Unveiling the Vocational Landscape of New Mechanical Engineering Students: A Case Study

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Abstract

This research aims to determine the abilities, weaknesses, and obstacles in the vocational skills of mechanical engineering students at the start of their studies. The research method uses a quantitative survey approach. The research sample was 140 students. Data analysis techniques used descriptive statistical analysis. The test results show the Manufacturing Engineering study program received the highest score, followed by the Mechanical Engineering Education study program and the Mechanical Engineering Diploma study program. Vocational abilities in machining received the lowest score, followed by metrology, design, and fabrication. These results also show that the vocational skills in the engineering field of the Mechanical Engineering Education Department are still lacking, with a score below 50%. The machining sector received a low score due to the lack of knowledge of conventional machines and their parameters. Most students come from high school graduates, so many have never seen these machines and practiced. The findings indicate an urgent need for curriculum development in mechanical engineering programs, particularly in enhancing practical training for machining, metrology, design, and fabrication skills. Institutions should consider incorporating more hands-on experiences with conventional machines into their programs, especially for students transitioning from high school to higher education. Additionally, targeted interventions and support mechanisms should be implemented to bridge the gap in vocational skills and ensure students are better prepared for industry demands.

Keyword: vocational skills, Mechanical engineering students, Curriculum development, Practical training

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1 INTRODUCTION

The industrial world is experiencing rapid development, characterized by technological advances such as automation, robotics, and artificial intelligence [1], [2]. This has brought about significant changes in labor needs, with industries increasingly demanding practical skills that can be directly applied on the job [3]. The rapid development of technology changes the production process and industrial operations [4], [5]. This requires a workforce capable of operating sophisticated machinery and equipment well. Automation and artificial intelligence in industry are increasingly being used to improve efficiency and productivity [6], [7], [8], [9], [10]. However, this technological development also requires a workforce that can adapt to support changes in their work [11].

Technological developments in the manufacturing industry are driving changes in labor recruitment patterns [12], [13]. Manufacturing companies are increasingly selective in recruiting workers and prioritize candidates with relevant experience and practical skills [14], [15]. Increased demand for skilled labor encourages vocational education to prepare for the development of vocational skills for its graduates [16], [17], [18], [19]. Higher education must improve skills training, broad professional knowledge, and good personality to meet industry demand and develop students' vocational abilities.

Vocational skills in mechanical engineering are an essential foundation for individuals who wish to pursue a career in the manufacturing industry [20], [21]. These vocational skills include machining, designing, fabrication, and metrology [20]. Through mechanical engineering vocational education and training, individuals can master the use of relevant tools and techniques, read and know technical drawings, and apply the principles of mechanics and thermodynamics [22]. Vocational education in mechanical engineering also plays a vital role in preparing a workforce that can keep up with technological developments and new inventions in the manufacturing industry [23], [24], [25].

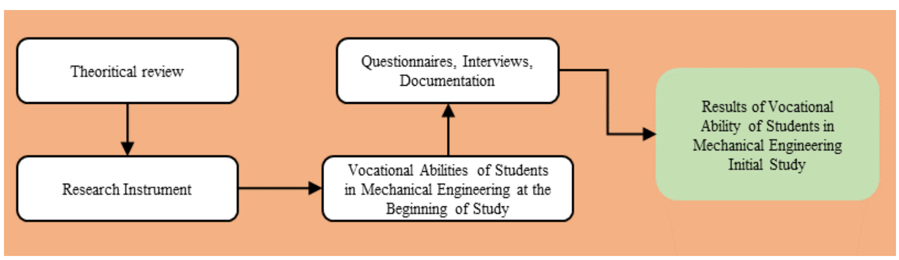
This study provides a unique contribution by specifically evaluating the initial vocational skills of mechanical engineering students, identifying critical gaps at the beginning of their educational journey. Unlike previous research that often focuses on outcomes after the completion of vocational programs, this study highlights the areas needing immediate attention to enhance students' practical skills early on. By pinpointing deficiencies in machining, metrology, design, and fabrication, this research offers actionable insights for curriculum developers to tailor educational programs more effectively, ensuring students are better prepared to meet the evolving demands of the manufacturing industry.

This research captures the knowledge of mechanical engineering vocational abilities, focusing on analyzing and developing skills needed in the manufacturing industry. This study aimed to determine the vocational abilities of first-year mechanical engineering students majoring in mechanical engineering education at Universitas Negeri Yogyakarta. The portrait of the vocational skills of new students is essential to know the strengths and weaknesses of aspects of vocational abilities in mechanical engineering for new students majoring in mechanical engineering education at Universitas Negeri Yogyakarta. The results of this research are essential for improving education and training programs, ensuring that graduates have relevant skills and can adapt to technological developments and changing labor market demands. Thus, this research contributes significantly to improving the quality of vocational education in mechanical engineering and the workforce's readiness in the industrial sector.

2 METHOD

The research used is quantitative descriptive research with a survey method. Descriptive research is a research method that describes the present research object based on the facts as they are then analyzed and interpreted [26]. This study aims to provide an overview of the vocational abilities of mechanical engineering first-year students majoring in Mechanical Engineering Education. According to the data type and how to process it, multiple choice questionnaires will be analyzed using statistical tests and classified as quantitative research using the survey method [27]. The survey research method was conducted to obtain data on the vocational abilities of new students by circulating multiple-choice questionnaires and interviews. The research flow chart is as follows:

Figure. 1. Research Flow Chart.



2.1 Subject and Object of Research

This research was conducted at the Department of Mechanical Engineering Education, Universitas Negeri Yogyakarta. The object of the study is vocational skills in mechanical engineering. The main subject is students. The research population is all new students in semesters 1 and 2 of the 2021/2022 academic year, Department of Mechanical Engineering Education, totaling 236 students. The sampling technique uses random sampling, so the number of samples used in this study is 140 students.

2.2 Data Collection Technique

This research data collection technique uses several techniques, including:

- The questionnaire instrument was prepared to determine the research respondents' perceptions of the vocational abilities of mechanical engineering students. Several experts validated the questionnaire instrument and tested it on a limited sample.

- Researchers used the interview instrument to obtain in-depth information about the vocational skills of mechanical engineering students.

- Documentation was used as secondary data for the study.

2.3 Data Analysis Technique

Data analysis techniques aim to make the data preparation process interpretable in depth. Data analysis refers to systematically examining something helpful in determining its parts. Quantitative data was obtained from questionnaires and then analyzed. The data that has been studied is then interpreted in descriptive or narrative form. Meanwhile, data obtained through interviews, documentation, and direct observation with an explanatory approach that emphasizes the meaningfulness of the data will be analyzed and interpreted by describing the data as it is in the field regarding the vocational abilities of mechanical engineering students majoring in mechanical engineering education at Universitas Negeri Yogyakarta.

3 RESULT AND DISCUSSION

3.1 Profile of Research Respondents

This study used research respondents from new Mechanical Engineering Education Department students, consisting of three study programs: Bachelor of Mechanical Engineering Education, Bachelor of Mechanical Engineering Education, and Bachelor of Applied Science in Mechanical Engineering. Data was collected in August 2022 during the new student orientation period. There were 202 respondents in this study. The distribution of the number of respondents based on the study program can be seen in Table 1.

Table 1. Profile of Research Respondents.

No.	Study Program	Number of Respondents	Male	Female
1.	Bachelor of Education in Mechanical Engineering	81	78	3
2.	Bachelor of Manufacturing Engineering	70	60	10
3.	Bachelor of Applied Science in Mechanical Engineering	53	51	2

Total	202	187	15

Based on the cumulative data above, it can be seen that the most respondents who filled out the questionnaire were Bachelor of Mechanical Engineering Education Study Program with a percentage of 40.1%, followed by Bachelor of Manufacturing Engineering Study Program with a percentage of 34.65% and Bachelor of Applied Science in Mechanical Engineering Study Program with a percentage of 26.24%. Based on gender, most respondents were male, with a rate of 92.6%, and the rest were female. This shows that the gender dominance in the mechanical engineering education department is male despite the increased number of women from year to year.

3.2 Vocational Ability Analysis

The multiple-choice questionnaire consists of 10 questions for four areas of mechanical engineering expertise: machining, design, fabrication, and metrology. The analysis emphasized the correctness of students' answers and compared scores on each item and overall in the three study programs: Bachelor of Education in Mechanical Engineering, Bachelor of Manufacturing Engineering, and Bachelor of Applied Science in Mechanical Engineering. The results of the descriptive analysis of each field of expertise are presented in more depth.

3.2.1 Vocational Skills in Machining

Machining expertise is among the sub-profiles of graduates from the Bachelor of Education in Mechanical Engineering, Bachelor of Manufacturing Engineering, and Bachelor of Applied Science in Mechanical Engineering study programs. The foundation of this field of expertise will be supported by courses such as machining theory, basic machining, advanced machining, and CNC. The application of these courses is adjusted to the characteristics of each study program. The initial study was conducted by distributing multiple choice questionnaire instruments to new Mechanical Engineering Education Department students. The pre-test results of students before exploring lectures in the Department of Mechanical Engineering Education obtained data and information shown in Figure 2.

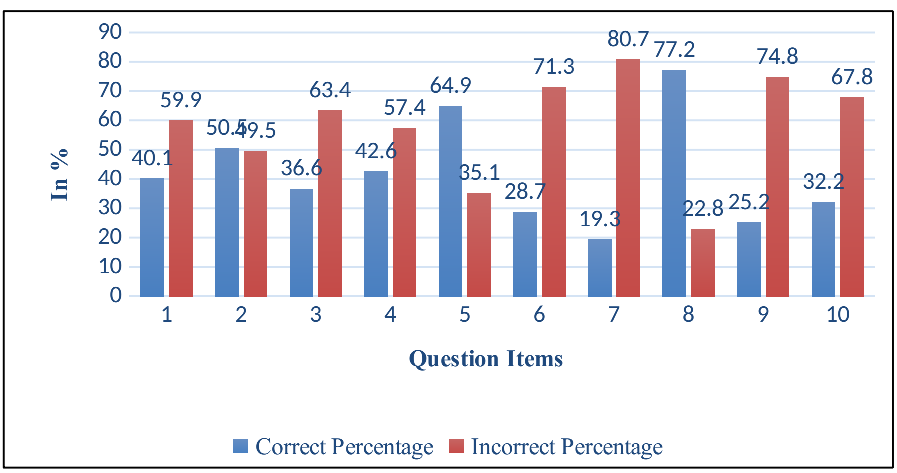


Figure 2. Percentage of answers to questions in the field of machining

The figure above explains that the dominance of incorrect answers is almost 70% compared to the correct answers. This shows that the input of students' vocational skills in machining at the beginning of their study in the Department of Mechanical Engineering Education is still low. This initial data can be used to strengthen the vocational ability of machining in improving the quality of teaching through learning tools based on student learners' characteristics. The results are shown in Table 2, which is detailed based on each study program.

Table 2. Differences in the Answer Value of Machining Field for Each Study Program.

Item	Bachelor of Education in Mechanical Engineering		Bachelor of Manufacturing Engineering		Bachelor of Applied Science in Mechanical Engineering	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
1	34	47	32	38	15	38
2	49	32	34	36	20	33
3	35	46	27	43	13	40
4	31	50	37	33	19	34
5	53	28	46	24	32	21
6	25	56	15	55	18	35
7	20	61	10	60	9	44
8	62	19	56	14	39	14
9	17	64	22	48	12	41
10	19	62	28	42	18	35
Total	345	465	307	393	195	335
%	42,59	57,41	43,86	56,14	36,79	63,21

3.2.2 Vocational Skills for Designing

The design field is a sub-profile of graduates expected from each study program. The foundation of this field of expertise will be supported by courses such as Engineering Drawing, CAD, Machine Elements, CAE, and Product Design, as well as the application of courses in the characteristics of each study program. The initial study was conducted by distributing multiple choice questionnaire instruments to new Mechanical Engineering Education Department students. The results of the initial multiple choice questionnaire (pre-test) of students before exploring lectures in the Department of Mechanical Engineering Education obtained data and information shown in Figure 3.

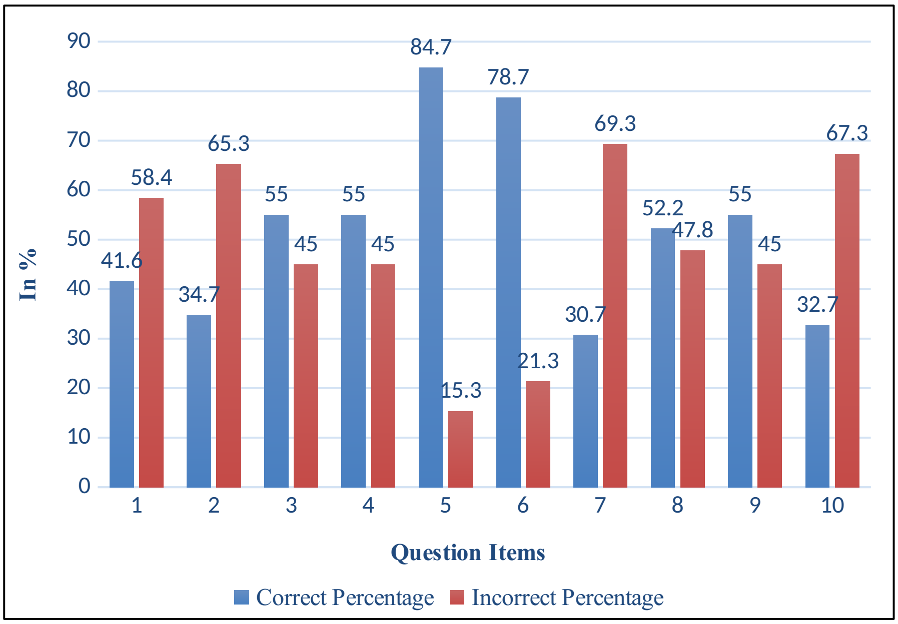


Figure 3. Percentage of Answers to Designing Field Questions

The figure above explains that the dominance of correct answers reached 60% compared to incorrect answers. This shows that the vocational skills input of students in the design field at the beginning of their studies in the Department of Mechanical Engineering Education is quite good. This initial data can inform the strengthening of vocational design skills in improving the quality of teaching through learning tools that are based on the characteristics of current students. If it is detailed based on each study program, the results shown in Table 3 are obtained.

Table 3. Difference in Answer Value of Design Field for Each Study Program

Item	Bachelor of Education in Mechanical	Bachelor of Manufacturing	Bachelor of Applied Science in Mechanical

	Engineering		Engineering		Engineering	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
1	29	52	33	37	22	31
2	33	48	21	49	16	37
3	43	38	42	28	26	27
4	47	34	40	30	24	29
5	70	11	59	11	42	11
6	65	16	59	11	35	18
7	19	62	34	36	6	47
8	39	42	40	30	26	27
9	42	39	42	28	27	26
10	19	62	28	42	19	34
Total	406	404	398	302	243	287
%	50,12	49,88	56,86	43,14	45,85	54,15

3.2.3 Vocational Skills in Fabrication

Fabrication expertise is among the sub-profiles of graduates from the Bachelor of Education in Mechanical Engineering, Bachelor of Manufacturing Engineering, and Bachelor of Applied Science in Mechanical Engineering study programs. The foundation of this field of expertise will be supported by courses such as welding, material forming, and fabrication construction, as well as the application of courses in the characteristics of each study program. The initial study was conducted by distributing multiple choice questionnaire instruments to new Department of Mechanical Engineering Education students. The results of the initial multiple choice questionnaire (pre-test) of students before exploring lectures in the Department of Mechanical Engineering Education obtained data and information shown in Figure 4.

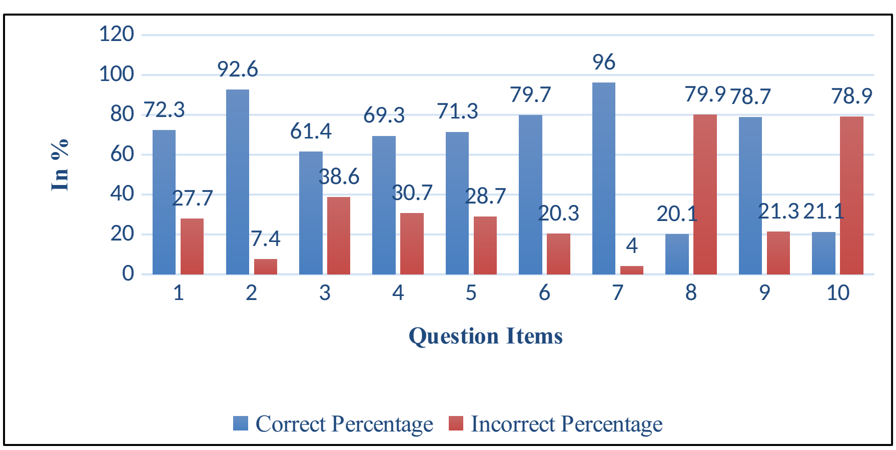


Figure 4. Percentage of Answers to Fabrication Field Questions

The figure above explains that the dominance of correct answers reached 80% compared to incorrect answers. This shows that the input of vocational skills in the field of fabrication of students at the beginning of their studies in the Department of Mechanical Engineering Education is good. This initial data can be used as information to strengthen design's vocational ability to improve teaching quality through learning tools based on current students' characteristics. If it is tailored based on each study program, the results are shown in Table 4.

Table 4. Differences in Answer Value of Fabrication Field for Each Study Program

Item	Bachelor of Education in Mechanical Engineering		Bachelor of Manufacturing Engineering		Bachelor of Applied Science in Mechanical Engineering	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
1	62	19	48	22	37	16
2	77	4	62	8	50	3
3	49	32	49	21	26	27
4	54	27	52	18	36	17
5	62	19	50	20	33	20
6	62	19	58	12	43	10
7	78	3	66	4	52	1
8	14	67	17	53	9	44
9	65	16	55	15	40	13
10	12	69	17	53	14	39
Total	535	275	474	226	340	190

%	66,05	33,95	67,71	32,29	64,15	35,85

3.2.4 Vocational Skills in Metrology

Metrology is a field of science that supports competence in the vocational field—metrology studies ways of measuring, calibrating, and ensuring accuracy in Engineering. Knowledge of metrology will support mastery of courses related to engineering. The initial survey of vocational skills in metrology was carried out by distributing multiple choice questionnaire instruments to new Mechanical Engineering Education Department students. The results of the initial multiple choice questionnaire (pre-test) of students before exploring lectures in the Department of Mechanical Engineering Education obtained data and information, as shown in Figure 5.

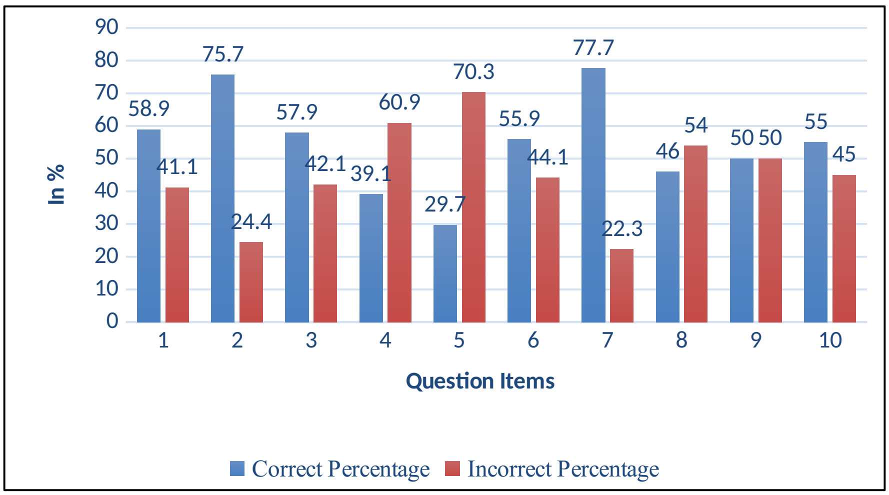


Figure 5. Percentage of answers to questions in the field of metrology

The figure above explains that the dominance of correct answers reached 60% compared to incorrect answers. This shows that the vocational skills input in metrology at the beginning of their studies in the Department of Mechanical Engineering Education is quite good. This initial data can be used as information to strengthen design's vocational ability to improve teaching quality through learning tools based on current students' characteristics. If it is detailed based on each study program, the results shown in Table 5 are obtained.

Table 5. Differences in the Answer Value of Fabrication Field for Each Study Program

Item	Bachelor of Education in Mechanical Engineering	Bachelor of Manufacturing Engineering	Bachelor of Applied Science in Mechanical Engineering

1	49	32	43	27	28	25
2	66	15	53	17	35	18
3	50	31	43	27	24	29
4	35	46	26	44	19	34
5	30	51	19	51	12	41
6	47	34	44	26	23	30
7	64	17	55	15	39	14
8	35	46	32	38	26	27
9	41	40	39	31	21	32
10	42	39	47	23	22	31
Total	459	351	401	299	249	281
%	56,67	43,33	57,29	42,71	46,98	53,02

Based on the data from filling out the questionnaire, it is known that most respondents are from the Bachelor of Education in Mechanical Engineering Study Program with a percentage of 40.1%, followed by the Bachelor of Manufacturing Engineering Study Program with a percentage of 34.65% and the Bachelor of Applied Science in Mechanical Engineering Study Program with a percentage of 26.24%. The questionnaire results show that the vocational abilities of each study program in the Mechanical Engineering Education department are different. There are four mechanical engineering vocational abilities fields in the Mechanical Engineering Education department: machining, design, fabrication, and metrology.

Vocational skills in machining for each study program are still relatively low, with a percentage value of less than 50%. Vocational ability in the field of machining for the Bachelor of Education in Mechanical Engineering Study Program is 42.59%. In the Bachelor of Manufacturing Engineering Study Program, the vocational ability in machining is 43.86. Vocational ability in machining for the Bachelor of Applied Science in Mechanical Engineering Study Program occupies the lowest position with 36.79%. These results show that the vocational ability in machining in both Education in Mechanical Engineering Study Program, Bachelor of Manufacturing Engineering Study Program, and Bachelor of Applied Science in Mechanical Engineering Study Program needs to be improved. The importance of improving machining skills cannot be overstated, as these skills are fundamental to many manufacturing processes and are in high demand in the industry [28]. Improving machining skills will enable students to be better prepared for the demands of new technologies and techniques in the industry, as well as enhance their ability to work with both conventional and modern machines

[29]. Thus, a greater focus on practical training and a deeper understanding of machine parameters will help students master these essential skills and enhance their readiness to enter the workforce.

The highest vocational design ability for machine drawing and design is the Bachelor of Manufacturing Engineering Study Program, with a percentage value of 56.86. These results indicate that the input of new Bachelor of Manufacturing Engineering Study Program students can be maximized in product design, analysis, and design. In the second position, the vocational ability in the field of drawing and design is Bachelor of Education in Mechanical Engineering Study Program with a percentage of truth of 50.12%, and in the third position is Bachelor of Applied Science in Mechanical Engineering Study Program with a percentage of truth of 45.85%. The special justification for the Bachelor of Applied Science in Mechanical Engineering Study Program shows the study program's efforts to increase students' self-potential and interest in the design field in supporting the graduates' profile. The importance of machine design skills should not be overlooked, as these skills are key to creating innovative and efficient products [30]. Improving design skills will enable students to master the techniques and tools necessary to develop designs that meet industry standards and market needs [31]. In addition, these skills also help in understanding the principles of mechanics and dynamics that are essential in the design process. Therefore, an emphasis on more comprehensive design training will enhance the competency of graduates and prepare them to face the challenges of the ever-evolving manufacturing industry.

The Bachelor of Manufacturing Engineering Study Program is the fabrication field's highest vocational ability, with a percentage value of 67.71%. These results indicate that the input of new Bachelor of Manufacturing Engineering Study Program students can be maximized in welding, forming, and fabrication construction. In the second position, the vocational ability in the field of fabrication is Bachelor of Education in Mechanical Engineering Study Program with a percentage of correctness of 66.05%, and in the third position is Bachelor of Applied Science in Mechanical Engineering Study Program with a percentage of correctness of 64.15%. These results show that students in both Bachelor of Education in Mechanical Engineering Study Program, Bachelor of Manufacturing Engineering Study Program, and Bachelor of Applied Science in Mechanical Engineering Study Program have good vocational abilities in fabrication. The importance of fabrication skills cannot be overstated, as they are the foundation for the manufacture of vital components and structures for a variety of industries [32]. Good fabrication skills enable students to perform construction, welding, and metal forming with precision and efficiency [33], [34]. With an emphasis on comprehensive fabrication training, students will be better prepared for the complex and varied demands of work in the industry.

The highest vocational ability for the field of metrology is the Bachelor of Manufacturing Engineering Study Program, with a percentage value of 57.29. In the second position, the vocational ability in the field of drawing and design is Bachelor of Education in Mechanical Engineering Study Program with a percentage of the correctness of 56.67%, and in the third position is Bachelor of Applied Science in Mechanical Engineering Study Program with a percentage of the correctness of 46.98%. Seeing these results, the study program needs to improve the ability of the metrology field of Bachelor of Applied Science in Mechanical Engineering students because the ability in the metrology field is the basis for studying mechanical engineering skills [35], [36].

The order of vocational skills for each field from highest to lowest is fabrication, metrology, design, and machining. The machining field scored low due to the lack of knowledge of conventional machines and their parameters. Most students come from high school graduates, so many have never seen these machines and practiced. Similarly, vocational skills in the design field because students still do not know the science of design, such as American and European projections. Vocational skills in fabrication and metrology received high scores because at the time of high school and vocational schools were introduced.

4 CONCLUSION

The results of multiple-choice questionnaires to measure the vocational abilities of Bachelor of Education in Mechanical Engineering students show that the Bachelor of Manufacturing Engineering Study Program obtained the highest score, followed by the Bachelor of Education in Mechanical Engineering Study Program and the Bachelor of Applied Science in Mechanical Engineering Study Program. Vocational skills in machining obtained the lowest score, followed by metrology, design, and fabrication. These results also show that the vocational abilities in the field of machining of students in both the Bachelor of Manufacturing Engineering Study Program, Bachelor of Education in Mechanical Engineering Study Program, and Bachelor of Applied Science in Mechanical Engineering Study Program are still lacking as seen from the acquisition of scores that are still below 50%. The order of vocational skills in each field is from highest to lowest, and they are in fabrication, metrology, design, and machining. The machining field received a low score due to the lack of knowledge of conventional machines and their parameters. Most students are high school graduates, so many have never seen these machines and practiced them.

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