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Computer-Aided Design (CAD) Training for Appropriate Technology (TTG) to Enhance the Competence of Vocational High School Students in East Java

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ABSTRACT
This community service programme aimed to enhance the competencies of vocational high school students in East Java through Computer-Aided Design (CAD) training for Appropriate Technology (AT). Held on 13 June 2025 at the Mechanical Engineering Study Programme, Universitas Muhammadiyah Sidoarjo (Umsida), the activity was part of the Institutional Community Service Grant initiative. A total of 20 students from four partner schools participated, with each school sending five representatives. The training focused on developing students' technical skills in designing AT products using CAD software and simulating basic fluid mechanics relevant to product development. Expert instructors, certified by the National Professional Certification Board (BNSP), delivered hands-on sessions to ensure strong practical learning outcomes. The results showed significant improvements in students' technical abilities in CAD-based product design, a better understanding of engineering concepts, and greater readiness to apply these skills in industry-related contexts. This programme represents a strategic effort to bridge the gap between vocational school graduates' competencies and industry demands, while also fostering innovation and the potential for technology-based entrepreneurship.

Keyword: Computer-Aided Design (CAD), Appropriate Technology (AT), Vocational High School, Technical Competence, East Java, Community Service, Engineering Education

1. Introduction

The Fourth Industrial Revolution has brought profound changes to the industrial landscape, with a strong emphasis on digitalisation, automation, and innovation. In this era, digital skills have become indispensable particularly in technology-based product design to deliver innovative, relevant, and competitive solutions [1,2]. One technology that plays a pivotal role in this context is Computer-Aided Design (CAD) software, which supports the design and production process with efficiency, precision, and compliance with industry standards [3].

CAD-based Appropriate Technology (AT) design holds significant potential in advancing community development, especially in rural areas. Through CAD, the AT design process can be executed with high precision, time efficiency, and adaptability to local needs [4]. Well-conceived AT can offer practical solutions across various sectors, including agriculture, post-harvest processing, and renewable energy [5].

Nevertheless, discussions with partner schools indicate that many vocational high school students in East Java still face considerable challenges in operating CAD software. These obstacles stem from limited facilities, a lack of structured training, and minimal practical exposure [6,7]. This skills gap hampers graduates' readiness to compete in the labour market or independently develop innovations based on AT.

Providing structured CAD training for AT design is a strategic approach to closing this gap. Tailored to industry needs, such training equips vocational high school students with relevant technical expertise, enabling them to create AT designs that are practical, innovative, and highly impactful [8,9]. This initiative also aligns with the Sustainable Development Goals (SDGs), particularly Goal 9, which underscores the importance of innovation and infrastructure in supporting sustainable development [10].

Through this programme, Universitas Muhammadiyah Sidoarjo, with the support of the Directorate of Research and Community Service (DRPM), is committed to empowering vocational high school students in East Java with the skills to design CAD-based AT ready for real-world application [11]. Beyond enhancing technical competencies, this effort seeks to cultivate an innovative mindset among the younger generation, enabling them to contribute meaningfully to both regional and national development [12].

2. Method

The training activity on AT design using CAD is carried out through a participatory training approach that combines theory with hands-on practice. This method is chosen to ensure that participants not only understand CAD-based design concepts but are also able to apply them in creating AT designs that are relevant to the needs of both the community and industry.

1. Preparation Stage
   This stage includes coordination with partner schools, scheduling of the programme, and selection of training participants. The partner institutions, namely vocational high schools in East Java, are asked to nominate five top students with an interest and basic knowledge in mechanical engineering or electrical engineering. In addition, a training module is prepared, covering topics such as an introduction to CAD, principles of AT design, and practical exercises in creating designs.
2. Implementation Stage
   The training is conducted in two main sessions:
   - ✓ Theory Session – Participants are introduced to the basic concepts of AT, principles of efficient design, and the main features of CAD software. The material is delivered through interactive presentations and group discussions to encourage active participation.
   - ✓ Practical Session – Participants engage in hands-on exercises using CAD software to design AT. At this stage, instructors provide step-by-step technical guidance, starting from sketch creation and dimension settings to visualising the design in 3D.
3. Mentoring and Evaluation Stage
   After the training, participants are assigned an independent task to complete an AT design according to the agreed theme. The resulting designs are then presented before the implementation team to receive feedback. Evaluation is carried out based on criteria such as design accuracy, innovation, and compliance with AT principles.
4. Equipment and Software
   The training utilises computers/laptops with specifications capable of running CAD applications, along with the educational versions of SolidWorks and AutoCAD software. These programs are selected because they are widely used in industry and offer features well-suited for the development of AT.
5. Success Analysis
   The success of the training is measured through pre-tests and post-tests to assess knowledge improvement, as well as an evaluation of the design outputs to measure participants’ technical skills. The collected data is analysed descriptively to observe the improvement in vocational high school students’ competencies after participating in the training.

3. Result and Discussion

3.1. Participant Characteristics

The training was attended by 20 students from partner vocational high schools in East Java (see Figure 1). Participant selection was based on school recommendations, taking into account their interest, basic knowledge, and learning motivation in the field of technical design. Based on initial data, the majority of participants had never received formal CAD training but possessed basic experience in manual technical drawing.

Figure 1. Resource Persons and Training Participants

3.2. Pre-Test and Post-Test Results

Based on the pre-test and post-test scores (see Figure 2), there was a significant improvement in participants' competencies after taking part in the CAD-AT Training. Before the training, the average participant score was 62.1, indicating that most students had not yet mastered CAD design techniques optimally. After the training, the average score increased to 85.4, representing an improvement of approximately 37.5%. Almost all participants experienced an increase of more than 15 points, indicating that the learning method combining theory and hands-on practice had a positive impact on their understanding and design skills. This demonstrates that the training was effective in enhancing the technical abilities of vocational high school students in designing AT.

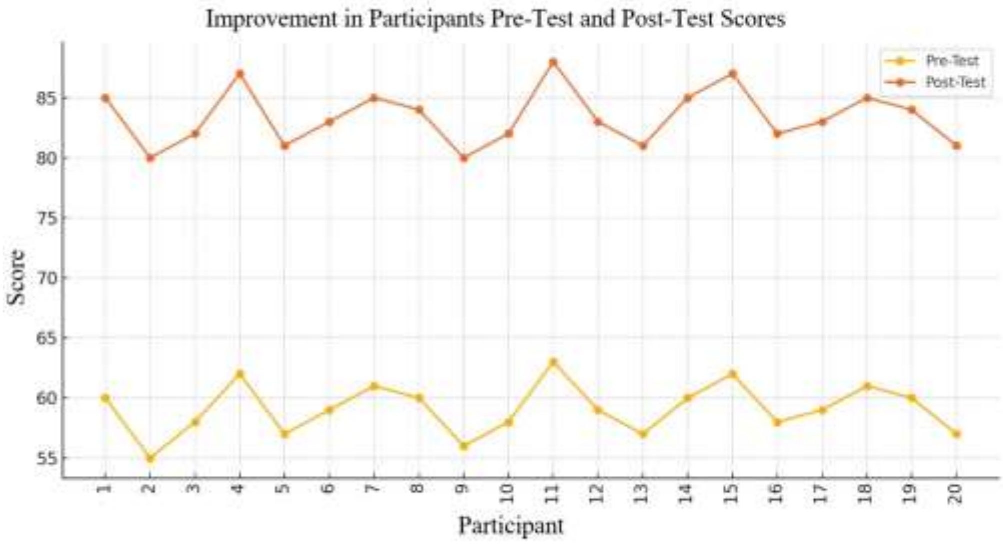


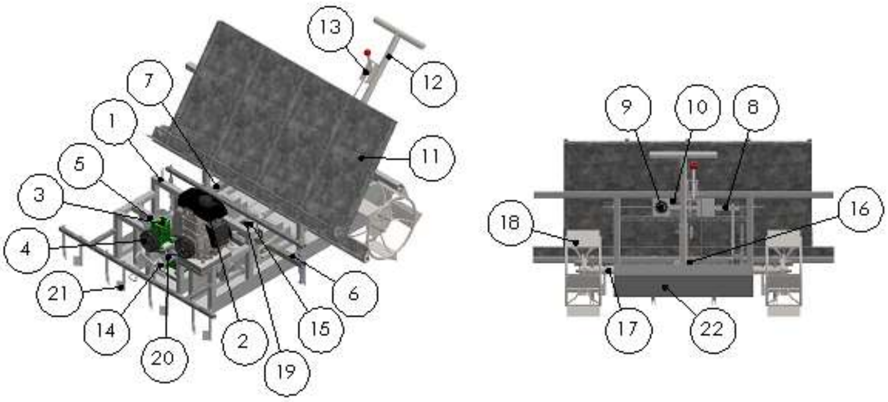
Figure 2. Graph of Pre-Test and Post-Test Score Measurements

In the AT design results of each group, it was evident that every team successfully completed their assigned tasks for designing the Rice Planting Machine powered by a petrol engine. Group 1, responsible for designing the Mechanical Working Arm for Seed Pickup, achieved the highest scores in design (90) and creativity (88), indicating that they produced a detailed, precise, and innovative design, although its functionality could still be further optimised. Group 2, tasked with designing the Mechanical Working Part for Seed Planting, earned a solid functionality score (87), suggesting that their design was capable of operating with sufficient precision and durability. Group 3, responsible for creating the Mechanical Part of the Seed Tray Table, obtained solid scores but a relatively lower creativity score (80), leaving room to develop more varied ideas, particularly in the seed distribution system. Meanwhile, Group 4, which designed the Mechanical Working Part for the Wheels, excelled in functionality (90), showing that their design strongly supported the tool's mobility and stability in various field conditions, with high design (88) and creativity (86) scores as well.

Overall, this training not only enhanced participants' theoretical understanding but also developed their practical skills in producing AT designs ready for integration into a complete prototype. The strengths of each group could complement one another, so that if all the design outputs were combined, they would form an innovative, functional rice planting machine design with strong potential for field testing.

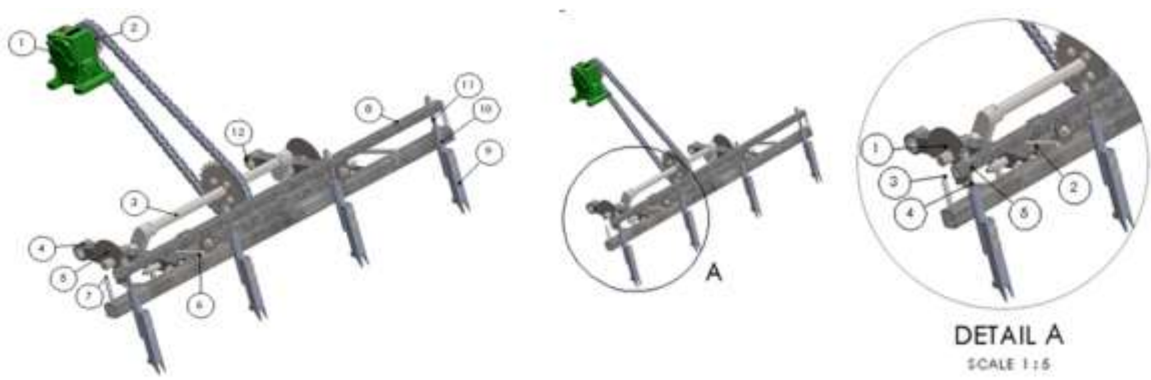
3.3. TTG Design Results

In the practical session, participants were divided into small groups, each consisting of five students, to design a part of the AT tool. The design of the AT tool can be seen in Figure 3. The group task distribution was as follows: Group 1 worked on the task shown in Figure 4(a), Group 2 worked on the task shown in Figure 4(b), Group 3 worked on the task shown in Figure 5(a), and Group 4 worked on the task shown in Figure 5(b).



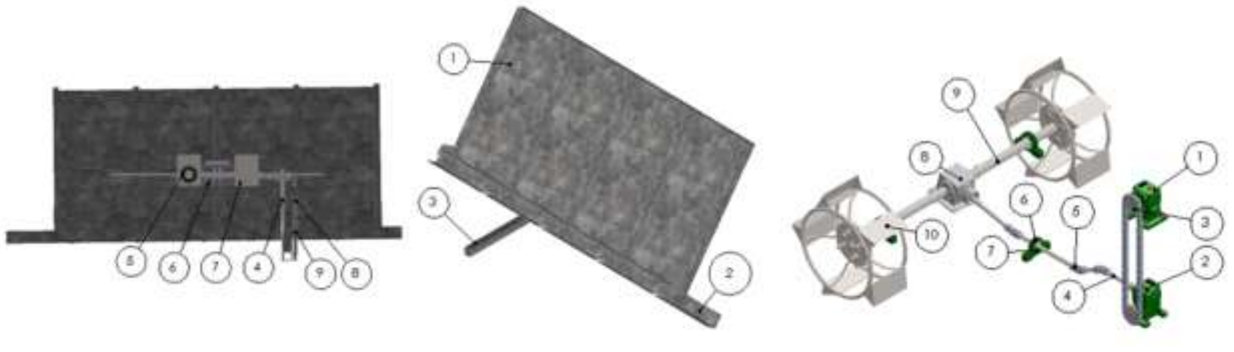
Item No	Part Name	Item No	Part Name
1	Frame	12	Handle
2	Gasoline Engine	13	Transmission Lever
3	WPA Gearbox	14	Pulley Stopper
4	Pulley	15	Connecting Shaft
5	Chain Drive	16	Bevel Gearbox
6	Seed Pickup Arm	17	Wheel Shaft
7	Table Drive Arm	18	Wheel
8	Table Sliding Plate	19	Pillow Block
9	Freewheel	20	Bearing
10	Chain Drive	21	Soil Cover
11	Seed Tray Table	22	Rice Planting Tool Base

Figure 3. Design of a rice planting tool with a gasoline engine drive



(a) **(b)**

Figure 4. (a) Mechanical design of seed picking arm ; (b) Mechanical design of seedling planter



(a) (b)

Figure 5. (a) Mechanical design of seedling collection table; (b) Mechanical design of rice planting wheel

The designs produced by each group met the basic criteria of AT, namely simplicity, low production cost, ease of operation, and potential for community application. These design outcomes are expected to serve as effective and beneficial solutions while also encouraging students' creativity in developing technologies relevant to local needs.

3.4. Competency Improvement Discussion

The improvement in students' competencies was evident in two main aspects:

1. Technical Skills – Participants were able to use basic CAD features to create 2D sketches, 3D models, and simple assemblies. They also understood principles of measurement, tolerance, and design rendering.
2. Design Creativity – Participants were able to identify problems in their surroundings and translate them into applicable AT concepts. This demonstrates that the training not only taught technical skills but also fostered problem-solving abilities.

These achievements are in line with Nugroho et al. (2022), who stated that practice-based learning can enhance mastery of CAD software while sharpening students' creativity. Furthermore, the results support the World Economic Forum's (2023) recommendation that digital skills and technology-based design are among the core competencies needed in the era of the Fourth Industrial Revolution.

3.4. Obstacles and Challenges

During the training, several challenges were encountered, including:

- Differences in participants' initial skill levels, which required additional time for guidance.
- Limited hardware in partner schools that did not fully meet the optimal specifications for running CAD smoothly.

However, these challenges were addressed through intensive mentoring and adjustments to the material, ensuring that all participants were able to follow the training effectively.

3.5. Impact and Sustainability

This training has had a positive impact by enhancing the technical competencies of vocational and senior high school students in CAD design for AT. Several partner schools have expressed their commitment to continuing similar activities independently by utilising the modules and materials provided. Thus, this programme has the potential to create a sustainable impact in improving the quality of vocational school graduates in East Java.

4. Conclusion

The Computer-Aided Design (CAD) Appropriate Technology (AT) Training conducted for vocational high school students in East Java proved effective in enhancing participants' technical competencies, particularly in product design skills using CAD software. The significant increase in post-test scores compared to pre-test results demonstrates that the hands-on learning approach, supported by instructor mentoring, was able to bridge the existing skills gap.

This activity not only strengthened the mastery of design skills relevant to industry needs but also equipped students to adapt to technological developments in the era of the Fourth Industrial Revolution. The future implementation of similar training is expected to be expanded in scope both in terms of the number of participants and the variety of technical topics in order to further prepare vocational school graduates to become competent, creative, and innovative professionals.

5. Acknowledgements

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