INTERNATIONAL COLLABORATION RESEARCH

FINAL REPORT

Research Title:

APPLIED CAD LEARNING MODEL FOR DESIGN PRODUCT INNOVATION AND OPTIMIZATION OF SMALL AND MEDIUM ENTERPRISES IN INDONESIA

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FACULTY OF ENGINEERING
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THE YEAR 2022

APPROVAL SHEET
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10. Research Time : May 1, 2022, to November 30, 2022
11. Proposed funds : IDR 30,000,000.00

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RESEARCH SUMMARY

APPLIED CAD LEARNING MODEL FOR DESIGN PRODUCT INNOVATION AND OPTIMIZATION OF SMALL AND MEDIUM ENTERPRISES IN INDONESIA

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The Computer-Aided Design (CAD) learning model needs to be optimized because it has excellent potential to produce impactful industrial designs. Researchers have studied several effective CAD learning models but have not found the benefits of CAD learning that impact industrial partners. Researchers explore that CAD learning is limited to product redesign. Barriers occur for students because of the limitations of student skills in producing creative and innovative designs. Researchers have also conducted a Focus Group Discussion (FGD) with the result that CAD courses and partner industries need the CAD learning model with industrial design output to produce impactful industrial designs. This study aims to (1) Experiment with applying a CAD learning model with impactful industrial design output and (2) Examine differences in the impact value of industrial designs at different industry levels.

The research and development method uses a modified Richey and Klein research step in the following order: (1) the pre-development stage; (2) the model development stage; (3) the model validation stage; (4) the implementation stage of the class scale model (limited); and (5) the implementation phase of the model is expanded with different industrial level scales. In this grant proposal, the Researcher continues implementing the class scale model (2022) and the different industrial-level scales (2023). The design of the model application uses a nonequivalent control group design where there are control and experimental classes. The research sample was students who took the 3D CAD course in the Mechanical Engineering D4 study program with 40 students, 2 CAD lecturers, and five industry partners. Data collection techniques using observation, questionnaires, interviews, and tests. The data analysis technique used descriptive statistics, T-test, and qualitative data analysis. The research outputs are published in the Journal of Engineering Education Transformation, published the Journal of Mechanical Engineering Vocational Dynamics, granted Intellectual Property Rights for Industrial Design, published in reputable international proceedings at ICTVT, and TKT 5 (2022) and TKT 6 (2023).

Keywords: computer_aided_design; cad_learning; industrial_design

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CHAPTER I
INTRODUCTION

A. Background of the Problem

Indonesia has begun to increase the number of impactful innovations to increase the Global Innovation Index (GII) ranking in 2021, which is still ranked 87 (Soumitra Dutta, et al., 2021). One of the sub-indicators that can be maximized is the potential of industrial design. The triple helix cooperation between government, industry, and universities can accommodate industrial design ecosystems. The government is a facilitator that brings together industry and universities. Universities as centers of industrial design innovation, and industry as design beneficiaries.

One of the engineering fields that has the potential to contribute to the advancement of industrial design is mechanical engineering. Industrial design can be integrated into Computer-Aided Design (CAD) courses. To fulfill industrial design-based learning outputs, CAD courses can be directed toward impactful industrial design. The impact value in question is to provide sustainable benefits for the industry's performance of higher education innovation and downstream product design.

A CAD learning survey has been conducted on three campuses, including the Applied Undergraduate Mechanical Engineering Study Program at UNY, the Diploma in Mechanical Design Technology at ATMI Polytechnic Surakarta, and the Applied Bachelor's Degree in Precision Tooling Engineering at the Bandung Manufacturing Polytechnic. The results of interviews with CAD lecturers resulted in several CAD learning models that were applied, including textbook-based CAD learning, contextual-based CAD learning assisted by real objects, internet literacy-based CAD learning, and CAD learning based on industrial product redesign. The weaknesses in this model are that the developed product design still refers to textbook references and internet literacy and is limited to redesigning products based on existing products. The entire learning model can limit student design creativity and innovation and stagnate industrial design innovations without impact.

Referring to the problems in CAD learning, the industry's will related to innovation, and the great potential of CAD learning, it is necessary to formulate a suitable CAD learning model to fulfill these solutions. The industrial design output CAD learning model is collaborative with the industry. Students have industrial design competence and have added value in solving industrial product design problems. Creativity and innovation in industrial design is the key for students to provide significant benefits to the advancement of industrial product design.

B. Problem Formulation

1. How effective is the implementation of the CAD learning model with an impact on industrial design output?
2. Are there differences in the value of the impact of industrial design at different industry levels?

C. Research Objectives

1. Experimenting with applying a CAD learning model with impactful industrial design output.
2. Examine differences in the impact value of industrial designs at different industry levels

D. Research Urgency

1. CAD learning has great potential to contribute to the quantity of industrial design.
2. The industry needs product design innovation from universities (Results of FGD with Industry).
3. With proof of the successful application of the model, it can become best practice for other universities with CAD courses.

E. Special Statement

This industrial design output CAD learning model is novel and has been recognized at model development FGDs attended by practitioners, professionals, CAD lecturers, and experts in vocational education, evaluation, learning, and CAD learning. In 2022 research is devoted to experimental testing between CAD classes, and in 2023 it is focused on examining the impact of different trials at different industry levels.

CHAPTER II
LITERATURE REVIEW

A. Literature Review

1. Vocational Learning

According to Proser, vocational learning will be effective if what is taught replicates the world of work (Prosser & Quigley, 1950). The problems, work culture, tools, and resources in schools are minimally replicated in industry. This primary demand is an example that vocational education is closely related to the readiness of students' competencies and work experience before entering the real world of work. According to Prosser's perspective, vocational learning is still relevant if the systemic thinking pattern is still attached where the competencies taught during education/training are relevant to industry needs.

This is in contrast to John Dewey's theory which asserts that taste and intention are the rights of all human beings after graduating from education and have no right to be regulated by anyone (Dewey, 2001). This theory is in line with the concept of an independent learning-campus curriculum in which every graduate of vocational education is free to choose his or her job interests according to their talents, interests, and abilities. Talking about talents and interests, Dewey said that talent could be born from heredity and deformed by desire, while interest is an intense desire and pursuing it into a hobby that becomes his passion. Both complement and support each other in forming competencies in the 4.0 era.

2. CAD

The advent of CAD began around the mid-1960s through the IBM Drafting System as a computer-aided design system that began to reproduce electronic drafting. Firms' drive for cost advantages led to a shift to CAD (Esther Adiji & Ibiwoye, 2017). CAD helps designers perform engineering calculations (Wu, Rosen, Wang, & Schaefer, 2015). CAD is a revolutionary change in the engineering industry, where drafters, designers, and engineering practitioners are starting to join forces. CAD is an example of the widespread influence computers starting to feel on the industry (Ng & Chan, 2019). Computer-aided design software packages range from 2D vector-based drafting systems to solid and surface 3D modelers.

Modern CAD packages also often allow rotation in three dimensions, allowing the view of the designed object from any desired angle, even from the inside looking out. Some CAD software is capable of dynamic mathematical modeling.

CAD can create various graphic images, both technical and artistic. A CAD system consists of hardware, software, and users. CAD software has been used in (1) generating geometric shapes, working drawings, assembly, simulations, and so on; (2) embodying the designer's imagination; and (3) modifying for editing, revision, and correction. Its wider use is to help designers to create solid models and analyze elements, kinematics, and simulations (Kurniawan, Khumaedi, & Sulisty, 2016). CAD is a design computer technology with hardware and software for the design process and documentation. Many CAD applications are prepared for various industrial sectors, such as designing houses, bridges, industrial machines, and products to fashion products. CAD applications are currently available for designing and creating patterns, 2-dimensional and 3-dimensional virtual visual merchandising to animation.

3. Industrial Product Design

Industrial Design, according to Law Number 31 of 2000 concerning Industrial Design is a creation of the shape, configuration, or composition of lines or colors, or lines and colors, or a combination thereof in the form of three dimensions or two dimensions which gives an aesthetic impression and can be realized in three-dimensional or two-dimensional patterns and can be used to produce a product, industrial commodity, or handicraft. Designers who produce an Industrial Design obtain rights called Industrial Design Rights. Industrial Design Right is an exclusive right granted by the Republic of Indonesia to Designers to carry out their creations for a specific time or give their approval to other parties to exercise these rights.

In the mechanical world, this is known as industrial product design. De Vere, Melles, & Kapoor (2010) define product design as a professional service in creating and developing concepts and specifications that optimize the product's function, value, and appearance to the system so that the product is more profitable for consumers and producers. Product design is a product (goods) to be produced (Choi, 2012). Citing this statement, the requirements to be considered a product design depend on the chosen target audience. Niu et al. (2018) explain that there are five crucial goals in the product design process, namely (1) Utility (usability) as the product used must be safe and easy to use; (2) Appearance as a product display must be unique and beautiful so that it becomes an attractive product; (3) Easy to maintenance as a product design is not only limited to its use but must be designed to be easy to maintain and repair as well; (4) Low cost (low cost) as a product that is designed to be produced at a low cost in order to be competitive; and (5) Communication (communication) as product design must be able to communicate the philosophy and mission of the company or designer to consumers.

Pahl et al. (2007) explained that product design creates new products through efficient idea generation and concept development to manufacture. The product design process is a series of planned activities that turn an idea into a product and make it commercially available to end users. Madsen (2012) classifies the product design process into four main stages: problem analysis, conceptual design, schema embodiment, and details. According to Dieter & Schmidt (2013), product design usually involves product analysis, concept stages, and product synthesis. The design process needs to be broken down into phases and then into small steps, each with its procedure to have a prosperous new product design (Pahl et al. 2007; Setiadi 2015). Pahl & Beitz divides the process into the following four phases: (1) Product planning and task clarification; (2) Conceptual design; (3) Embodiment design; and (4) Detailed design.

B. State of the Arts

Previous research and a study by researchers on several CAD lessons at Academic and Vocational Colleges only came to redesigning industrial products. The CAD learning model with industrial design output is a newer model where students' creativity and innovation in solving industrial product design problems are the claims of the researchers' findings. Students are not just working on an industrial design; industrial designs are used by industry to be commercialized. With the emergence of Industrial Design, it is hoped that it will improve the innovation performance of universities, rank GII Indonesia, become a portfolio of student innovation projects, and bridge industrial productivity acceleration in enriching impactful design variants.

C. Research Roadmap

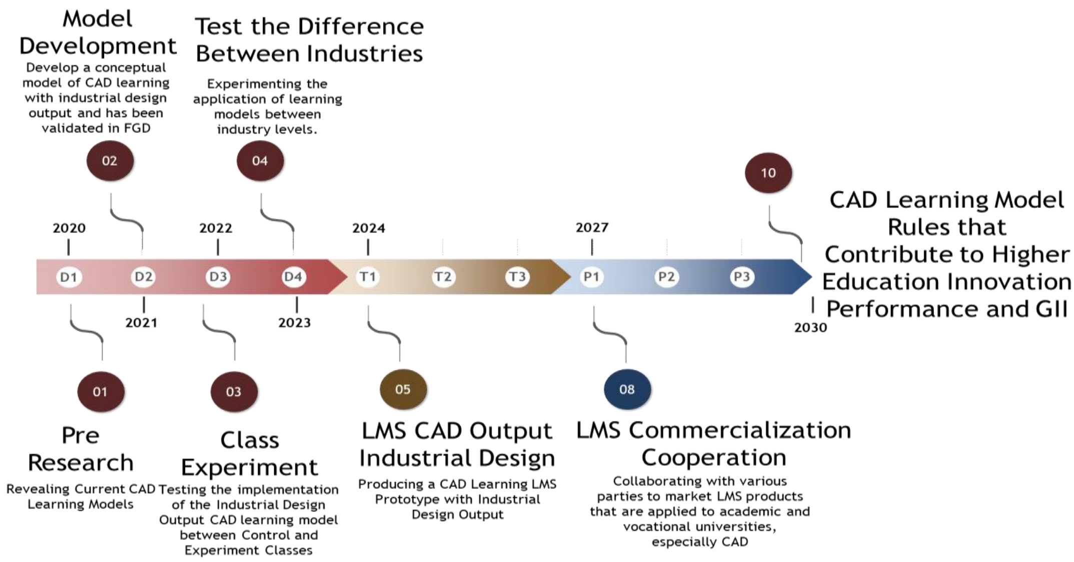


Figure 1. Research Roadmap 2020 to 2030

CHAPTER III
RESEARCH METHODS

A. Research Information

This dissertation uses the Research & Development (R&D) method as Richey & Klein (2007) modified the research method. The Researcher developed the Richey & Klein research model by conducting the pre-development stage, development stage, validation stage, and model use stage. In this grant proposal, the Researcher has reached the stage of using the model. The model use phase consists of two sessions, namely session I testing the effectiveness of using the model between lecture classes, and session II, testing the effectiveness of application between industry levels. The scheme for implementing research and development is as follows.

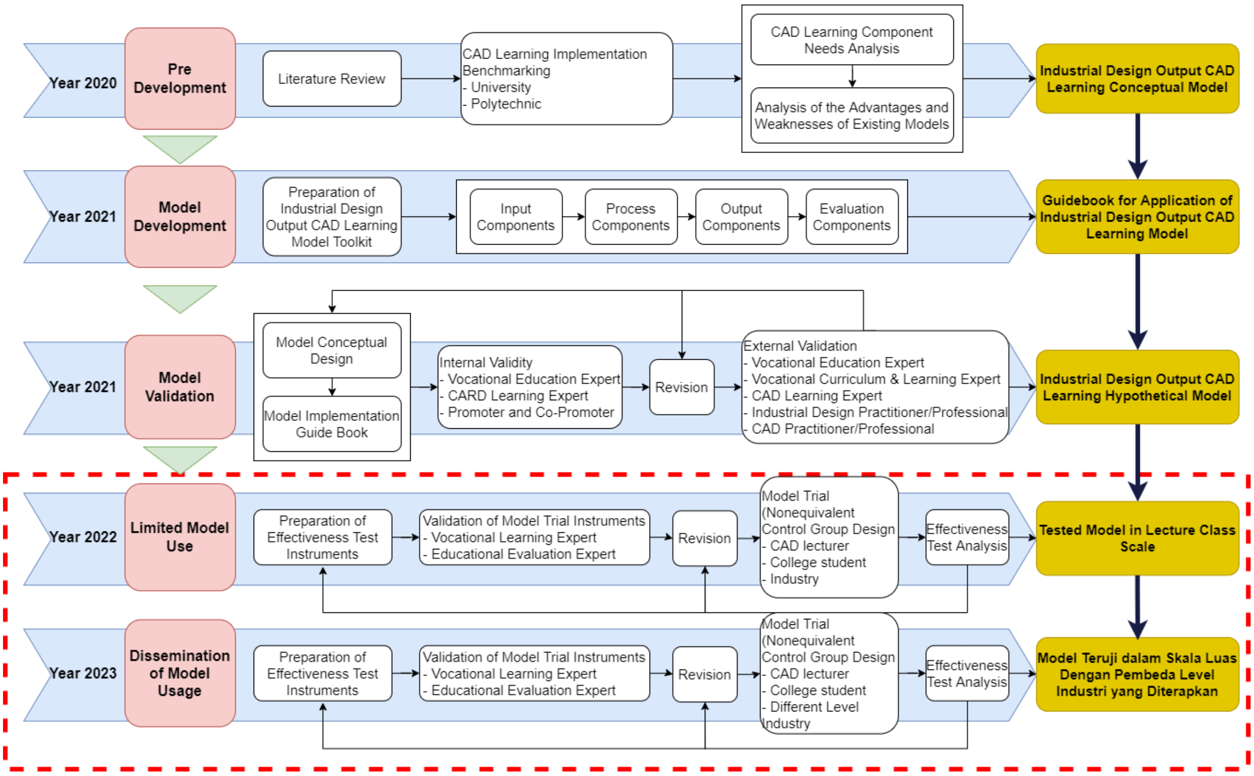


Figure 2. The Procedure for Developing a CAD Learning Model

1. Model Usage Stage (The years 2022 & 2023)

This stage is the stage of using the model, which is realized through model testing in the field. The results of internal and external validation revisions as the output of a hypothetical model of CAD learning with industrial design output need to be proven effective to be said to be a tested model. The stage of using the CAD learning model with industrial design output using quantitative methods with an experimental design of Nonequivalent Control Group Design is illustrated as follows.

O1 X O2
O3 O4

X = Application of CAD Learning Model

O = Value of 3D CAD Courses, Creativity and Innovation Questionnaire based on student perceptions

Impact Value = (O2 – O1) – (O4 – O3)

2. Population and Sample Research

The object of research in the model trial is the 3D CAD course at the UNY Mechanical Engineering Applied Undergraduate Study Program. A total of 2 classes were used to test the model as control and experimental classes. The research subjects used were CAD lecturers, students, and industry partners. The research population, especially students as research respondents, were 40 people, SMEs 5 people, and CAD lecturers two people. The sampling technique used to select the class as a sample of students is purposive sampling.

3. Data Collection Techniques

Data collection techniques at this research stage used observation, questionnaires, tests, and interviews. The performance test instrument measures CLO or learning achievement of 3D CAD courses. There are 5 CLOs that students take for one semester, namely (1) Understanding advanced CAD applications for modeling machine elements effectively and efficiently; (2) Simulating CAD modeling and manufacturing processes according to mechanical engineering design rules; (3) Analyzing numerically CAD modeling with the finite element method; (4) Solving product design problems collaboratively with industry; and (5) Communicating the results of product design innovations to the industry. The questionnaire/questionnaire instrument was used to measure students' perceptions of the creativity and innovation obtained when this output CAD learning was applied. The interview instrument was arranged in an interview protocol intended as secondary data to complement the information. Observation instruments are embedded in the Guide to the Use of the Model.

4. Data Analysis Techniques

After the data collected both quantitatively and qualitatively were obtained, the researchers conducted data analysis. Considering that the pilot application of this model is based on an assessment based on student performance tests and student perceptions of creativity and innovation, the primary data analysis technique emphasized is quantitative descriptive analysis. The T-test is an alternative analysis that can test whether there are differences in student CLO scores and changes in creativity and innovation in the industry.

B. Research Outcomes and Targets

The outputs and indicators for achieving the research targets are as follows.

Table 1. Research Outcomes, Targets, and Indicators of Achievement

Nu.	Types of Research Outcomes		Targets and Achievement Indicators	
			2022	2023
1.	International Journal	Journal of Engineering Education Transformations (Q3)	Published	Published
2.	Intellectual property rights	Model Copyright	Granted	
3.	International Seminar Proceedings	ICTVT	Published	Published

C. Team Division

The composition of the research team's work is in Table 2 below.

Table 2. Team Division Matrix

No.	Name/NIP	Position and Time Allocation Team, hours/weeks	Research Assignments
1.	Dr. Apri Nuryanto, S.Pd., S.T. M.Pd./ 197404212001121001	Lead Researcher, 4 hours/week	1. Coordinating research 2. Account for research results and budget use 3. Review research outputs
2.	Prof. Dr. Ir. Dwi Rahdiyanta, M.Pd., IPU./ NIP. 196202151986011002	Research Member, 2 hours/week	1. Determine the research sample and collaboration partners 2. Validate the instrument internally 3. Reviewing research data
3.	Prof. Dr. Thomas Sukardi, M.Pd./NIP. 195311251978031002	Research Member, 2 hours/week	1. Collecting research data on campus and industry. 2. Analyze research data and provide a summary of the results of data collection

No.	Name/NIP	Position and Time Allocation Team, hours/weeks	Research Assignments
			3. Develop research outputs.
4.	Prof. Dr. Sugiyono, M.Pd./NIP. 19531214 1978111001	Research Member, 2 hours/week	1. Reviewing research methods comprehensively. 2. Provide input related to research results and input from external sources/validators 3. Reviewing the research outcome
5.	Bayu Rahmat Setiadi, M.Pd. / 198810092019031010	Research Member, 2 hours/week	1. Compile research reports 2. Collecting research data on campus and industry. 3. Analyze research data and provide a summary of the results of data collection 4. Develop research outputs.
6.	Dr. Tee Tze Kiong	Research Partner, 2 hours/week	1. Reviewing research results 2. Submitter and review of International Journals
7.	Sulaeman Deni Ramdani, M.Pd.	Research Partner, 2 hours/week	1. Reviewing research results 2. Submitter and review of International Journals

D. Time Schedule

Table 3. Research Implementation Schedule

Nu	Activity Programs	Month						
		1	2	3	4	5	6	7
1	Research Coordination							
2	Preparation of Effectiveness Test Instruments							
3	Validation of Model Trial Instruments							
4	Revision							
5	Model Trial Experiments							
6	Effectiveness Test Analysis							
7	Research Output							
	a. Feasibility Study							
	b. Research Product							
	c. International Journal							
	d. National Journal							
	e. International Conferences							
	f. Copyright IPR							
8	Report and Monitoring							

CHAPTER IV
RESEARCH RESULTS AND DISCUSSION

A. Research Results

The results of the study are divided into eight steps. The steps include descriptive data of research respondents, group division, product selection, reverse engineering, initial product evaluation, optimization design, final product evaluation, and comparison of results. The explanation and exploration of research results at each stage are as follows.

1. Descriptive Data of Research Respondents

The research respondents used two CAE courses in the D4 Mechanical Engineering Study Program at Yogyakarta State University. The respondent is an active student in semester five who has taken 2D CAD, 3D CAD, and machine element courses. The provisions of the three supporting courses can be fulfilled to be involved in this research. Students first take CAE lectures for four meetings, and in meetings 5th and sixth, students are in the industry to carry out reverse engineering and design optimization processes.

This initial research data discusses the subject of the study, namely students. Student profile data collection to identify gender, availability of support facilities, and experience in conducting engineering analysis and simulation. The results of the data collection of the profile of the research respondents are described as follows.

Based on the data collection results, information was obtained that the total number of students involved in this study was 38. A total of 37 people are male, and one person is female. Based on the ownership of computers/laptops supporting the CAE analysis, 36 people have computers/laptops, and four people do not have computers/laptops. The four people who do not have a computer/laptop do resource sharing with their colleagues so that self-study efforts related to CAE are still fulfilled. According to gender, the four students who do not have computers/laptops are male.

The installed software's availability shows students' willingness and motivation to carry out the CAE learning process optimally. This data collection is important so that researchers know the distribution of students collaborating on product design and design optimization that combines CAD and CAE. The following are the results of identifying design software installation on student computers/laptops.

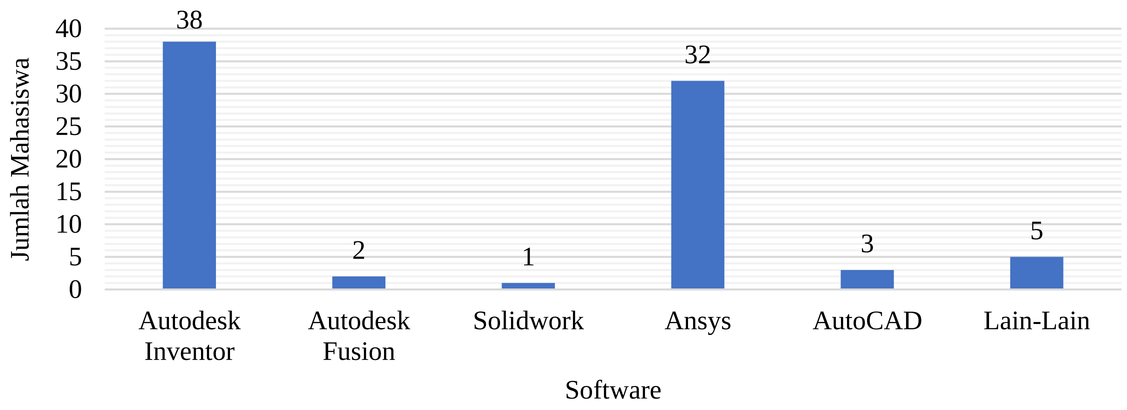


Figure 3. Identify Design Software Owned by Students

Based on the histogram above, it can be seen that all students have installed Autodesk Inventor software, and most of them have installed Ansys software. Students have installed the Autodesk Inventor software since students took CAD 2D and CAD 3D courses, while students in CAE courses have only installed Ansys software. If referring to the availability of student computers/laptops with installed Ansys software, an analysis was obtained that two students who have computers/laptops but do not install Ansys because the hardware capabilities of the computer/laptop are not by the minimum specifications of Ansys software installation. To support how often students operate Ansys software, data was obtained; namely, 36.8% of students stated that they rarely use Ansys software, and 63.2% often use Ansys software. The definition of rare is that students activate Ansys software within a week/once a week, while the definition of often is to activate more than once in one week. If these results are compared, most students' motivation is a serious interest in learning Ansys software as a tool in CAE lectures.

2. **Group Division**

Students equipped with competence in product design and product design and optimization skills can use a combination of CAD and CAE software to solve industrial product design problems. To support the smooth running of students in analyzing direct industrial product designs, it is necessary to have a brief description to partners through a cooperation agreement mechanism to support the smooth research process. After the cooperation is implemented, students and lecturers can jointly carry out CAD learning in the industry. The research partner in testing CAD-CAE learning is an Aircraft UKM located in Wates, Kulon Progo Regency, DIY. The partner has a core business about appropriate technology ventures. The reason for choosing a research partner in Aircraft SMEs is that there are many obstacles, especially to the problem of Appropriate Technology products that have been sold in the market with various complaints that need to be anticipated and solved through applied CAD learning in the industry.

The implementation of CAD learning with two classes is broken down into two sessions. The morning session is for student group A, and the afternoon session is for student group B. The number of students in group A is 18, and in a group B is 20. Students in each group then form a group where each group consists of a maximum of 5 people so that the total of groups A and B is eight groups. Group division using a random drawing technique. This technique is fair and equitable because no grouping intervention can give the CAD practicum in the industry solid. Aircraft SMEs have many appropriate technology machines so that each group can use one engine for product redesign and optimization. However, student groups need to conduct in-depth interviews and observations by exploring the main problems in each machine by interviewing owners and workers in Aircraft SMEs.

3. **Product Selection**

Students carry out product selection by referring to 3 main products that need to be innovated. The three products are brainstorming students with industry to choose one of three alternative products that can be worked on in each group. However, students choosing these three alternative products must do reverse engineering to get product comparisons that are really beneficial to the industry. Identification can be made by selecting, documenting, and visually analyzing selected products in applied CAD learning. The following are the results of the tabulation of the data of the eight student groups in product design and optimization work.

Table 4. List of Alternative Product Selections for Each Group

Group	Appropriate Technology Machine	Product		
		Product 1	Product 2	Product 3
A1	Mini Grass Chopper Machine	Chopping knife	Chopping shaft	Cover Body Machine
A2	Large Grass Chopper Machine	Chopping knife	Chopping shaft	Machine Construction
A3	Mini Corn Sheller Machine	Sheller Knife	Sheller shaft	Engine Hinges
A4	Large Corn Sheller Machine	Sheller Knife	Sheller shaft	Corn filter
B1	Mini Cassava Chopper Machine	Chopper knife	Knife plate	Blade shaft
B2	Big Cassava Chopper Machine	Chopper knife	Engine wheels	Blade shaft
B3	Mini Composting Machine	Static Knife	Blade shaft	Engine Cover
B4	Large Composting Machine	Dynamic Blades	Motor Mount	Main Shaft

Figure 4. Examples of Appropriate Technology Machines that Students Describe in Product Selection

Students with the team (group) outlined the three product alternatives to choose one of the urgent problems that impact partner problems. Each group discusses each product selected and presented in front of lecturers and industry. Students then assess the results of this election as an illustration of obtaining information and discussing why the product needs to be evaluated. The following are the reasons these products were chosen.

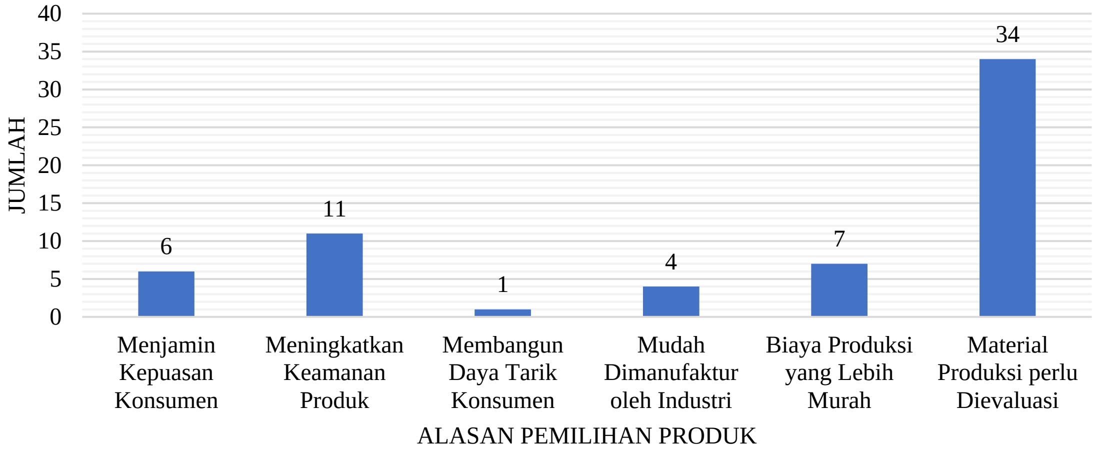


Figure 5. Why Student Groups Choose Products that Need to Be Innovated

Based on the picture above, it can be seen that most respondents (every student) choose product evaluation and innovation because of the need to replace materials. Materials developed by industry are materials on the market, and their needs can be said to affect insecurity or inconsistency of specifications with the scope of work of the material. In addition, without careful consideration, material selection errors can impact the sustainability of business units, work accidents, raw material and production costs, and efficiency in material consumption.

4. Reverse Engineering

Reverse engineering is the stage of designing authentic industrial products that are carried out from measurement to design. The design begins with measuring the innovative product's accurate dimensions using digital and mechanical measuring instruments. The equipment includes calipers, micrometers, high gauges, protractors, steel crossbars, and meters. The measuring instrument has been calibrated and can be used to detail the required dimensions. Next, students make sketch drawings to provide a concise product overview and the accompanying dimensions. The equipment used includes an A3 size drawing book, mechanical pencils of sizes 0.3 and 0.5, markers, ballpoint pens, erasers, crossbar rulers, elbow rulers, protractors, and term. The sketch is very helpful for students in starting product design because the results of their work can be visualized quickly and as a guide in redesigning computer-based products.

The products designed by students for all eight groups are eight designs. These innovative designs include (1) chopping knives on mini grass chopper machines; (2) chopping shafts on large grass chopper machines; (3) the sheller knife on the mini corn sheller machine; (4) the sheller shaft on the large corn sheller machine; (5) a chopper knife on a mini cassava chopper machine; (6) the engine wheels on the large cassava chopper machine; (7) static knife mini composting machine; and (8) dynamic knives on large composting machines.

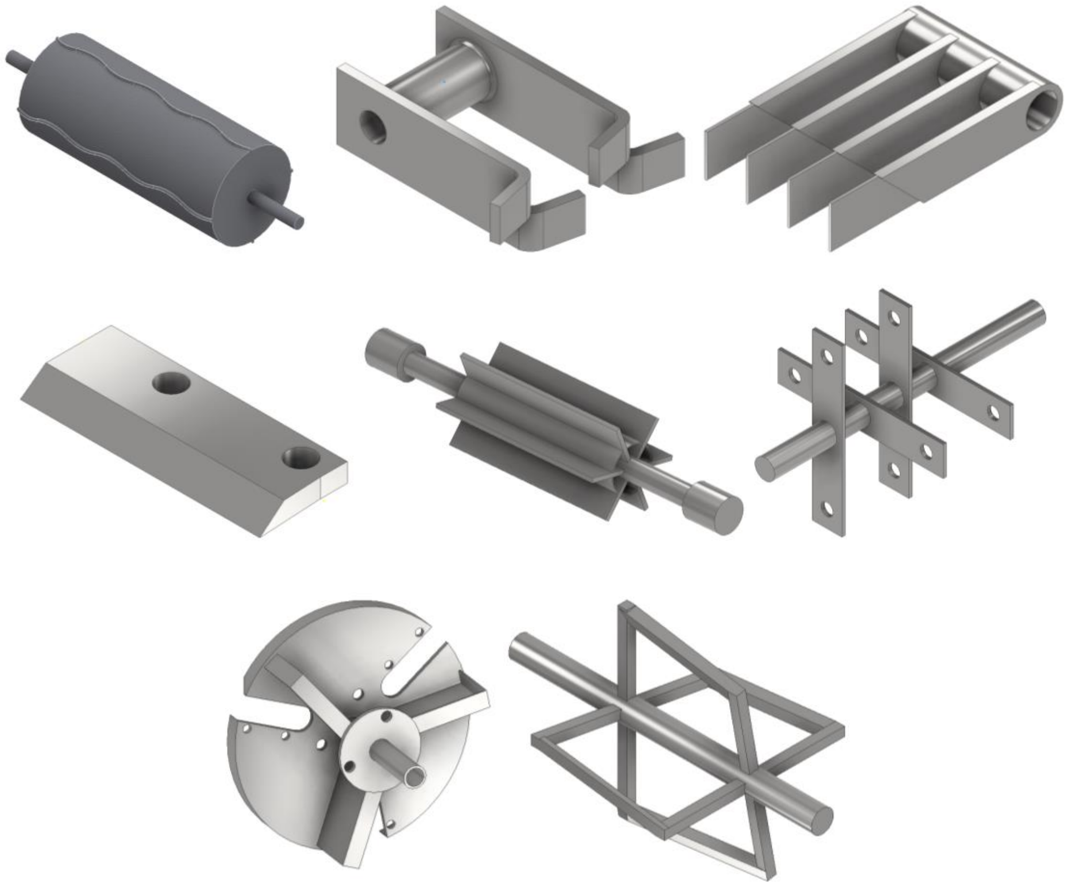


Figure 6. Student Reverse Engineering Results

5. Initial Product Evaluation

The results of reverse engineering, as described by the students in Figure 6, show that in 1 meeting, lecture activities in the industry have completed the stage completely. Students with collaboration have redesigned industrial products that require problem-solving. To detail these problems, students with industry determine critical points that are prone to damage, deformation of shapes, and experience large loadings due to the force effects of objects that are cut, chopped, crushed, and smoothed. The details of the loading of styles, moments, and fixed support in the analysis settings in the ANSYS software are presented as follows.

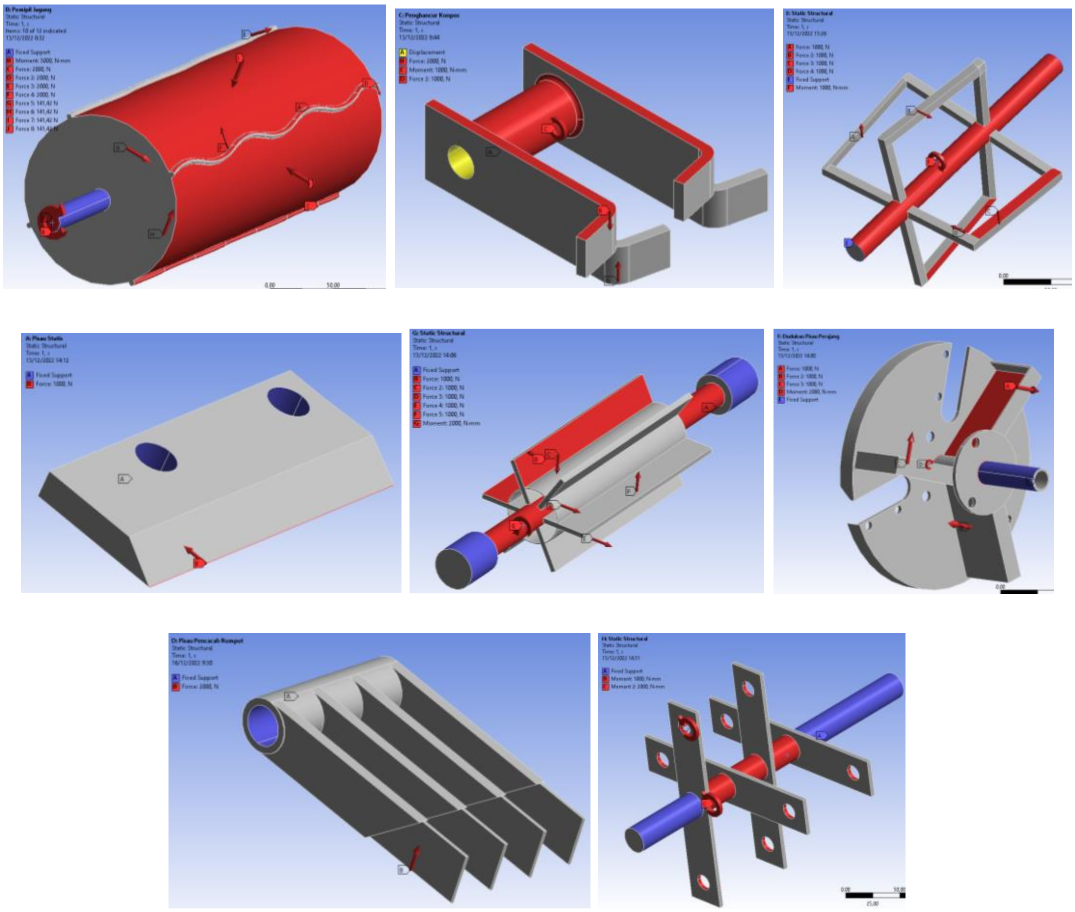


Figure 7. Loading and Styling Direction and Product Moments

The results of the loading based on the illustration in figure 7 vary. This is because the force contact generated from each test product follows the needs and problems faced by the partner. The material of the entire component/product is ASTM A36. Partners commonly use this material to make tools, covers, shafts, and other raft components because of the easy availability of raw materials. To support the initial product analysis information, it is necessary to identify engineering data on ASTM A36 materials based on generally available standards. The following is the data engineering on the ASTM A36.

Table 5. ASTM A36 Material Properties

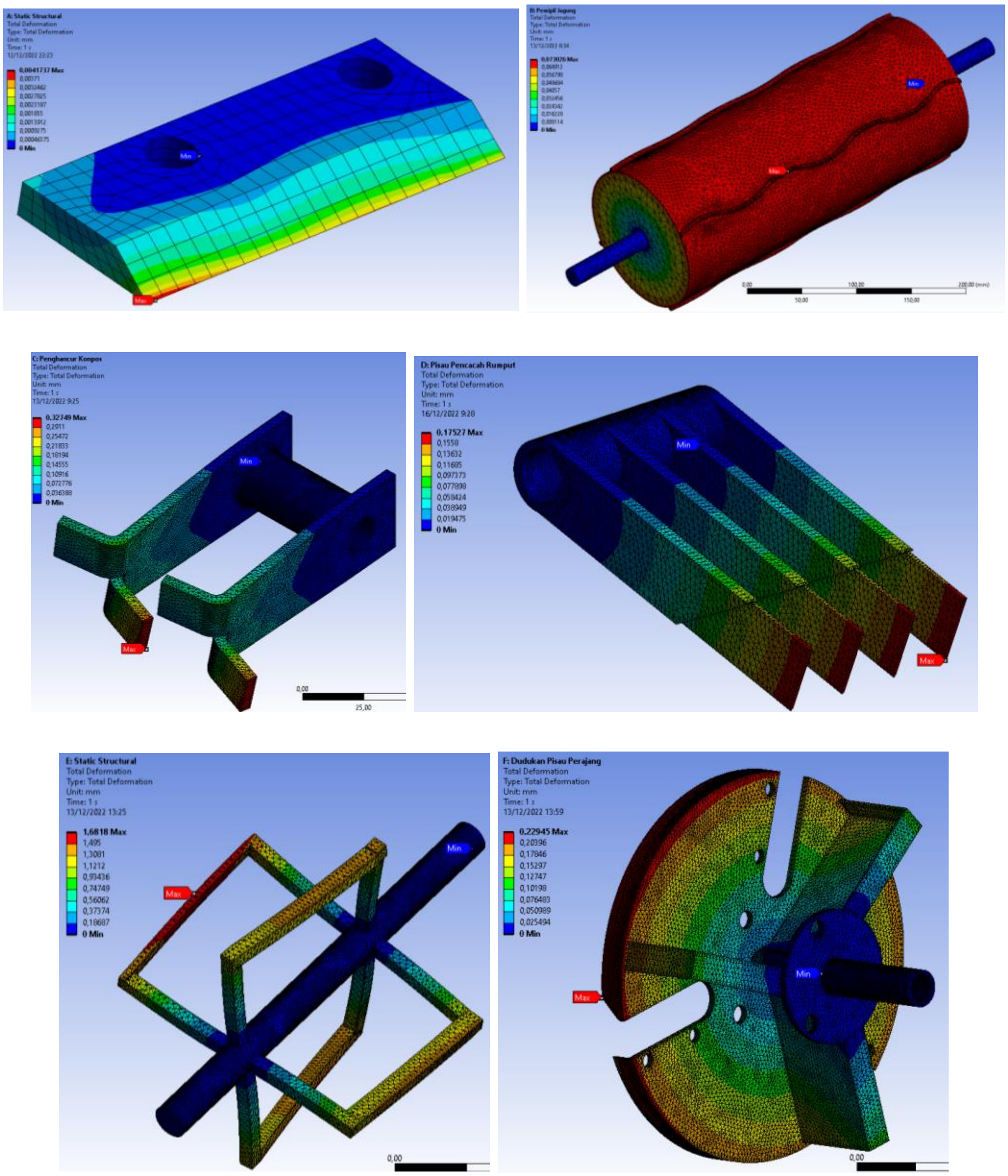
No.	Material Property	Value (in Unit)
1.	Density	$7850\ \frac{kg}{m^3}$
2.	Coefficient of Thermal Expansion	$1{,}2 \times 10^{-5}\ \frac{1}{C}$
3.	Young's Modulus	$2 \times 10^{11}\ Pa$
4.	Poisson's Ratio	$0{,}3$
5.	Bulk Modulus	$1{,}667 \times 10^{11}\ Pa$
6.	Shear Modulus	$7{,}692 \times 10^{10}\ Pa$
7.	Strength Coefficient	$9{,}2 \times 10^{8}\ Pa$
8.	Strength Exponent	$-0{,}106$
9.	Ductility Coeficient	$0{,}213$
10.	Ductility Exponent	$-0{,}47$
11.	Cyclic Strength Coefficient	$10^{9}\ Pa$
12.	Cyclic Strain Hardening Exponent	$0{,}2$
13.	Tensile Yield Strength	$2{,}5 \times 10^{8}\ Pa$
14.	Compressive Yield Strength	$2{,}5 \times 10^{8}\ Pa$
15.	Tensile Ultimate Strength	$4{,}6 \times 10^{8}\ Pa$
16.	Compressive Ultimate Strength	$0\ Pa$

Based on reverse engineering products in the form of 3D modeling and the selection of ASTM A36 materials, information related to material weights can be known. In addition, the number of elements / mesh and nodes of each product component that students work on can also be known. The analysis of the data can be found through ANSYS Mechanical. Here is the tabulation of the initial data of the reverse engineering component results.

Table 6. Preliminary Data on Student Reverse Engineering Products

Group	Product Name	Dimensions (mm)	Volume (mm^3)	Mass (kg)	Nodes	Elements
1.	Static Knife	106.7x40,5x8,4	28962	0,22735	14753	2925
2.	Corn Sheller	500x144x144	8951500	70,269	174811	95647
3.	Compost Crusher	116x38x108.15	65004	0,51028	142823	82205
4.	Lawn Chopping Knife	21.2x67x114.35	38001	0,29831	130362	72830
5.	Compost Blade Mount Shaft	205.18x202.5x340	292520	2,2963	100474	55455
6.	Cassava Chopper Knife Holder	333.5x332.58x261.3	870650	6,8346	327478	180181
7.	Automatic Shaft Feeding	78.21x88x380	301430	2,3662	70657	38689
8.	Compost Mixer Shaft	207x207x340	274190	2,1524	40823	21199

The table above shows that the dimensions and elements of the meshing of a student-tested product can be read in the ANSYS Mechanical program. According to these results, the most significant object/component is a corn sheller, and the smallest product studied by students is a static knife. The initial data serves as a benchmark for comparing product innovations when computers perform mathematical and infinite element modeling to see total deformation, equivalent elastic strains, and equivalent stress. The simulation results are based on loading, force moments, and fixed support at points agreed upon between students and the industry. There is no specificity in presenting meshing techniques, but the meshing size scale is reduced from 1 – 5 mm so that cylindrical shapes can make the mesh look perfect. The loading and laying of crucial component points produce the results of the analysis of total deformation as follows.



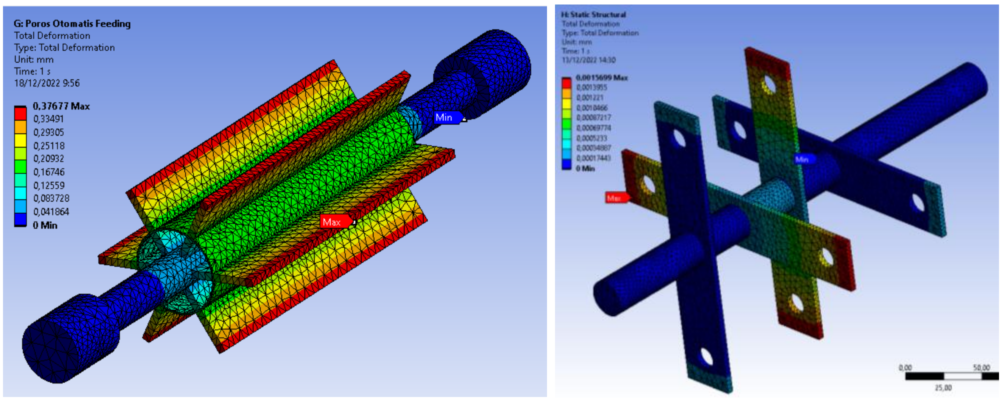


Figure 8. Results of Preliminary Evaluation of Total Deformation of Student Reverse Engineering Products

The results of these deformations indicate critical points that need to be evaluated. Students confirm with the industry to ascertain whether the correctness of this simulation is an actual condition that occurs in the industry, as well as consumer complaints and inefficiencies in product development. The red color indicates maximum deformation, and the blue indicates minimal deformation. To record the final results on total deformation, equivalent elastic strain and equivalent stress in each product are presented in the following data tabulation.

Table 7. Preliminary Data on Student Reverse Engineering Products

Group	Product Name	Total Deformation(mm)		Equivalent Elastic Strain (mm/mm)		Equivalent Stress (MPa)	
		Min	Max	Min	Max	Min	Max
1.	Static Knife	0	4.8186×10^{-3}	1.6363×10^{-7}	2.5601×10^{-5}	2.9086×10^{-2}	38,971
2.	Corn Sheller	0	7.3026×10^{-2}	3.0569×10^{-12}	1.2768×10^{-3}	3.3275×10^{-7}	199,65
3.	Compost Crusher	0	0,32749	9.4822×10^{-9}	$1,846 \times 10^{-4}$	1.8964×10^{-3}	315,26
4.	Lawn Chopping Knife	0	0,17527	$1,735 \times 10^{-8}$	1.6569×10^{-3}	1.1523×10^{-3}	331,39
5.	Compost Blade Mount Shaft	0	1,6809	2.4554×10^{-7}	4.1281×10^{-3}	4.9108×10^{-2}	824,22
6.	Cassava Chopper Knife Holder	0	0,22945	1.2853×10^{-21}	6.6449×10^{-4}	2.4053×10^{-16}	113,08
7.	Automatic Shaft Feeding	0	0,37677	2.8511×10^{-8}	9.0481×10^{-4}	3.0684×10^{-3}	164,99
8.	Compost Mixer Shaft	0	1.5699×10^{-3}	1.5341×10^{-16}	4.6765×10^{-6}	1.9966×10^{-11}	0,83095

Various results characteristics were obtained based on the recording results of Total Deformation, Equivalent Elastic Strain, and Equivalent Stress. The highest voltage and deformation are on the shaft of the compost blade mount. Although when reviewed in weight, the component belongs to the category of lightweight even though the results of the influence of loading and moments at strategic points are significantly deformed in contrast to the compost mixer shaft with the lowest total voltage and deformation values due to the influence of the working moments on the chopping knife holder. The tabulation results are used as a baseline for students to innovate with more effective demands, namely reducing the effects of loading and being efficient in material consumption to encourage engine rotation to be efficient and save electrical power.

6. Optimization Design

Optimization design is the process of improving the quality of the reverse engineering process. This optimization design is an effort to cover the shortcomings of the initial 3D modeling of the results of simulation and engineering analysis so that changes and modifications are needed at points that are considered critical and design product efficiency. Students carrying out optimization designs conduct several experiments to obtain the latest product designs that are safer, stronger, and more efficient are obtained. Students can do the 3D modeling process using Autodesk Inventor software and test simulating through ANSYS. If the results are still above the initial evaluation value, students revise the product design by discussing it with friends in their group. This process is carried out repeatedly until it gets the industry's expected results.

The products that students optimize consist of eight products in line with the number of the entire group, namely 8. The designs and optimization of the final design developed by students for verification from the industry include (1) Static Knives; (2) Corn Shellers; (3) Compost Crushers; (4) Grass Chopping Knife; (5) Compost Blade Mount Shaft; (6) Cassava Chopper Knife Holder; (7) Automatic Feeding Shaft; and (8) Compost Mixer Shaft. The results of design evaluation and optimization are as follows.

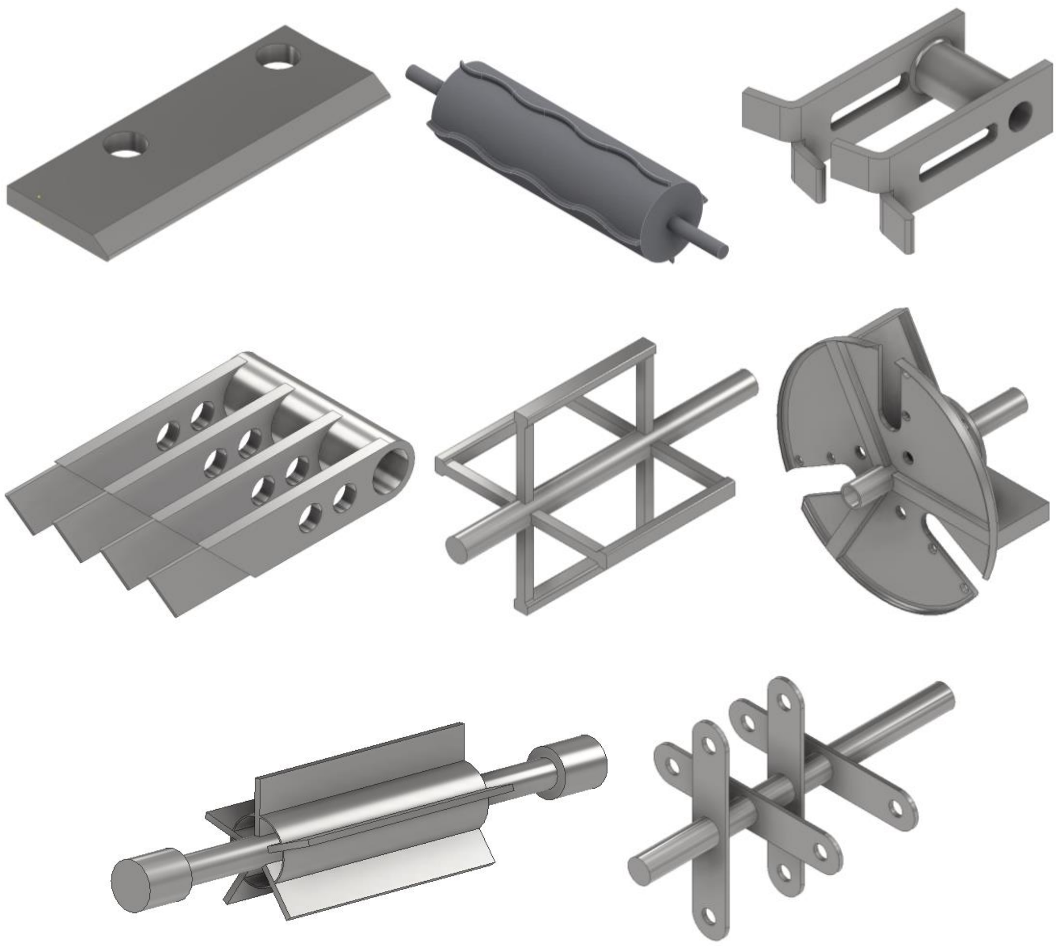


Figure 9. Student Optimization Design Results with Industry

7. **End Product Evaluation**

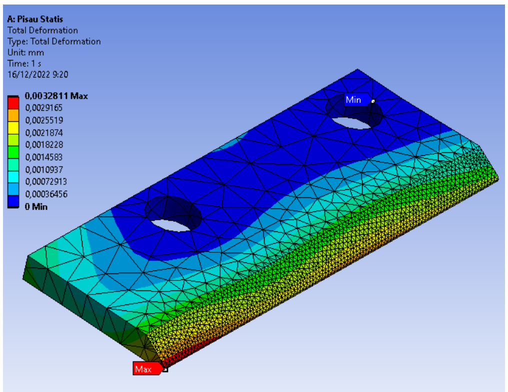
The results of the product optimization design, as described by students in Figure 9, show that in 1 meeting, lecture activities in the industry have completed the design optimization stage with the team and industry. Students with collaboration have optimized product design based on alternative problem-solving solutions to the results of the initial design evaluation. To solve design optimization problems, students and industry are looking for solutions to solving problems at critical points that are prone to damage, deformation of shapes, and experience large loadings due to the force effect of objects being cut, chopped, crushed, and smoothed. Details of force loading, moments, and fixed support in the analysis settings in ANSYS software and refer to the initial evaluation data so that the comparator variables are homogeneous under the same conditions. In addition, the use of ASTM A36 materials is also made on the same engineering data to avoid bias in comparative simulation testing of product design optimization results.

Based on the results of product design optimization in 3D modeling, information can be found related to the latest material weights from innovations. In addition, the number of elements / mesh and nodes of each product component that students work on can also be known. The analysis of the data can be found through ANSYS Mechanical. The following is a tabulation of the components' final data resulting from the design optimization.

Table 8. Final Product Data From Student Design Optimization

Group	Product Name	Dimensions (mm)	Volume (mm^3)	Mass (kg)	Nodes	Elements
1.	Static Knife	106,59x38,443x6	21539	0,16908	12949	7074
2.	Corn Sheller	500x1 16 x116	4174600	32,77	254446	144209
3.	Compost Crusher	116x38x107.77	60016	0,47113	137630	78406
4.	Lawn Chopping Knife	21.2x67x114.35	34525	0,27102	132180	73716
5.	Compost Blade Mount Shaft	20 0x200x340	322340	2,5304	106590	58691
6.	Cassava Chopper Knife Holder	333.5x332.58x261.3	952230	7,475	332096	185369
7.	Automatic Shaft Feeding	84,929x80,772x380	278810	2,1887	68067	36998
8.	Compost Mixer Shaft	207x207x340	269290	2,1139	40178	20987

The table above shows that the dimensions and elements of the meshing of a student-tested product can be read in the ANSYS Mechanical program. According to these results, the most significant object/component is a corn sheller, and the smallest product studied by students is a static knife. The initial data serves as a benchmark for comparing product innovations when computers perform mathematical and infinite element modeling to see total deformation, equivalent elastic strains, and equivalent stress. The simulation results are based on loading, force moments, and fixed support at points agreed upon between students and the industry. There is no specificity in presenting meshing techniques, but the meshing size scale is reduced from 1 – 5 mm so that cylindrical shapes can make the mesh look perfect. The loading and laying of crucial components points produce the results of the analysis of total deformation as follows.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Unit: mm
Time: 1 s
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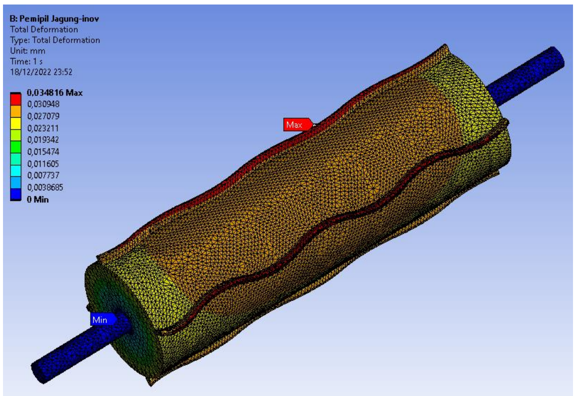
B: Pemipil Jagung-inov
Total Deformation
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Unit: mm
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18/12/2022 23:52
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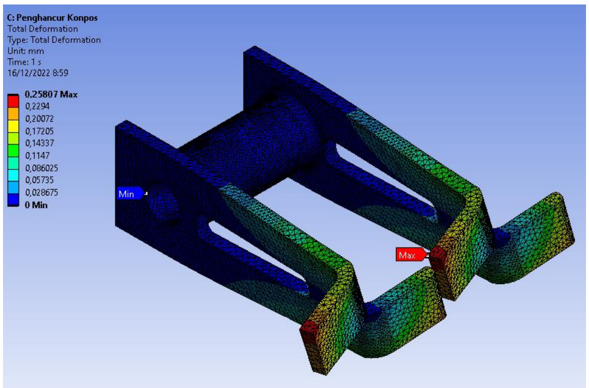
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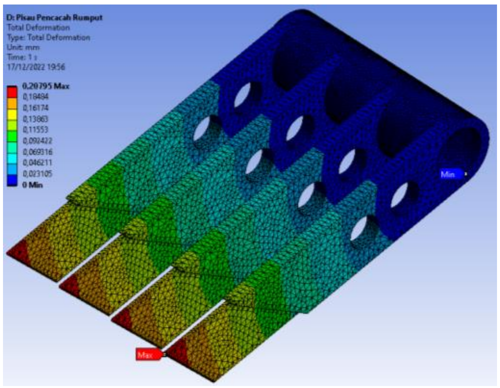
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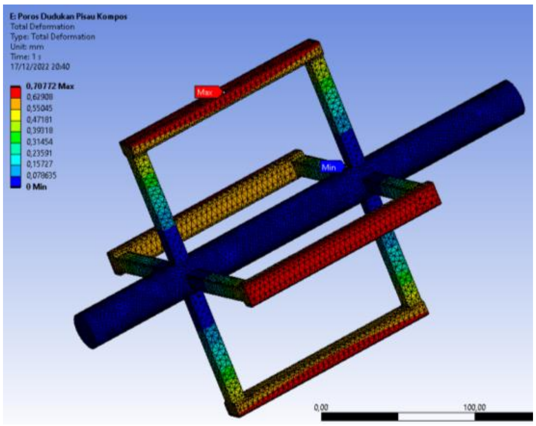
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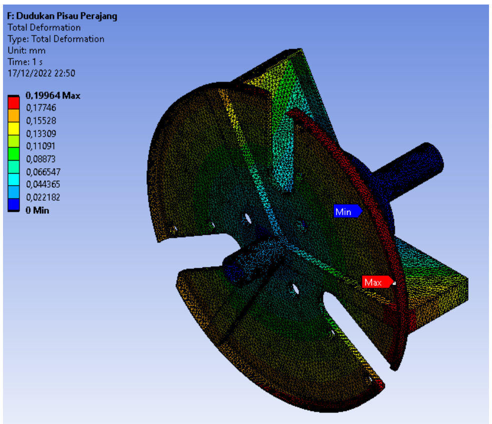
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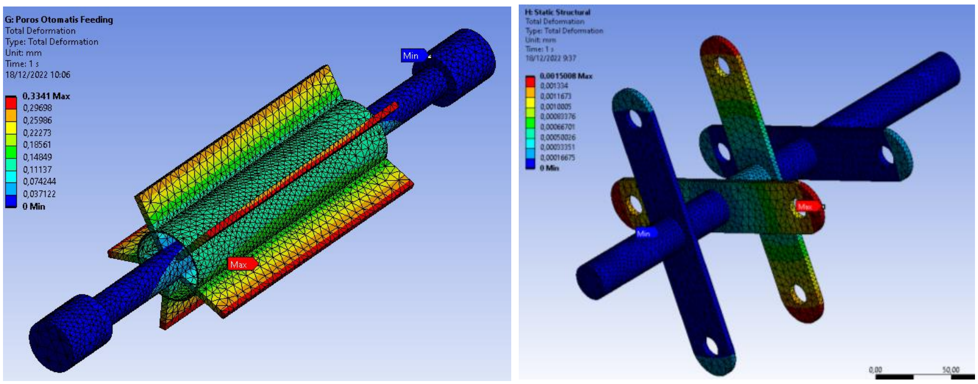

Figure 10. Final Evaluation Results of Total Deformation of Student Design Optimization Products

The results of these deformations indicate critical points that need to be evaluated. Students confirm with the industry to ascertain whether the correctness of this simulation is an actual condition that occurs in the industry, as well as consumer complaints and inefficiencies in product development. The red color indicates maximum deformation, and the blue indicates minimal deformation. To record the final results on total deformation, equivalent elastic strain and equivalent stress in each product are presented in the following data tabulation.

Table 9. Final Product Data from Student Optimization Design

Group	Product Name	Total Deformation(mm)		Equivalent Elastic Strain (mm/mm)		Equivalent Stress (MPa)	
		Min	Max	Min	Max	Min	Max
1.	Static Knife	0	3.2811 x 10-3	7.6994 x 10^{-8}	5.8878 x 10-5	1.5399 x 10^{-2}	11,672
2.	Corn Sheller	0	3.4816 x 10-2	3.1573 x 10^{-13}	9.6789 x 10^{-4}	4.5697 x 10^{-8}	139,02
3.	Compost Crusher	0	0,25807	2.3122 x 10^{-8}	1.0754 x 10^{-3}	1,523 x 10^{-3}	201,22
4.	Lawn Chopping Knife	0	0,20795	2.2671 x 10^{-8}	7.5943 x 10^{-4}	2.3095 x 10^{-3}	137,29
5.	Compost Blade Mount Shaft	0	0,70772	3.3893 x 10^{-13}	1.4996 x 10^{-3}	5.6535 x 10^{-8}	295,48
6.	Cassava Chopper Knife Holder	0	0,19964	3,428 x 10^{-21}	6.8888 x 10^{-4}	3.3326 x10^{-16}	110,61
7.	Automatic Shaft Feeding	0	0,3341	1.1266 x 10^{-7}	9.3235 x 10^{-4}	9.7594 x 10^{-3}	175,21
8.	Compost Mixer Shaft	0	1.5008 x 10^{-3}	9.1366 x 10^{-17}	4.4055 x 10^{-6}	1.2608 x10^{-11}	0,79026

Various results characteristics were obtained based on the recording results of Total Deformation, Equivalent Elastic Strain, and Equivalent Stress. The highest voltage and deformation are on the shaft of the compost blade mount. Although when reviewed in weights, these components include having changed product safety improvements from before. In contrast, the compost mixer shaft with the lowest total voltage and deformation values due to the influence of the working moments on the chopping knife holder.

8. Comparison of Results

Comparison of results is a process of calculating changes due to optimization design. The optimization design refers to the results of simulations and technical analysis obtained when evaluating the initial design. Various alternative possibilities of product design innovation have been taken into account by students with industry so that significant changes are obtained to improve safety, durability, and production efficiency. To see the difference in the initial and final results in the whole group, the difference can be presented in percentage changes. Positive means an increase in value from before, and negative is a decrease in value from before. The following is a tabulation of the initial and final design evaluation percentage change.

Table 10. Differences in Early and Late Evaluation Changes

Group	Product Name	Percentage change (+ = Up, - = Down) Units in %				
		Volume	Mass	Total Deformation	Equivalent Elastic Strain	Equivalent Stress
1.	Static Knife	-25,63	-25,63	-31,91	129,98	-70,05
2.	Corn Sheller	-53,36	-53,36	-52,32	-24,19	-30,37
3.	Compost Crusher	-7,67	-7,67	-21,20	482,56	-36,17
4.	Lawn Chopping Knife	-9,15	-9,15	18,65	-54,17	-58,57
5.	Compost Blade Mount Shaft	10,19	10,19	-57,90	-63,67	-64,15
6.	Cassava Chopper Knife Holder	9,37	9,37	-12,99	3,67	-2,18
7.	Automatic Shaft Feeding	-7,50	-7,50	-11,33	3,04	6,19
8.	Compost Mixer Shaft	-1,79	-1,79	-4,40	-5,79	-4,90

The differences above show significant changes from each optimization design developed by students with industry. In group 1, static knives experienced a decrease in weight and considerable total deformation. In addition, the resulting voltage value has decreased significantly, but the strain that occurs has experienced considerable magnification. This means to achieve deformation of the form is a tremendous effect due to the presence of strain. The strain will give the material a change at a certain point to the maximum strain, while the voltage has been overcome by lowering the value at the loading that occurs. In group 2, corn shellers decreased by half of the original weight. The reduction of stuffing in corn shellers must be adjusted to production capacity because the shelling area becomes narrower. Total deformation also impacts a decrease of up to 50%, thus providing a decrease in voltage and strain. This result is entirely satisfactory for the industry because it can reduce the initial simulation's high weight and product safety.

Group 3, namely compost crushers, experienced a slight decrease in weight. This decrease was not very significant compared to the previous two groups due to considerations of the effects caused if you want to lower the weight in large quantities. Total deformation has decreased considerably, but there is a very high increase in the resulting strain. This is enough to signal future innovation so that this component can be further innovated. The resulting voltage has decreased significantly. Group 4, namely grass chopping knives, experienced a small decrease in weight. This decrease is due to the effect of the initial simulation results that need to optimize only a few points that need to be innovated. A decrease of up to 50% occurs in stress and strain, but the total deformation produced increases. This happens because of the student's inability to make more innovative design edits and even change the product's shape. Using an existing product will still produce total deformation even if the voltage and strain produce a falling value.

Group 5, namely the shaft of the compost knife holder, is unique compared to others. In this component, the resulting weight increases. This change refers to the product's revision of the effects that occurred with the initial design that the industry had developed. Product innovation provides a very high decrease in total deformation, stress, and strain. This adds value to components that are integrated forward to provide product safety. Group 6, namely the cassava chopper knife holder, experienced an increase in weight due to the initial simulation and revision results. The weight supports the outside of the stand so that the plate becomes safer when loading and moment. The decrease in total deformation and voltage does not drop significantly. In addition, the strain has increased, indicating that the plate covering part needs to be further innovated.

Group 7, namely the feeding automation shaft, is a component that does not work very well but will impact the fins of automatic feeding. Innovation is carried out by reducing the automatic fins to 5. Therefore, the resulting weight decreases, and the total deformation also shows a decrease in value. However, there is an increase in voltage and strain, although it is not very large. Group 8, namely the compost stirring shaft, experienced a slight weight loss. It is not as significant as other groups because it only innovates certain parts that need deformation reduction of the form. Total deformation, stress, and strain have a small decrease. This is because the shape and construction of components are challenging to develop, except for changing the total shape of the components without reducing their function.

B. Discussion

Applying CAD learning in the industry is one of the regular learning integrations contributes significantly to study program partners. CAD learning in the industry means that students get two main activities: attending regular lectures on campus and gaining real experience in the industry related to industrial product design problems. These two aspects need to be integrated into a CAD learning model that innovates with complex problems in the industry.

The concept of learning on campus emphasizes that CAD learning is sought to equip students with cognitive skills in mastering CAD. CAD has many ways to use it to realize and interpret a product design. Various CAD vendors can color student competencies to ensure that every learning achievement can be met. The provision of students fulfilling CAD skills can be developed by following the lecturer's instructions and developing CAD skills on their own by using the internet. There are many things that students can learn related to CAD, but little material enrichment when dealing with actual product design in the industry.

Regular CAD learning collaboration with real problems in the industry is an era of impactful collaboration learning. The impact collaboration in question is to provide opportunities for cooperation between universities and industry through regular microlearning mechanisms. The learning indeed discusses real industry problems to be raised in regular learning. Students can concretely conduct little research in the industry to comprehensively understand the real problems facing the industry and package them into the concept of collaborative learning. This collaborative learning is integrated with CAD learning so that the university's inputs, namely students, software, hardware, lecturers, and supporting facilities, can be collaborated with the industry to complete product design innovations. The industry, as a beneficiary, can capture this great potential as a step in realizing innovation and economic growth that impacts the survival of business units.

Applied learning of CAD in the industry goes through various stages of refinement. The CAD learning model outputs industrial design as the master plan of future CAD learning. The CAD learning will later encourage collaboration in developing industrial product designs to produce industrial designs with a balanced division of rights and obligations between students and industry. Students' ideas, ideas, creativity, and innovation will be honed when dealing directly with the problems of product innovation problems. Students' provisions in making CAD learning work successful if they work in a team and collaboratively with the industry. The key to the industry's openness to industrial product design is the main thing that students must explore by exploring these problems.

CHAPTER V
CONCLUSIONS AND SUGGESTIONS

A. Conclusion

Based on the research results and discussion presented, the conclusions drawn in this study include the following.

1. The year 2022 focuses on the application of CAD learning in the industry. The results of this application involve two classes assigned equivalent to 3 meetings in small and medium-sized industries (IKM) in the field of appropriate technology. The result of the two groups' division was eight groups. Deepening the problems of appropriate technology machines in the industry obtained eight machines, namely: Grass Chopper Min I Machine, Large Grass Chopper Machine, Mini Corn Sheller Machine, Large Corn Sheller Machine, Mini Cassava Chopper Machine, Large Cassava Chopper Machine, Mini Compost Making Machine, and Large Composting Machine. The results of the identification of students with the industry narrowed down to the selection of products for each group as follows: (1) Static Knives; (2) Corn Shellers; (3) Compost Crushers; (4) Grass Chopping Knife; (5) Compost Blade Mount Shaft; (6) Cassava Chopper Knife Holder; (7) Automatic Feeding Shaft; and (8) Compost Mixer Shaft.
2. The results of the evaluation of the eight components of the design test for the student group obtained a variety of dynamics. Students apply Autodesk Inventor software to design 3D modeling and evaluate it with ANSYS. Students carry out the product measurement process as part of reverse engineering and perform optimization designs for the results of simulations and engineering analysis. The dynamics of simulation results vary from the various considerations that students choose with the industry. The conclusion of what the students presented was not solely on the results obtained but the mechanism for developing product innovations aimed at providing improved product design quality, production efficiency, and safety guarantees for consumers in the future.

B. Suggestion

This research is phasing out for the next two years, so it still needs further research and development. To support these efforts to run simultaneously according to the research roadmap, several suggestions can be considered by the industry and advanced researchers as follows.

1. The certainty of inputs that must be matured by the study program to apply CAD learning can be well considered. These inputs include lecturers, students, supporting facilities, and good cooperation with industry. These four things must be prepared to provide student comfort in solving product design problems in the industry.
2. Accuracy in placing lecture meetings in the industry must be adjusted to complete the required learning outcomes. The learning design emphasizes students' mastery of 3D modeling and Finite Element Analysis as the key to providing a complete design embodiment with Detail Engineering Design.
3. The industry's openness in expressing all product design problems that hold on to a change needs to be adequately conveyed to students. Students also explore this sharply and meticulously so that the essence and priorities of problem-solving can be right on target and on time. This means that the industry's interest in innovating products can be helped directly when students are in the industry. This is what the industry expects, so there is mutualism that has an impact.

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ATTACHMENT

IMPLEMENTING ARRANGEMENT
JOINT RESEARCH PROGRAM

BETWEEN

MASTER OF MECHANICAL ENGINEERING EDUCATION DEPARTMENT, FACULTY OF ENGINEERING, YOGYAKARTA STATE UNIVERSITY

AND

DR. TEE TZE KIONG, UNIVERSITI TUN HUSSEIN ONN MALAYSIA

No:**___**

This Arrangement sets forth Joint Research Agreement made on this 18th day of March by and between Dr. **Apri Nuryanto, M.T**, a lecturer from the **Master of Mechanical Engineering Education Department**, **Universitas Negeri Yogyakarta,** and **Dr. Tee Tze Kiong, a lecturer from Universiti Tun Hussein Onn Malaysia** here in after referred to singularly as "the Party" and collectively as "the Parties."

The Parties have decided to conduct a Joint Research Program on International Collaborative Research. Now, therefore, in consideration of the mutual promises recited herein, the parties agree as follows:

I. Period of Services

Dr. Apri Nuryanto, M.T. from Universitas Negeri Yogyakarta and Dr. Tee Tze Kiong from Universiti Tun Hussein Onn Malaysia agree to conduct a joint research program on **International Collaborative Research for the period of Mei 1st,** 2022, to **November 30, 2022**.

II. Employee Status

During this Agreement, Dr. Apri Nuryanto, M.T., will always remain an employee of Universitas Negeri Yogyakarta. Universitas Negeri Yogyakarta will be responsible for continuing and making all appropriate employee payrolls for "**Applied Cad Learning Model for Design Product Innovation and Optimization of Small And Medium Enterprises in Indonesia."** For no purpose will Dr. Tee Tze Kiong be considered an employee of the Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia. Otherwise, Dr. Tee Tze Kiong will remain at all times an employee of Fakulti Pendidikan Teknisal Dan Vokasional, Universiti Tun Hussein Onn Malaysia will be responsible for continuing and making all appropriate employee payrolls for "An Applied Learning Model for Small and

Medium Enterprise Product Design Innovation and Optimization in Indonesia" For no purposes will Joint Research Program be considered an employee of Universitas Negeri Yogyakarta.

III. FUNDING

Each Party will bear any costs, expenses, or other charges of whatever nature incurred by such Party, which are not expressly detailed in the approved Joint Research.

IV. JOINT INTELLECTUAL PROPERTY

a) The protection of intellectual property rights shall be enforced in conformity with the respective national laws, rules, and regulations of the Parties and with other international agreements signed by both Parties.
b) The use of the name, logo, and official emblem of any of the Parties on a publication, document, or paper is prohibited without the prior written approval of either Party.
c) The ownership of all intellectual property arising from the work or any project under this Agreement (from now on referred to as "**Joint Intellectual Property**") shall be shared equally between both Parties.
d) Either Party may, by giving prior written notice to the other Party and upon specific payment, the amount of which to be agreed later by the Parties, to the other Party abandon its share in the Joint Intellectual Property and transfer its share in the Joint Intellectual Property to the other Party.

V. PUBLICATIONS POLICY

Both Parties shall have the right to use and publish any information derived from the work or project under this Agreement, provided that written consent is obtained from the other Party. If any Parties wishes to publish, disclose, and present (in any form of disclosure) the data and outcome arising from this Agreement, the Party shall submit a draft of each such publication or presentation to the other Party and give the right to the other Party to have certain parts of the said publication. In any such publications, the contribution of both Parties shall be acknowledged.

VI. DURATION OF AGREEMENT

This Agreement is valid for a year and becomes effective on the date that the official representatives of both institutions sign it. This Agreement may be terminated according to the same terms outlined in the Joint Research Agreement between Universitas Negeri Yogyakarta Universiti Tun Hussein Onn Malaysia a. If either institution intends to terminate or to modify this Agreement, a written notice should be given to the other institution 30 days prior to the desired effective date of termination.

VII. Force Majeure

If, as a result of an act of force majeure, including without limitation, an act of God, war, riot, labor dispute, strike, or threat thereof, the intervention of a government agency or instrumentality or another occurrence beyond the control of either Party, either Party is substantially hindered in performing its obligations hereunder then, in such event, that Party shall have the right, upon notifying the other of the occurrence of force majeure as herein defined, to suspend performance of the cooperative activity according to this Agreement and any contract based on this Agreement until the force majeure has passed IN WITNESS of which, the parties hereto have executed this Agreement as of the date fit written above.

FOR

Master of Mechanical Engineering Education Department, Faculty of Engineering
Yogyakarta State University

Dr. Apri Nuryanto, M.T.
Researcher from Indonesia

Faculty of Technical and Vocational Education
Universiti Tun Hussein Onn Malaysia

Dr. Tee Tze Kiong
Researcher from Malaysia

INSTITUTION TRACK RECORD

A. UNY Track Record

UNY has the main task of organizing academic, professional, and vocational education in several disciplines, engineering, technology, arts, and sports. The main task is listed in the 2021-2025 research strategic plan. In the strategic plan, it was agreed that the scientific field is divided into two, namely, the field of educational science and the field of non-educational science. The field of educational science is the primary *field (central core*) of UNY, which was born and developed as an Educational Personnel Educator Institute (LPTK). Non-educational science is a science field aimed at strengthening education's development through updates and innovations in the context of achieving world-class educational universities. Specifically, in the non-educational field, three domains are focused on research, namely (1) The Subfields of Mathematics and Natural Sciences, Engineering, and Technology; (2) Social, Humanities, Economics, Language, and Arts Subfields; and (3) Sports and Health Subdivision.

In the Subfield of Mathematics and Natural Sciences, Engineering and Technology consist of various engineering disciplines of engineering, mathematics, and natural sciences (MIPA). His research is aimed at supporting the national research agenda in terms of the management and development of Indonesia's biological resources in the field of health and food security; new and renewable energy; development of MIPA, engineering, basic and future technologies; appropriate and applied technologies; advanced and functional materials; climate change, preservation, and control of environmental quality. Therefore, research on the SWM Dynamic System Model is very relevant to the research field planned by UNY in the 2020-2025 Research Strategic Plan.

B. **UTHM** Track Record

The history of Universiti Tun Hussein Onn Malaysia (UTHM) began on September 16, 1993, with the establishment of the Polytechnic Staff Training Center (PLSP), which aims to produce and train knowledgeable and proficient teaching staff in various vocational fields to be placed in polytechnics throughout the country. On April 12, 1996, PLSP was designated as the Tun Hussein Onn Institute of Technology (ITTHO) by maintaining its function to train teaching staff in Polytechnics throughout Malaysia. At the same time, ITTHO continues to grow with increased academic program offerings, and the number of student takes. On September 27, 2000, history was sculpted when ITTHO was upgraded as a university kolej under Deed 30 of the Universiti Deed and the 1971 Universiti Kolej (AUKU) by being known as the Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO). Starting February 1, 2007, KUiTTHO was named once again Universiti Tun Hussein Onn Malaysia (UTHM) to align with other lay universities in the country. In line with the demands and developments of the times, on January 1, 2011, UTHM spread its wings by establishing a cawangan campus in the Pagoh Education Hab known as UTHM Cawangan Pagoh Campus. He placed three faculties/recitation centers, namely the Faculty of Vocational Technology, the Faculty of Science and Technology, and the Center for Diploma Recitation.

CERTIFICATE OF STUDENT INVOLVEMENT

The undersigned:
Name: Dr. Apri Nuryanto, S.Pd., S.T., M.T.
NIP: 19740421 200112 1 001
Fak / Jur / Study Program: Faculty of Engineering / Mechanical Engineering Education
Structural Position: Chair of the Department of Mechanical Engineering Education

It is at this moment explained that :

No	Name	NIM	Department / Study Program
1	Helmi Kusuma Prime	19503241044	Mechanical Engineering Education
2	Laksa Kelana Aditya Sentanu	19503241002	Mechanical Engineering Education
3	Yussuf Faisal Jeffry	19503241032	Mechanical Engineering Education
4	Omar Adityo Winoto	21508334078	D4- Mechanical Engineering
5	Friska Lathifa Zhahir	21539141048	Manufacturing Engineering
6	Arjun Dwianggoro	21539141050	Manufacturing Engineering

the names mentioned above are still recorded as active students
in the Department of Mechanical Engineering Education.

Thus this certificate is made to be used as appropriate.

Yogyakarta, 24 May 2022
Ketua Jurusan Pendidikan Teknik Mesin

Dr. Apri Nuryanto, M.T.
NIP. 19740421 200112 1 001

THE STATEMENT OF WILLINGNESS TO COLLABORATE IN INTERNATIONAL RESEARCH

The undersigned below,

Name	:	Dr. Tee Tze Kiong
Position	:	Associate Professor
Affiliation	:	Universiti Tun Hussein Onn Malaysia
Address	:	Batu Pahat, Johor, Malaysia

Here by declares that he is willing to corporate International Collaborative Research with the title:

APPLIED CAD LEARNING MODEL FOR DESIGN PRODUCT INNOVATION AND OPTIMIZATION OF SMALL AND MEDIUM ENTERPRISES IN INDONESIA

As the Head of International Cooperation Research is:

Name	:	Dr. Apri Nuryanto, M.T.
Employee ID Number	:	19740421 200112 1 001
Rank/Class	:	Assistant Professor
Study Program/Department	:	Master of Mechanical Engineering Education
Faculty	:	Faculty of Engineering, Yogyakarta State University

Thus, this Statement Letter is made with full awareness and responsibility, without coercion, so that it can be used properly.

Malaysia, March 24, 2022

Dr. Tee Tze Kiong