

Analysis of questionnaire results obtained from each aspect will be calculated using the following formula:

$$P = \frac{f}{N} \times 100\% \quad (7)$$

(Yamasari, 2010:4)

3. Learning Outcomes Analysis

The posttest is used to calculate student learning outcomes. Analysis of student learning outcomes is used to determine the difference in student scores after doing posttest questions. The calculation of learning outcomes is carried out according to the scoring guidelines shown in the table as follows:

Individual Completeness:

Final Grade = (Student Score)/(Maximum Score) x 4 (8)

Information:

Student score = The score the student gets

Max score = Maximum score obtained

**Table 3** Learning Outcome Value Guidelines

| Letter | Competency Value of knowledge and skills |
|---|---|
| A | 3,85 - 4,00 |
| A- | 3,51 - 3,84 |
| B+ | 3,18 - 3,50 |
| B | 2,85 - 3,17 |
| B- | 2,51 - 2,84 |
| C+ | 2,18 - 2,50 |
| C | 1,85 - 2,17 |
| C- | 1,51 - 1,84 |
| D+ | 1,18 - 1,50 |
| D | 1,00 - 1,17 |

(Regulation of the Minister Education and Culture No. 104 year 2014)

4. Completeness of Classical

   P = (number of students completed)/(total students) x 100% (9)

   Information:

   P = Percentage of classical learning completeness

   (Regulation of the Minister Education and Culture No. 104 year 2014)

**Table 4** Learning Completeness Category

| Criterion | Information |
|---|---|
| $85\% \leq P \leq 100\%$ | Excellent |
| $70\% \leq P \leq 85\%$ | Good |
| $55\% \leq P \leq 70\%$ | Good enough |
| $40\% \leq P \leq 55\%$ | Not Good |
| $P < 40\%$ | Very Lacking |

(Regulation of the Minister Education and Culture No. 104 year 2014)

## RESULTS AND DISCUSSION

### Correction of Measuring Instrument Readings

Calibration is carried out by comparation the readings of the tool with similar tools, in this case, digital scales, because both use strain gauge sensors (Miró et al., 2023). It aims to ensure that the readings from the digital scale are accurate and under applicable standards. In digital balance calibration, one method often used is to use a solid weight reference with a known mass with certainty. This solid object reference is then placed on the scale's surface and measured at the value of its mass or weight (Tsai et al., 2021). After that, the measurement results can be compared with the reference value of solids to determine whether there is a difference between the two values. If a difference exists, adjustments or resettings can be made to the measurement system to produce even more accurate readings.

Calibration is essential in maintaining the accuracy and accuracy of a measuring instrument such as a digital scale. By calibrating regularly, we can also know when to clean the strain gauge sensor. Before the tool is calibrated, the readings need to be corrected so that the output data of the HX711 module is easy to understand. The raw data from this module is HEX data between 800000 to 7FFFFF, with the first bit used for the negative sign. The steps to adjust the correction factor can be seen in the correction sub-program of the program (Asyraf et al., 2020). Setting the correction factor starts by emptying the load on the sensor to get a value of 0. Then give the measured load on the digital scale, in this case, using a load of 5 kg, which is read on the digital scale weighing 5210 grams or 5.21 kilograms. After the load is placed on the measuring instrument, adjust it so it can measure according to the load given. After the calibration factor value can be stored in the Arduino EEPROM memory so that there is no need to calibrate, each measuring instrument is turned on (Gu et al., 2019). From the calibration results that have been carried out, a calibration value of -63970.25 is obtained. The raw data obtained will be divided by the calibration value to obtain the measurement results in Newtonian units.

**Measure measurement results (in Newtons)**

**Table 5** Measurement (in Newton)

| No. | Offset = -1,714 | | | | | |
|---|---|---|---|---|---|---|
| | 5 kg (45,59 N) | + offset | 10 kg (96,648 N) | + offset | 15 kg (144,952 N) | + offset |
| 1. | 46,892 | 45,178 | 99,013 | 97,300 | 147,021 | 145,308 |
| 2. | 46,732 | 45,018 | 99,135 | 97,421 | 146,699 | 144,985 |
| 3. | 46,705 | 44,991 | 99,004 | 97,290 | 146,474 | 144,761 |
| 4. | 46,526 | 44,812 | 99,020 | 97,307 | 146,337 | 144,623 |
| 5. | 46,406 | 44,692 | 99,139 | 97,425 | 146,429 | 144,715 |
| 6. | 46,638 | 44,924 | 99,045 | 97,331 | 146,520 | 144,807 |
| 7. | 46,720 | 45,007 | 99,030 | 97,316 | 146,566 | 144,853 |
| 8. | 46,763 | 45,050 | 99,055 | 97,341 | 146,564 | 144,851 |
| 9. | 46,772 | 45,059 | 99,092 | 97,378 | 146,539 | 144,825 |
| 10. | 46,879 | 45,165 | 99,094 | 97,380 | 146,490 | 144,776 |

From the results of the calculation above and referring to Table 5 on accuracy test effectiveness indicators, it can be seen that the jaw strength measuring instrument tested is classified as less effective, namely the average RMSE value of 1.72, but this less effective measuring instrument can be corrected by giving an offset value to the measurement results (Mohamed et al., 2021). The offset value is calculated by calculating the average measurement difference between the reading and the measured load so the measurement results are closer to the measured load value. The average RMSE value after offset is 0.508.

**Measurable data results**

The collected data is displayed:

**Table 6** Data on Measured Tooth Strenght Result (in Newton)

| Tes no. | Wight (±0,0098) |
|---|---|

| | 45.590 N | 96.648 N | 144.952 N |
|---|---|---|---|
| 1 | 45.178 | 97.300 | 145.308 |
| 2 | 45.018 | 97.421 | 144.985 |
| 3 | 44.991 | 97.290 | 144.761 |
| 4 | 44.812 | 97.307 | 144.623 |
| 5 | 44.692 | 97.425 | 144.715 |
| 6 | 44.924 | 97.331 | 144.807 |
| 7 | 45.007 | 97.316 | 144.853 |
| 8 | 45.050 | 97.341 | 144.851 |
| 9 | 45.059 | 97.378 | 144.825 |
| 10 | 45.165 | 97.380 | 144.776 |
| Average | 44.990 | 97.349 | 144.850 |
| Standard Deviation | 0,149 | 0,049 | 0,187 |
| Total Uncertainty | 0,154 | 0,054 | 0,192 |
| Precision | 0,332 | 0,051 | 0,129 |
| RMSE | 0,508 | | |

Table 6 can be calculated the average value using formula (1), and we get an average reading value of 44,990 N at a weight of 45,590 N, 97,349N at a weight of 96,648 N, and an average value of 144,850N at a weight of 144,952 N. From this average value, we can calculate the standard deviation using the formula and obtain a standard deviation of 0.149 at a weight of 45,590 N, 0.149 at 96.648 N, and 0.187 at 144.952 N. If we add the standard deviation with the uncertainty of the weight, we get a total uncertainty of a gnathodynamometer of 0.192N. Uncertainty is chosen from the most significant uncertainty. The RMSE value is calculated using a formula, and an RMSE value of 0.554 is obtained, so it is concluded that this tool is quite effective for measuring bite force because the result is close to the weight of the mass (Wang et al., 2019).

**Media Validation Results**

Media validation is divided into three aspects, which is broken down into 13 indicators. Each of these aspects is the aspect of media display, programming and expediency. Validation results are obtained from two validators. The following are the results of media validation in graphic form.


**Figure 8.** Media Validation Graph

Based on the graph as Figure 8, the validation value for the media display aspect obtained a result of 94%, for the programming aspect obtained a validation result of 100%, while for the expediency aspect it obtained a value of 90%, so that the overall media validation data recapitulation result was 94.6%. The results of media validation are included in the **category of very valid** for use in learning digital photo composition.

**Student Response Questionnaire Validation Results**

The student response questionnaire was validated by three validator lecturers covering three aspects, namely system analysis, user satisfaction, and information quality. Each aspect produces which is depicted in the graph as follows.

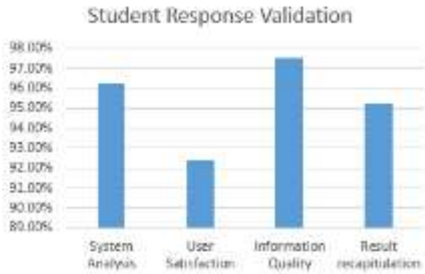


**Figure 9.** Validation Results of Student Response Questionnaire

Based on the graph Figure 9 of the validation results, it can be seen that the system analysis aspect obtained 96.27% results, the user satisfaction aspect obtained 92.4% results and the information quality aspect obtained 97.5% results, so that the overall results for student response validation obtained 95.27% which is included in the range of 81-100%, thus showing that the student response questionnaire questions are included in **the Very Valid** category.

**Psychomotor Question Validation Results**

The psychomotor problem consists of five questions validated by two validators. Based on the recapitulation results, the average value shows that the pricomotor validation results get 90% results. The average result of the psychomotor validation question shows that the validation results are included in the **Very Valid category**.

**Student Response Results**

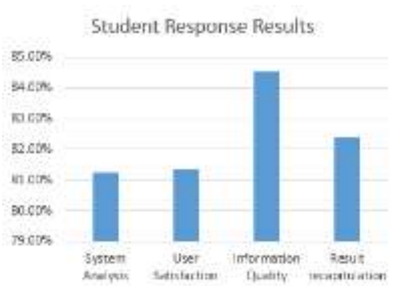


**Figure 10.** Student Response Results

The students' response after using Cantilever Jaw media obtained a total score of 3063 with a percentage of 82.4% in the positive category. With the value of each aspect of 81.27% for system analysis, 81.37% for User satisfaction value and 84.52% for information quality as Figure 10.

**Results of Psychomotor Analysis**

Student learning outcomes are obtained from posttest scores on Psychomotor questions after using Cantilever Jaw media. The class average is 79.03 while the KKM score is 80 which means that the class average score has not exceeded the KKM score for gnathodynamometers subjects. Of the 73 students, there were 68 completed students and 5 incomplete students.

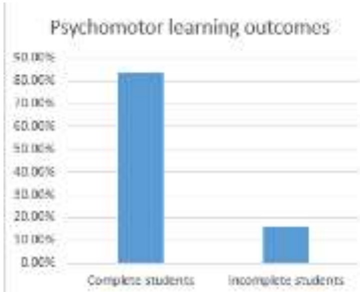


**Figure 11.** Graph of Student Psychomotor Learning Outcomes

The percentage of classical learning completeness displayed based on the graph obtained the percentage of students who completed 83.87%, and the percentage of students who did not complete it was 16.13% as Figure 11.

## CONCLUSION

This research has succeeded in designing and making an Arduino nano-based bite force measuring device with a strain gauge sensor, and to used as a trainer/learning medium as an educational implementation in Electrical Engineering Education student learning courses. Basically, in some areas of geoscience, parameter calibration has been an accepted practice for many years (Oliver, 2021). This measuring instrument has been calibrated by comparing measuring instruments and digital scales. So, a correction factor of -63970.25 is obtained. This correction factor is needed to understand the raw data obtained from the HX711 module. After the raw data is divided by the correction factor, data will be obtained in kilograms. Then the data is converted into Newtonian units. This study also successfully tested the accuracy of measuring instruments by calculating the RMSE value from the data obtained. They can measure humans' bite force at different ages, so they must be small enough to be inserted into people's mouths. The study showed that the gnathodynamometer was effective enough to be used with an uncertainty of 0.192 and an RMSE value of 0.554. This study did not measure the maximum capacity of the tool due to the limitations of the test equipment, and further research is needed before testing on human subjects. This tool has been tested in the laboratory by electrical engineering education students and can be used as a trainer for health or medical students. It can be concluded that this tool can be used as a learning medium in the form of a bite measuring trainer (gnathodynamometer) which can help students understand the process of using the tool until empirical measurements are recorded and become learning in the use of gnathodynamometer.

### Acknowledgment

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