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DEVELOPMENT PROTOTYPE JIG AND FIXTURE USING PNEUMATIC SYSTEM FOR TEACHING AID

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ABSTRACT

Technical and Vocational Education and Training (TVET) is essential for workforce preparation, as it blends theoretical knowledge with practical, competency-based learning to equip learners with industry-specific skills and real-world experience, setting it apart from traditional education. In Polytechnic Banting Selangor, students in semester five (5) are learning "DJF51072 Jig and Fixtures Design" course. Jig and fixtures are mechanical devices used to support the workpiece while it is being held during manufacturing. One of the issues that can be found in delivering the teaching process to the students of TVET is when those students try hard to understand the concept and function of jigs and fixtures in the drilling process, without having teaching aids and proper tools as a reference. To overcome this problem, a development prototype teaching aid jigs and fixtures for process drilling using a pneumatic system, 3D printer, CAD software, an automotive part, and several types of clamping are required. The results of the development of this prototype teaching aid, all students who followed the learning of the subject DJF51072 gave 90.3% of respondents strongly agreed that the use of this prototype helped them understand the concept of jig and fixture using pneumatic systems better. In conclusion, the development of this innovative Jig and Fixture teaching aid has a positive impact on the learning experience of TVET students and supports the objective of sustainable education. This study suggests that this teaching aid can be widely used in TVET institutions as an innovative, environmentally friendly learning tool, and has the potential to be improved with the integration of Augmented Reality (AR) applications in the future.

1. Introduction

In manufacturing, getting things right every time is critical—and that's where tools like jigs, fixtures, and clamps make a big difference. These tools help hold, guide, and support parts during processes like drilling, cutting, welding, or putting things together. They might seem simple, but they play a big role in keeping production accurate, consistent, and efficient.

Jigs are tools that guide a cutting tool, making sure each hole or cut is done the same way every time. Fixtures don't guide tools but instead keep the part being worked on steady and in the right place. Clamps are another essential tool. Whether they're holding parts in place while machines work or keeping things together temporarily during assembly, clamps help ensure everything stays stable and precise. From basic C-clamps to high-tech hydraulic systems, there are many types to suit different jobs and industries.

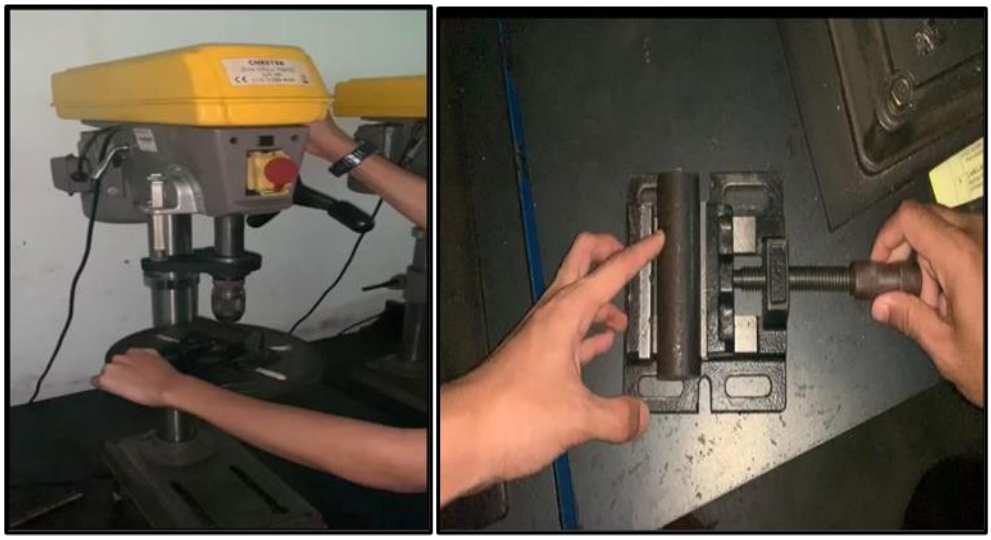

Figure 1. Clamp in Polytechnic Banting machining workshop for drilling process

Lecturers face challenges in effectively teaching Jig and Fixture concepts in the DJF51072 course due to inadequate teaching methods and the need for off-site visits, which lead to time constraints and increased costs. Based on Figure 1. is the example of clamp in Polytechnic Banting machining workshop for drilling process.

2. Materials and Methods

Methodology is the structured, theoretical examination of the methods used within a particular field of study. It includes the underlying concepts and principles that guide these methods and offers a framework for understanding which methods are suitable for given research and the reasons behind their use. Based on Figure 2.0 is a flow chart of design process and Figure 2.1 is a fabrication process.

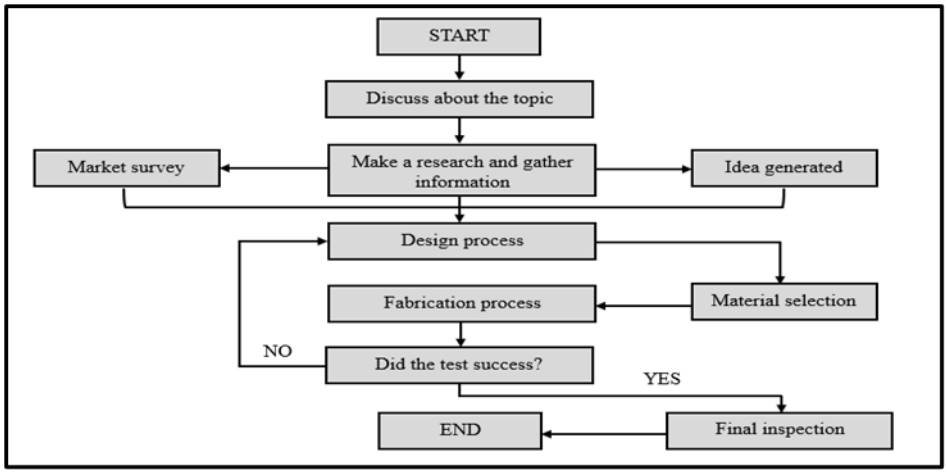

Figure 2. Flow chart of design process

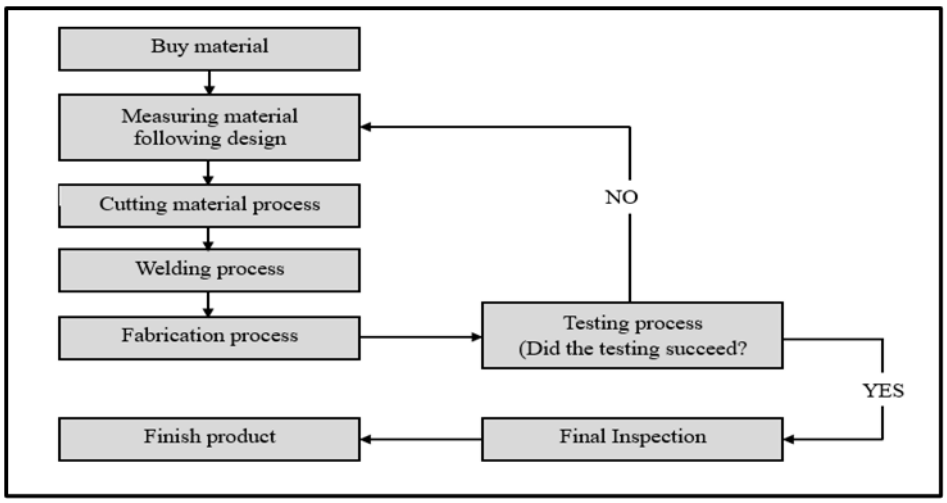

Figure 3. Fabrication process

3. Result

The development of this prototype teaching aid yielded promising results; 90.3% of students enrolled in the DJF51072 course strongly agreed that its implementation significantly enhanced their understanding of jig and fixture concepts, particularly those involving pneumatic systems. In conclusion, the innovative design of this instructional tool positively contributes to the educational experience of TVET students and aligns with the broader objectives of promoting sustainable education.

3.1 Product Description

Table 3. Product description for jig & Fixture using pneumatic system

Component	Product Description
1. Jig & Fixture using pneumatic system	For drill hole will be used for teaching and learning for subject DJF51072 Jig and Fixture.
2. Air compressor	• Maximum pressure for compressor is 150psi • Weight: approx. 5.5kg • Tank capacity: 6L(1.6GAL) • Size: 400 mm (L) x 150 mm (W) x 300 mm (H)
3. Pneumatic system	• Size of outlet pipe diameter is 6 mm • Material: Stainless steel • Working pressure: 0.1 – 0.7 Mpa
4. Workpiece	• Crankshaft casing
5. Material workpiece	• Mild steel
6. Workpiece size	• Workpiece size

3.2 Product picture

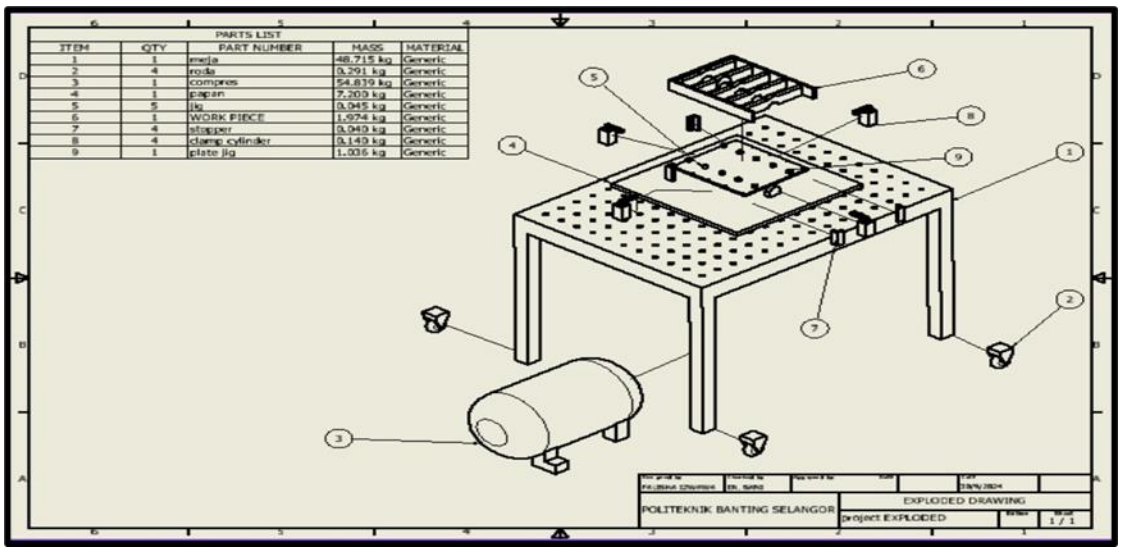

Figure 4. Detail design with exploded

Figure 5. Description of final design Air Compressor

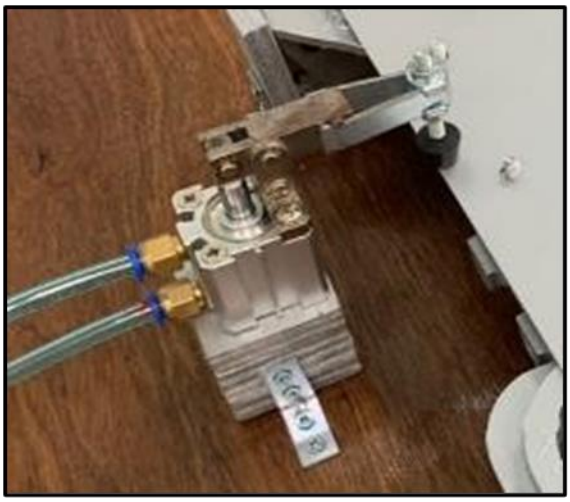

Figure 6. Pneumatic cylinder

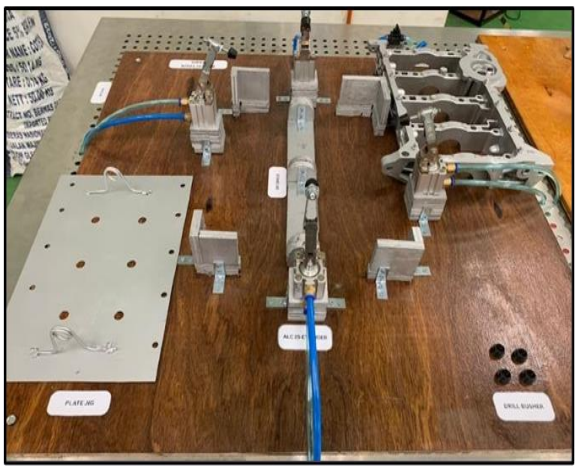

Figure 7. Project picture and result

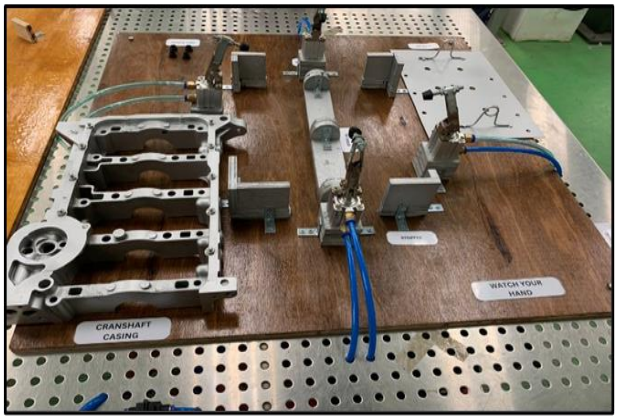

Figure 8. Project picture and result (Another side view)

4. Discussion

a. Cost consideration

The initial plan involved fabricating the jig using 3D printing technology. However, if the production cost proves to be disproportionately high relative to the functional benefits, a design revision may be warranted to minimize material usage or reduce structural complexity, while maintaining the essential performance requirements of the fixture.

b. Safety Improvement

- Stabilization of Workpiece

A fixture functions to securely constrain the workpiece, preventing any unintended movement or rotation during machining operations such as drilling. This stability minimizes the risk of workpiece displacement, thereby reducing the potential for accidents and mitigating the likelihood of damage to both the equipment and the operator. Although jigs and fixtures significantly contribute to operational safety, their design must incorporate ergonomic considerations. Inefficient or ergonomically deficient designs can lead to operator fatigue, improper handling, or misuse, thereby compromising both safety and process accuracy.

c. Precision and Accuracy

- Hole Accuracy and Consistency

A precisely engineered jig guarantees that the drill bit is consistently positioned at the exact predetermined location and angle relative to the workpiece, effectively eliminating any variability introduced by manual positioning. This level of precision ensures uniformity in the drilled holes, which is crucial for downstream assembly processes where the accuracy of component alignment directly impacts the integrity and functionality of the final product. The controlled positioning facilitated by the jig also contributes to maintaining tight tolerances, enhancing both quality and repeatability in production.

- Minimize Defect

In the absence of a properly designed fixture, misalignment, angular inaccuracies, and variations in drilling depth can lead to critical defects, such as off-center holes, inconsistent hole depths, or improper positioning of features. These issues can compromise the structural integrity and functionality of the part, especially in high-precision applications. The integration of a fixture significantly reduces these sources of variability by ensuring consistent and repeatable alignment, controlled depth, and precise angular positioning of the workpiece. As a result, the likelihood of defects is minimized, leading to improved dimensional accuracy, tighter tolerances, and enhanced overall part quality, which is essential for downstream processes such as assembly and functional testing.

5. Conclusion

The development of a pneumatically actuated jig and fixture prototype for the DJF51072 – Jig and Fixture course at Polytechnic Banting Selangor successfully demonstrates the practical application of industrial automation technologies in an educational setting. The integration of pneumatic systems into jigs and fixtures offers substantial improvements in clamping speed, consistency, precision, and safety key factors in modern manufacturing environments.

By incorporating this prototype into the curriculum, students gain hands-on experience with real-world manufacturing tools and systems, thereby enhancing their technical competency and industry readiness. The reduction in setup time, increase in process reliability, and improvement in workplace safety highlight the system’s practical advantages, while also reinforcing theoretical learning objectives.

Despite the relatively high initial investment, the long-term benefits such as enhanced operational efficiency, reduced error rates, and lower maintenance demands make the implementation of pneumatic technology a cost-effective and pedagogically valuable solution. This initiative ultimately supports the institution's commitment to providing industry-aligned technical education and equipping students with relevant, future-ready skills.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the author(s) used OpenAI's ChatGPT to assist in improving the readability and language of the text. All content generated by ChatGPT was subject to thorough review, editing, and revision by the author(s) to ensure its accuracy, completeness, and alignment with the research objectives. The author(s) take full responsibility for the integrity and content of the published work. This declaration complies with ICGESD 2025 guidelines on the use of generative AI in scientific writing.

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