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Innovation of a Flattening Tool for Optimizing the Water Hyacinth Weaving Process at Maeswara Basket: A Preliminary Study and Technology Implementation

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ABSTRAK

Maeswara Basket menghadapi masalah dengan alat pemipih manual yang tidak efektif dalam produksi kerajinan dari serat eceng gondok. Solusi yang diusulkan adalah pengembangan alat pemipih dengan memperhatikan ergonomi, keamanan kerja, dan fitur pengaturan kecepatan serta kontrol utama. Studi ini menggunakan pendekatan penelitian berbasis masyarakat (CBR) dengan lima tahap: identifikasi masalah, analisis literatur, perencanaan desain, pembuatan, dan evaluasi. Enam orang menilai alat pemipih berdasarkan kemudahan penggunaan, efisiensi proses, kualitas hasil, dan evaluasi keseluruhan menggunakan skala Likert 1-5. Hasil menunjukkan alat memenuhi kriteria penting seperti ergonomi, kemudahan operasional, kecepatan pemipihan, konsistensi ketebalan, kualitas hasil, dan ketahanan komponen, dengan skor 4,3 hingga 4,8 dari 5,0, yang dikategorikan "sangat memuaskan." Alat baru ini unggul dalam kemudahan penggunaan, efisiensi proses, dan kualitas hasil, dengan fitur utama pengaturan kecepatan dan kontrol yang menjaga stabilitas ukuran serat selama proses pemipihan. Studi ini berkontribusi pada pengembangan produk sesuai kebutuhan masyarakat dan berpotensi meningkatkan kapasitas produksi pengrajin eceng gondok, dengan peluang untuk pengembangan lebih lanjut menggunakan teknologi otomasi.

ABSTRACT

Maeswara Basket faces problems with manual flattening tools that are ineffective in producing crafts from water hyacinth fibre. The proposed solution is developing a flattening tool by considering ergonomics, work safety, speed settings, and primary controls features. This study uses a community-based research (CBR) approach with five stages: problem identification, literature analysis, design planning, manufacturing, and evaluation. Six people assessed the flattening tool based on ease of use, process efficiency, quality of results, and overall evaluation using a Likert scale of 1-5. The results showed that the tool met important criteria such as ergonomics, ease of operation, flattening speed, thickness consistency, quality of results, and component durability, with scores ranging from 4.3 to 4.8 out of 5.0, categorized as "very satisfactory." The new tool excels in ease of use, process efficiency, and quality of results, with the main features of speed settings and controls that maintain the stability of fibre size during the flattening process. This study contributes to the development of products according to community needs. It has the potential to increase the production capacity of water hyacinth artisans, with opportunities for further development using automation technology.

1. INTRODUCTION

Water hyacinth is often regarded as a weed or nuisance by farmers, but it holds significant potential for small and medium enterprises (SMEs) to be transformed into high-quality handicrafts and home decor. Some farmers even cultivate water hyacinth in waterlogged areas specifically to sell it to craftsmen, utilizing it as a strategy for economic improvement. When properly maintained, water hyacinth can produce high-

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quality fibers that are highly sought after by craftsmen (Athaillah et al., 2023; Uddin et al., 2022). Moreover, the characteristics of water hyacinth, such as stem thickness, length, and fiber content, vary across regions (Aisyah & Dartono, 2022; Ajithram et al., 2023; Ilo et al., 2024). These variations affect the production process of handicrafts, as shorter and smaller water hyacinth fibers are more difficult to shape and can even cause injuries during the fiber-pulling process. Craftsmen prefer long water hyacinth fibers with intact stems, which are easier to work with and produce better quality products. Maeswara Basket, an SME, sources dried water hyacinth fibers from farmers across various regions, including Ambarawa and Tuntang in Semarang District, as well as Klaten, Sragen, and surrounding areas, to ensure a steady supply of raw materials.

Maeswara Basket, based in Kulonprogo, is an SME dedicated to producing handcrafted goods and home decor. Maeswara Basket has been operating for approximately seven years since 2016. Despite its relatively young age, the company has achieved several milestones, including participation in national and international communities through various events such as seminars, exhibitions, and showcases. However, behind its successful marketing strategy, Maeswara Basket faces internal challenges in production management that require regular improvements. The company currently employs five people, including the owner, craftsmen, and a marketing admin. This small team has struggled to meet growing consumer demand, which exceeds 500 products sold monthly, while the existing resources can only produce two items per day. Moreover, the entire production process is carried out conventionally, including steps such as receiving raw materials, sorting, flattening, weaving and product creation, drying, painting and mold removal, further drying, embroidery or accessory application (for certain products), and finishing. Maeswara Basket needs to gradually integrate technology into these production processes.

Sales evaluations over recent months revealed that the most popular products include Mauri, Klabby, Calista, Renata, Hantara, Caludia, Ciko, Lilo, and several others. These products require special processing, particularly where certain surfaces are woven or braided. The water hyacinth stems must be flattened to a thin layer to facilitate weaving, with the flattened fiber meeting uniform thickness standards to ease material joining. At Maeswara Basket, this process is currently done manually, often leading to significant issues, such as the need for repeated flattening due to certain fiber characteristics. This repeated treatment results in time loss and production delays, highlighting the need for technological upgrades to improve efficiency. To mitigate various losses and expedite the production process, innovation in manual flattening tool technology is crucial. The proposed technology employs an automated mechanism capable of processing multiple water hyacinth fibers simultaneously in one cycle. It is ergonomically designed and equipped with stringent safety systems. The working principle of the designed flattening tool relies on two closely placed cylindrical pipes that press the water hyacinth stems into thinner fibers. As the fibers are fed into the machine, the pipes rotate in opposite directions to ensure effective pressing. This approach has also been applied in various other machines, such as dough and noodle flatteners, and water hyacinth choppers (Budiarto, 2017; Tobing et al., 2023). Principles in machine design can improve efficiency and final product quality, which is also relevant in the context of water hyacinth fiber flattening (Ina, 2021; Putra, 2022).

Several community service activities have been carried out to develop this leveling technology. The results of previous community service studied the efficiency of the mechanical-based leveling process and showed that the use of mechanical technology can increase productivity and reduce losses in the production process (Listiyanto & Santoso, 2023; Rahman et al., 2022). Other community service developed a semi-automatic leveling tool with manual control that provides flexibility in operation and allows craftsmen to adjust the leveling speed according to their needs (Muo & Azeez, 2019; Trapp & Kanbach, 2021). Despite advancements in the development of flattening tools, there are still limitations in the design and effectiveness of the technology produced. Further studies are needed to address these issues and ensure that the developed flattening tool is not only efficient but also ergonomic and safe to use. Consequently, innovation in flattening technology will not only enhance productivity but also ensure the safety of artisans during the production process. Overall, the development of an automatic flattening tool, designed with efficient and safe working principles, can have a positive impact on the water hyacinth-based craft industry. By utilizing this technology, it is expected that the production process can be accelerated, and the quality of the fibers produced can be improved, thereby benefiting the artisans and increasing the competitiveness of craft products in the market.

2. METHOD

This research employed a Community-Based Research (CBR) approach, actively involving community members throughout the research process, thereby enhancing the relevance and utility of the study for the community (Israel et al., 2010; Wallerstein & Duran, 2010). One of the key strengths of CBR is its ability to produce thoroughly tested products that meet user needs through collaboration between researchers and the community, in this case, the flattening machine (Tucker et al., 2016). CBR is also highly effective in addressing social issues by integrating local knowledge and context, which allows for culturally sensitive interventions that align with the community's specific needs (Peace & Myers, 2012). This participatory process fosters a sense of ownership among community members towards the research outcomes, increasing the likelihood of successful implementation. Furthermore, the method facilitates continuous feedback and adaptation, which is crucial in responding to the dynamic needs of the community.

The product development project at Maeswara Basket (ꦩꦌꦱ꧀ꦮꦫꦧꦱ꧀ꦏꦺꦠ꧀) in Kulon Progo, Yogyakarta Figure 1., employed a participatory approach, involving key stakeholders including the owner, two craftsmen, an admin staff member, and a marketing representative (Triyanto et al., 2024). This community service project, conducted from March to May 2024, focused on collaborative discussions and joint evaluations, capturing key events from problem identification to product testing. The participatory nature of the project ensured that the final product was well-tested and aligned with user needs, making it both functional and culturally relevant (Das et al., 2016; Soenjaya et al., 2015). By engaging three Maeswara Basket users and three mechanical engineering lecturers, the project facilitated the creation of a tool that effectively meets community needs (Arivendan et al., 2022). Additionally, the strategic location of Maeswara Basket, close to Yogyakarta State University and Yogyakarta International Airport, offers significant potential for business development, positioning it as a prime hub for traditional handicrafts in the region (Rohman et al., 2022).

Figure 1. (A) Maeswara Basket Storefront and (B) Community Service Implementation Site Location Maps: (https://maps.app.goo.gl/8LWfzKRZ1bcV4f117)

This community service activity was carried out in five stages: need identification, literature analysis and study, design planning, manufacturing and development, and testing and evaluation. The need identification stage is the initial phase where data and information are gathered to identify and address the specific problems faced by the partner (Farmer & Nimegeer, 2014; Mukasa et al., 2023). The literature analysis and study stage involves analyzing similar information from various sources, such as the internet or previous studies, to aid in creating accurate innovations and designs. The design planning stage includes creating the design with the assistance of AutoCAD software (Göttgens & Oertelt-Prigione, 2021; Masterson et al., 2022). The manufacturing and development stage focuses on the constructive and detailed process of product creation (Trischler et al., 2019). The testing and evaluation stage is conducted to assess the functionality and effectiveness of the product in solving the partner's issues (Lehning, 2012). These stages are visualized in detail in Figure 2 and further elaborated with related activities in Table 1 below:

Figure 2. Workflow of Community Service Activities for the Development of the Flattening Tool

The stages outlined are described in the approach and activities carried out by the service team in collaboration with Maeswara Basket, showed in Table 1.

Table 1. Description of Process Stages and Results

Stage	Activity	Action Taken
Problem Identification	Focus Group Discussion (FGD) with Partners	Discussing with partners (craftsmen) to understand the need for a flattening tool
	Observation and Interviews with Workers	Observing workers' activities and interviewing them about challenges in the water hyacinth flattening process.
	Production Process Observation	Observing the techniques and processes of water hyacinth weaving, particularly the flattening process
Literature Analysis and Study	Literature Review on Flattening Tools	Analyzing references of similar technologies for design and functionality comparison
		Comparing manual and automatic tools in other industries
Design Planning	Design of Flattening Tool	Creating designs using CAD software to visualize the components and mechanisms of the tool
	Team Coordination Meeting	Discussing to align perspectives and adjust the design based on partner needs
Manufacturing and Development	Manufacturing Process	Performing material cutting, component assembly, and installation of the pressure control system
		Supervising the process to ensure quality meets specifications
Testing and Evaluation	Flattening Tool Testing (Function and Capability)	Testing the tool's performance in real conditions and analyzing the results
	Feedback Analysis and Adjustments	Collecting feedback on ease of use, speed, and quality of the output

The developed flattening tool was subsequently tested to achieve the following objectives: (1) to assess the performance and functionality of the tool under real working conditions; (2) to measure the effectiveness of the tool in enhancing the efficiency and quality of water hyacinth flattening; and (3) to identify the tool's weaknesses and potential improvements based on user feedback. The testing methods were as follows: (1) the testing was conducted collaboratively between the community service team (3 members) and Maeswara Basket partners (3 members); (2) each team operated the tool in a production simulation to evaluate ease of use, flattening time, and final output; and (3) the test results were recorded using instruments such as checklists and questionnaires with measurable parameters showed in Table 2).

Table 2. Flattening Tool Assessment Instrument and Measurement Scale

Aspect	Indicator	Measurement Item	Measurement Scale
Ease of Use	Ergonomics	How comfortable is the tool for the craftsmen to use?	1 (Very Uncomfortable) - 5 (Very Comfortable)
	Operational Process	Is the tool easy to operate without requiring special training?	1 (Very Difficult) - 5 (Very Easy)
Process Efficiency	Flattening Speed	How quickly can the tool flatten water hyacinth fibers?	1 (Very Slow) - 5 (Very Fast)
	Thickness Consistency	Does the flattening result have consistent thickness?	1 (Not Consistent) - 5 (Very Consistent)
Quality of Results	Flattening Quality	Does the flattening result meet the desired quality standards (e.g., smooth and neat surface)?	1 (Very Poor) - 5 (Very Good)
	Component Wear Rate	How quickly do the tool components wear out after multiple uses?	1 (Wears Out Quickly) - 5 (Very Durable)
Overall Evaluation	Meeting Craftsmen's Needs	Does the tool overall meet the craftsmen's needs and expectations in the water hyacinth flattening process?	1 (Does Not Meet at All) - 5 (Fully Meets)

3. RESULT AND DISCUSSION

Result

The first stage undertaken by the community service team (PkM) was an industry visit to the Maeswara Basket partner. The objective was to identify issues in the production process of water hyacinth fiber products. This activity was conducted through a Focus Group Discussion (FGD), followed by interviews with workers and observation of the production process. Figure 3(A) shows the observation activity with workers involved in producing water hyacinth fiber products. They revealed that a common issue is the difficulty in achieving consistent thickness during the flattening process. Additionally, fibers frequently break or become damaged during flattening, rendering them unsuitable as raw materials. Following the interviews, the team practiced the flattening process using a manual tool (Figure 3(B)). The observations indicated that the process often required multiple passes to achieve fibers that meet the desired specifications. Subsequently, a detailed observation was conducted on the flattening tool, focusing on its working mechanism and performance. The tool operates manually, with adjustments controlled by springs on both sides. To achieve optimal thickness, a step-by-step process is required, influenced by the spring's capability during the pressing process. Additionally, the type of water hyacinth fiber varies depending on the raw material suppliers from different regions, including Tuntang, Ambarawa, Boyolali, Klaten, and surrounding areas. Therefore, the problem identification in this PkM activity focuses on innovating the technology of the water hyacinth fiber flattening tool to facilitate product manufacturing.

Figure 3. Problem Identification Stage, (A) Interview Process with Workers; and (B) Manual Flattening Process

Based on the results of problem identification, the community service team conducted an analysis and literature review on flattening tools as an innovation for manual tools. The review identified three different constructions that share similar working principles and main components, primarily a pressing system utilizing rollers driven by an electric motor. Figure 4(a) represents a tool that has been tested and shown to have better performance in terms of time and flattening quality compared to manual tools. Figure 4(b) shows a commercially available product sold online, while Figure 4(c) depicts a tool used in previous community service activities, although it was not discussed in detail. These findings form the basis for further innovation and development of the flattening tool design. One of the key shortcomings of both Figures 4(a) and 4(c) is the safety of moving components, particularly the rotational speed of the electric motor, which has become a focus for new design improvements. The next community service activity involved the development of a design based on observations of the manual flattening tool and previously developed flattening tool designs. Several innovations were considered in the design, including the press roll, electric motor as a driver, work safety, and speed control. The working principle of the designed technology involves pressing water hyacinth using a roll driven by an electric motor connected to a V-belt pulley (Figure 5). The main components and specifications are detailed in Table 3. The design process utilized AutoCAD Inventor software, which is equipped with various features tailored to the needs of designing pressing tool technology.

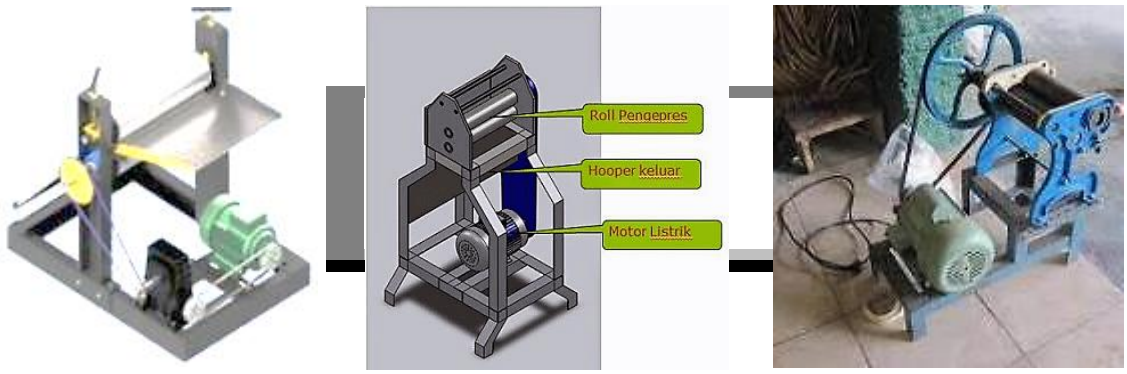

Figure 4. Flattening Tool Based on Literature Study Results
Sources: Syafaat et al. (2022) and (Rapitasari & Amirullah, 2016)

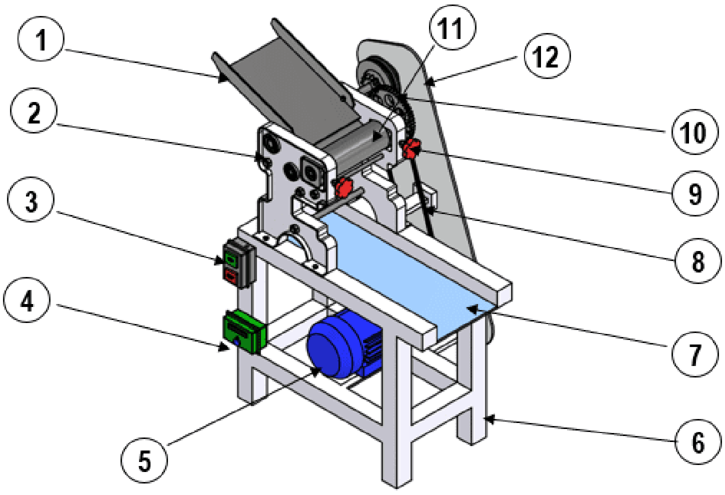

Figure 5. Design of Water Hyacinth Flattening Tool

Table 3. Water Hyacinth Flattening Tool Technology Specifications According to Repair Design

No	Name of Part	Specification	No	Name of Part	Specification
1	Alas Serat	Plat galvanized	7	Glass Meja	Acrylic Glass
2	Cover Alat	Plat baja 3mm	8	Pulley Hub	Mitsubishi Standard V-Belt B Type
3	Push Button	Push button On/Off	9	Key Control	Threaded iron and plastic holder
4	Speed Control	Kontrol tegangan 50-220 Volt	10	Gear Set	MJ180 & DZM180
5	Motor Listrik	Motor ½ Pk, 750 watt, 220V/50Hz	11	Roll pengepres	Stainless steel roll 22 cm
6	Rangka	Hollow 40x40	12	Cover Gear	Acrylic Glass

The design also considers ergonomic values based on anthropometric data of Indonesian workers in a sitting position, including: forearm length, shoulder breadth, elbow span, and functional reach. For a comfortable work desk height, the general range is between 70-75 cm. A height of 74.4 cm falls within the ergonomic range for Indonesian workers in a sitting position. Elbow Span Length: If the elbow span in a sitting position is around 50-60 cm, a tool with a width of 61.6 cm can still be comfortably reached. Forearm Length: The typical forearm length is around 25-30 cm, ensuring that the operator can operate control parts located within this distance.

The next stage is manufacturing and development as an implementation of the design plan. Activities at this stage include: (1) fabrication of the frame as a holder for the flattening tool components, Figure 6(A); (2) cleaning and tidying up the connections, Figure 6(B); and (3) precise and careful assembly of the press components, Figure 6(C). After all work is completed, the frame is cleaned and tidied up before coating. It is then coated with colored paint to prevent corrosion. The finished product is shown in Figure 6(D) and is equipped with a user and maintenance manual in Figure 6(E).

Figure 6. Design Process of Flattening tool, (A) Frame fabrication; (B) Joint grinding; (C) Pressing Roll component connection; (D) Flattening Tool Technology Visualization; (E) User Manual; and (F) Flattening Tool Evaluation and Testing.

The final stage of this community service activity was testing and evaluation, as shown in Figure 6(F). This activity involved the community service team and six Maeswara Basket workers. They observed and tested the tool based on the following criteria: ease of use, process efficiency, quality of results, and overall evaluation. The assessment results are presented in Figure 7 below.

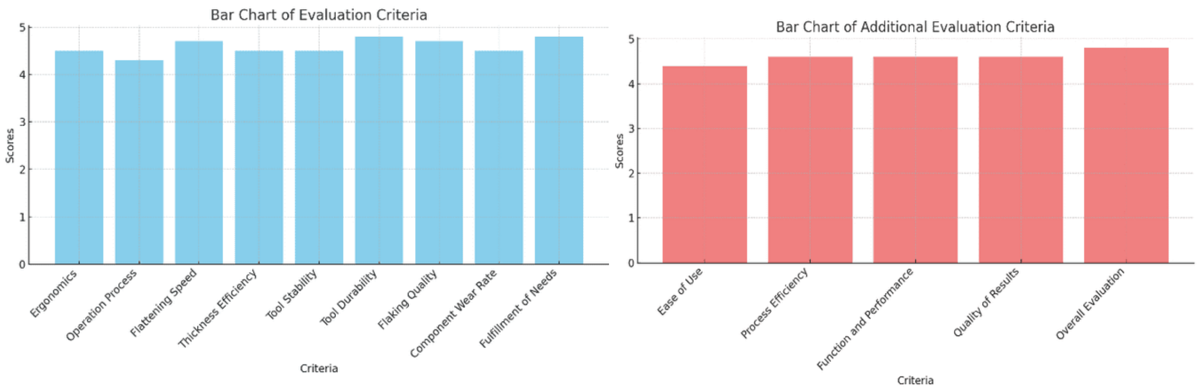

Figure 7. The Assessment Results are Based on Indicators and Aspects of Convenience, Efficiency, Quality and Comprehensive Evaluation.

Figure 7 shows the evaluation results based on important aspects of the flattening tool, including ease of use, process efficiency, function and performance, quality of results, and overall evaluation. The Ease-of-Use aspect was assessed through ergonomics and the operating process, with an average score of 4.3 to 4.5, indicating the comfort and ease of using the tool. The Process Efficiency aspect included speed and thickness efficiency, receiving scores of 4.5 to 4.7, indicating that this tool outperforms manual methods. The Function and Performance of the tool, including stability and durability, received high scores (4.5 to 4.8), demonstrating that the tool is stable and durable under various working conditions. In terms of Quality of Results, both the quality of flattening and the wear rate of tool components were assessed as very satisfactory with scores of 4.5 to 4.7. The overall evaluation indicates that this tool successfully meets user needs, with the highest score of 4.8, making it a highly effective solution in craft production.

Figure 8. Initial Stage of Community-Based Empowerment Implementation: Testing of Flattening Tools

Finally, the implementation of the initial study in community service activities has been completed. Figure 8 shows the collaborative evaluation stage of flattening tool technology. The next activity will involve education and training on the use of flattening tool technology to assist the production process at Maeswara Basket.

Discussion

The development of water hyacinth flattening tools has not been a primary focus in community service activities, despite the potential of such tools to support environmental solutions and sustainable product innovation. This initiative represents an initial study using a scientific approach aimed at producing an optimal product tailored to the needs of the partner, particularly in the eco-friendly processing of water hyacinth fibers (Arivendan et al., 2022; Nguyen & Nguyen, 2022). Observing the manual processes employed by the craftsmen was crucial in designing the tool, with considerations given to user ergonomics, workplace safety, and the selection of key components and alternatives (Pasilo & Teeboonma, 2019). The proposed technology leverages automation mechanisms with an electric motor starter connected via a V-belt, adapting the concept from noodle maker technology to consistently flatten fibers (Nguyen & Nguyen, 2022). However, the challenge of high rotational speed, which can potentially damage fiber ends, necessitates the implementation of machine speed control to adapt the technology to the varying characteristics of water hyacinth fibers (Arivendan et al., 2022; Dewi et al., 2023). The inclusion of speed control and key control features allows for adjustments in speed and fiber thickness according to needs, ensuring that the tool is not only effective in processing but also safe and adaptable to different fiber variations (Hoc Thang & Thuc Boi Huyen, 2020; Risdanareni et al., 2023).

Evaluation results indicate that the developed water hyacinth flattening tool performs exceptionally well and meets user expectations. In terms of ease of use, the tool's ergonomics scored 4.5, while the operational process scored 4.3, demonstrating that the tool is comfortable to use and does not require special training, aligning with ergonomic design principles that prioritize the compatibility of the tool with the user's physical characteristics (Abral et al., 2013; ShakilaBegam et al., 2024). Regarding process efficiency, the tool scored 4.7 for speed and 4.5 for thickness consistency, confirming its ability to work quickly with consistent results, which is crucial in water hyacinth fiber processing to maintain production quality (Janssens et al., 2022). For function and performance, the tool's stability was rated 4.5, and durability reached 4.8, indicating that the tool is stable and highly durable, capable of withstanding various intensive work cycles (Lata & Veenapani, 2011; Soleh et al., 2024). Additionally, the tool's design has considered ergonomic aspects based on anthropometric data of Indonesian workers, such as a work table height of 74.4 cm and tool width of 61.6 cm, which fall within the comfort range for local users, enhancing effectiveness and productivity (Archer et al., 2020). The successful development of this tool not only supports increased productivity but also contributes to the well-being of craftsmen through ergonomic and user-friendly technology, promoting a sustainable approach to utilizing water hyacinth fibers (Carver et al., 2021; Isma'il et al., 2023).

The advantages of this research lie in the development of an innovative flattening tool that improves the efficiency and quality of water hyacinth fiber processing for artisans. The results significantly contribute to the water hyacinth craftsmen by reducing the manual effort required, ensuring consistent product quality, and increasing production speed. The implications of this study are crucial for enhancing the productivity and competitiveness of small-scale artisans, particularly those in the eco-friendly craft industry. However, limitations include the small number of evaluators involved in the assessment process and the use of a semi-automatic machine, which could be further enhanced with full automation. Future research should address these limitations by expanding the number of evaluators and improving the machine's automation capabilities for broader application in the craft industry. This activity represents the first step in producing a tool that supports SMEs in crafting and home decor production based on natural fibers. Although the developed flattening tool has demonstrated good performance, there are still some aspects that need improvement to achieve more accurate flattening results. One challenge to consider in the tool's development is minimizing fiber breakage during the flattening process, which can be caused by the hollow quality of the water hyacinth stems or trapped air within them. Additionally, technical factors such as excessively high flattening speeds also contribute to fiber damage, even though the tool is equipped with a speed control component. Further development should focus on adjusting operational parameters such as speed and pressure to optimize the flattening process while keeping the fibers intact. Beyond technical improvements, manufacturing cost efficiency must also be considered to ensure the tool remains affordable for SMEs, particularly those at the micro and small levels. Future activities will include education and training for craftsmen on the use and maintenance of the flattening tool, ensuring that the technology can be utilized to its fullest potential with minimal risk of fiber damage.

4. CONCLUSION

This community service activity successfully developed a water hyacinth flattener designed to enhance the efficiency and quality of the Maeswara Basket production process. The tool addresses the inefficiencies of manual flattening by integrating ergonomic design, workplace safety, and adjustable speed and control buttons. The results of the community service activities indicated that the flattener meets key performance criteria, including ease of use, process efficiency, and quality consistency, with high user satisfaction. However, further improvements are necessary to minimize fiber damage during the flattening process, particularly due to the hollow nature of the stems and variations in raw material quality. Future efforts should focus on refining operational parameters such as speed and pressure to ensure optimal fiber flattening. Additionally, maintaining cost efficiency is crucial to ensure the tool remains accessible to micro and small businesses. Recommendations are directed at technology developers and SMEs involved in water hyacinth processing to enhance productivity.

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