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Redesign Shovel to Be More Efficient, Convenient and Safe

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ABSTRACT

Shovel, hoe, fork hoe, and hole digger are commonly used in various material handling work manually. So far, only a few studies have been done for a special ergonomically designed tool that will serve the purposes of the shovel, hoe, fork hoe, and hole digger. This research examined the efficiency of specifically combined tools shovel, hoe, fork hoe, and hole digger named as a multifunction shovel for digging, lifting, and moving bulk materials such as soil, coal, gravel and sand. This project was built to minimize physical workload, reduce the time taken to perform this task, and mitigate health and safety risks. There were 20 respondents involved in this study and they were required to test the project before completing observation checklists and questionnaires. The findings revealed that the students had strong approval on each function and feature of the project. There were a few recommendations on how the project could be improved to be safer and more efficient

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1. INTRODUCTION

To advance the construction sector, working conditions need to be improved and this includes increasing the efficiency of working conditions without imposing excessive workloads on workers. The macro ergonomic analysis is an approach of accumulating data on the occupational performance of workers in specific working environments assigned to work in designated positions within the organizations particularly on the tasks and the operation [1]. Shovels have been used in many cultures throughout human history. During the Neolithic Age, people began to farm, build communities, produce goods, and trade. Shovels are tools for digging, lifting, and transferring bulk materials, such as soil, coal, gravel and sand [2]. A shovel bar is usually made of a hard steel sheet or hard plastic and has a folded seam or hem on the back to make a socket to handle it. This fold also usually gives extra rigidity to the blade. A piece is usually mounted at the end of the holder to help grip and control where the shovel is designed to move the ground and heavy material. The shovel blade also consists of several types of blades such as AMES blades (gardening), razorback blades, drain blades, and blades of different sizes and different functions. Now, many types of shovels can be used for a variety of different occupations such as working either digging, lifting, and transferring the same material.

Nowadays, there is a lot of technology has been created by people to facilitate daily work and at the same thing trying to look at the safety of use, effectiveness, and functionality [3]. So in our project here, we are looking for shovels. We are looking for the innovations of shovels nowadays which had a lot of design and functions. The point is we want to have an idea to make a project, to getting a design to build our product for the shovels users out there because we want to help the shovels users facilitate their works in lifting material.

This research examined the efficiency of a specifically multifunction shovel, which had been combined with tools like shovel, hoe, fork hoe, and hole digger. There were several concerns related to this task that needed to be addressed and these included workplace hazards and physically demanding workload. This could have negative effects on students at a vocational institution who had to learn to perform this task and possibly, construction workers and people whose jobs used construction tools. Thus, this multifunction shovel was

designed to help students in performing this task efficiently in a more convenient manner within a safer environment.

1.1 Problem Statement

Based on the research that has been done, some problems need to be changed. This change is much needed to add work in the field of construction as it also provides comfort, space-saving, and convenience for users. The first issue discovered was that there was no way for users to hold several tools at once. It's due to the equipment's unnecessary weight and height. In terms of observation, this issue appears insignificant and does not need attention, but it is one of the causes of the problem. This innovation aims to make it easier for users to carry tools more quickly, safely, and effectively. The next issue is that users believe that consumption costs are also high. It is triggered by the inventor company's procurement of tools separately as well as the value of income taken. Not only that, but it's also likely that the business concerned would charge high supply costs during the equipment purchase. Another problem is that the quality of the material produced has its limitation; for example, the tool point is easily blunt, rusty, and also easily damaged. With the production of "Multi-Function Shovel," there is a reason to help or ease the burden of users.

1.2 Objectives

The purpose of this research was to modify the existing equipment to create a more practical and efficient type of equipment that could facilitate the process of digging, lifting, and transferring bulk materials, such as soil, coal, gravel, and sand. There were three objectives of this project:

1. To minimize the physical workload involved in the process of digging, lifting, and transferring bulk materials, such as soil, coal, gravel, and sand.
2. To merge four tools that are Shovel, Hoe, Fork Hoe, and Hole Digger, into one single type of equipment that could be used to perform the entire task.
3. To mitigate health, time and safety risks at the workspace especially during practical classes.

2. MATERIAL AND METHODS

2.1 The Design of Multifunction Shovel

2.1.1 Process of measuring marks

A project needs to start with planning, evaluating, and measuring. As a result of the discussion with the supervisor, they agreed to choose the Galvanized Iron Pipe in the workshop as the main element of the product. The researchers performed this process by measuring the length of the tool and according to the length of the hoe shaft available in the workshop as a draft or reference. The importance of drafting a work that was first re-made is taken from [4] to complete a work or project after the research and production of a work is done. Wheeled pipe cutters are used during steel pipe cutting works. After the measuring work is done, then the cutting work is started. The first step of cutting is to use a tripod clamp by erecting and adjust a comfortable position to cut this pipe.

Figure 1: Process of measuring mark and cutting pipe

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2.1.2 Binding on each component

Each component of this product will be fitted with the fastener to strengthen the designed components. Researchers have used washer screws and screw liners. The common function of screws on components of this product is to fasten assembled connectors and tool points and is easy to remove when to be stored. Meanwhile, the "washer" screw liner is welded and placed on the connector to reduce the looseness between the blade and the iron pipe holder.

Figure 2: Washer screw liner is welded and placed over the connector

2.1.3 Make an outer thread on the pipe section

According to the design that has been produced and sketched, the iron pipe must be drawn manually using a GI Pipe Threader. The part of the pipe is pulled slowly until it gets enough thread surfaces to rotate the connector socket.

Figure 3: Make an outer thread on the pipe section

After threading the pipe section will be like a coil, like a screw. The thread is used for screws, bolts, triangular nuts because it serves as a fastener.

Figure 4: Examples of threads that have been pulled

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2.1.4 Connecting parts

Students from the Welding program demonstrate to the researcher on welding process by using the method of Inert Gas Metal Arc Type Welding. The welding process using a blowtorch (gun) is placed and the switch is turned on for welding. This process must be done carefully so that there are no errors during welding.

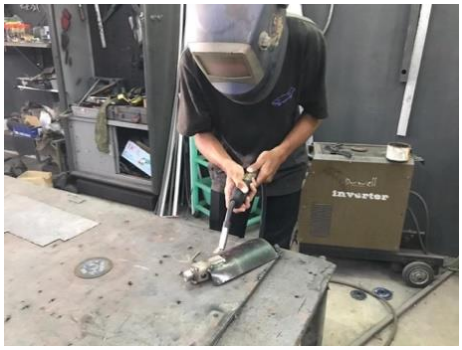

Figure 5 : Process of welding the entire component

2.1.5 Painting process

All products from beginning to end process must have good finishing so that the end product looks cleaner, tidy and beautiful. In addition, this finishing work also includes an important aspect that is the final testing of the project to check if there is any damage or anything that could affect the results of the project. Therefore, to make the result more neat and beautiful, the researchers use rubbing sandpaper to make the iron surface smoother. Next, the researcher paints the product using a vehicle-type paint sprayer so that the finishing quality lasts longer. A portable paint sprayer was used because this painting method is easier to use.

Figure 6: Painting works on all components

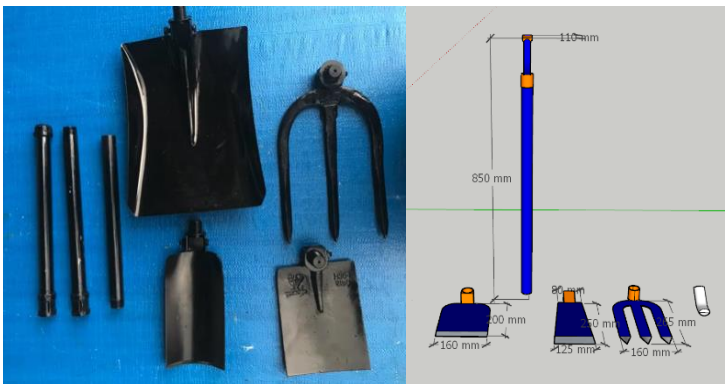

Figure 7: Multifunction Shovel

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2.2 Research Method

20 respondents took part in this study. These 20 individuals were students of the Construction Technology Program at a local vocational institution. There were two main instruments and these were the testing checklist and questionnaire. The questionnaire was used to identify what the respondents thought of the project while the testing checklist was used to determine whether the project was operational. Three students were randomly selected to test this project while being observed by the researcher as well as other respondents. The three randomly selected students were required to use the multifunction shovel to determine whether the four main features of the project; blades for shovel, hoe, fork hoe, and hole digger were functional and operational. They were then expected to fill in the testing checklist. All 20 respondents were given the questionnaires which they had to complete in 10 minutes.

3. RESULTS AND DISCUSSION

The results of the testing checklist were presented in Table 1. There were two indicators which were P for pass and F for fail. The component was given a pass (P) if it worked properly when the project was being used while the fail (F) indicated that the component did not work as well as expected.

Table 1: The Finding of the Testing Checklist on the Tool

No	Component	Trial			Remarks
		1	2	3	
1	Shovel blade	P	P	P	No complication occurred on the shovel blade all three trials
2	Hoe blade	F	P	P	the hoe blade is loose because it is too heavy. Therefore the hoe blade is re-welded
3	Fork hoe blade	P	P	P	No complication occurred on the fork hoe blade all three trials
4	Hole digger blade	F	P	P	the hole digger blades are loose because it was pressed too hard. Therefore the hole digger blades are re-welded

Table 2 illustrated the students' rating on each of the six items in the questionnaire that attempted to elicit their opinions on the features, functions, and design of the project. There were five rating scales and these numbers represented students' level of approval on the statements regarding the project. 1 was for "strongly disagree", 2 meant "disagree", 3 indicated "neutral" position, 4 was meant to express "agree" while 5 signified the highest level of approval which was "strongly agree" [5]

Table 2: Analysis of the Students Rating on Features & Functions of the Project

No	Item	1	2	3	4	5
1	It had an appealing design			3	6	11
2	This reduces the amount of time required to change another tool because the work is completed with only one tool				3	17
3	It mitigated workplace health and safety risks			4	6	10
4	It minimized the physical workload that might be exhausting and time-consuming				4	16
5	It was fully operational				3	17
6	It was easy to handle				2	18

It could be deduced from the findings of the questionnaire that the students had positive opinions on the functions and features of the project. The majority of them believe that it had a great aesthetic feature and it improved the efficiency of the process in a way that it could reduce the amount of time taken to perform the task, minimized the risk of undesirable incidents from occurring and it elevated the students' experience by decreasing the physical demand of the task. They also thought that it was easy to handle, practical, and useful. [6] stipulated the safety hazards of the working conditions that individuals who work at a construction site are exposed to and highlighted a few that could be considered as highly harmful. Some of the hazards were the risk of overstrained organs and physical impacts. These findings necessitated prompt solutions to protect

workers from any undesirable incidents at their workplaces. Urged companies to provide proper equipment that could help workers lift and carry heavy objects more safely with ergonomic features [7]. The findings in this research implied that the respondents' approval of the characteristics and advantages of this multifunction shovel could assist automotive shops to offer better safety to their workers while reducing their physical workload.

The findings from the testing observation revealed that the project was functional and operational. Few minor flaws could be seen during the first trial that could be attributed to basic mistakes that might have occurred during the building of this prototype. However, these minor flaws had been repaired and subsequent trials showed that every component functioned accordingly. The testing checklist showed that the project could still be improved as the hoe and hole digger blade is loose because it is too heavy and pressed too hard. Therefore the hoe blade is re-welded. Presented their objectives in modifying the shovel to increase its capacity, enhance its stability, and improve its efficiency [8]. The findings of this research indicated that multifunction shovel mitigate health, time and safety risks at the workspace especially during practical classes.

4. CONCLUSION

There were three objectives of this study. The first one was to minimize the physical workload involved in the process of digging, lifting, and transferring bulk materials, such as soil, coal, gravel, and sand. The second objective was to merge four tools that are shovel, hoe, fork hoe, and hole digger, into one single type of equipment that could be used to perform the entire task. The third objective was to mitigate health, time and safety risks at the workspace especially during practical classes. The findings showed that all three objectives were achieved and this suggested that this project could be potentially used for building work either at learning institutions, construction industries, or commercial centres.

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