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Design and Development of Portable Sports Post

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Abstract

Sports are essential for a healthy life of university students. However, sports facilities such as playing courts for badminton, volleyball, and netball at the residential college are not enough for the number of active university students. Students have to walk for 15 to 20 minutes to get to the sports facilities area at the main campus. In this study, numerous Portable Sports Post ideas are compared using a variety of elements and criteria. This project aims to produce a convertible post for three types of sports: badminton, volleyball, and netball. This project also targets education centres with limited areas to provide portable sports equipment for their students to play the sport. This convertible design can save up more space in storage than other sports equipment. The development runs through concept design, configuration design and parametric design. The prototype is developed, tested, and analyzed based on performance, structure construction, and development cost.

1. Introduction

1.1 Project Background

Sports are essential for a person's health. For students, it can also be a way to release stress after a day of class. However, sports facilities such as playing courts for basketball, badminton, netball, and volleyball at the residential college are not enough for the number of active university students. Students have to walk for 15 to 20 minutes to get to the sports facilities area at the main campus. From that, students are unmotivated and less interested in playing sports and prefer to rest in their rooms as soon as they finish their classes [1][2].

Therefore, the root cause of why students lose interest in playing sports must be found to gain students' interest. Firstly, due to the shortage of space at student residential colleges, many sports facilities are available on the main campus. Students without transportation had to walk to the main campus for about 15 to 25 minutes or had to take a bus that was provided limitedly. Secondly, the sports facilities available at the main campus, such as badminton and netball courts, are still insufficient for active students who want to play.

This project aims to produce a Portable Sports Post through low-cost design. This project is a portable post with various types of sports it can transform, such as badminton, volleyball, and netball posts. This project can overcome many university students' issues when playing the desired sport. This project also targets education centres such as universities and schools with limited areas.

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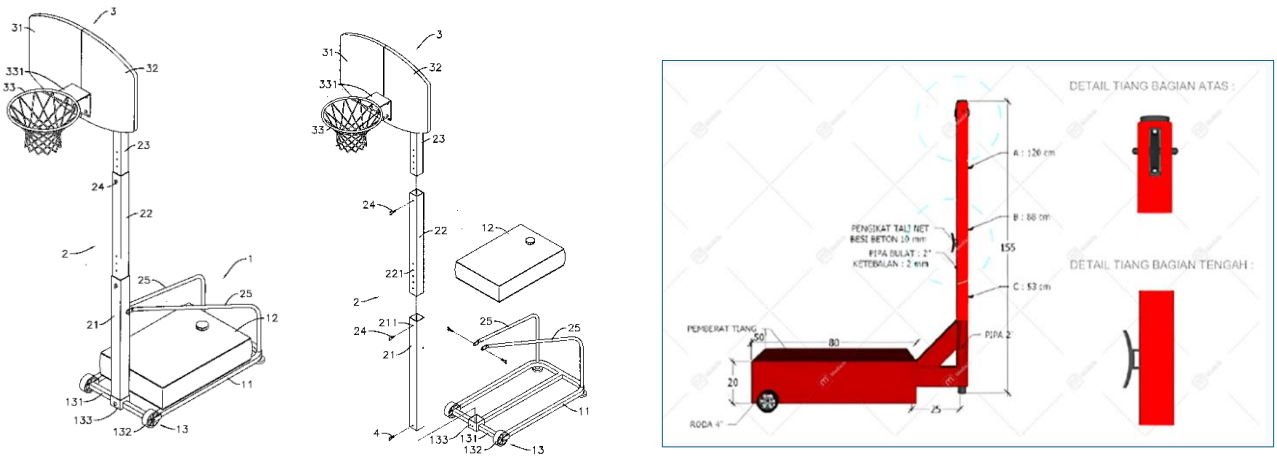
1.2 Literature Review

Numerous efforts have been made to create solutions for a portable and convertible sports post. Among the products sold in the market are Volleyball Tennis Posts with Cast Iron bases, Perfly Poteaux-filet Badminton-Tennis Portable Post and Adjustable Netball Post with Bases as depicted in Fig. 1 below [3][4][5]. Although this product is already portable, the consumer must purchase each item separately because the sports type is for different purposes, which is costly. Hence, if all of these sports posts could be combined, the product cost could be reduced.

Fig. 1 *Sport Post examples in the market*

In addition, there is a patent for a portable and foldable basketball stand, as shown below in Fig. 2(a). It consists of a seat with a supporting frame, a transfer unit attached to one end of the frame, and a weight attached to the frame. The weight is a foldable water box with a supporting unit with a few rod bodies. One of the ends of the supporting unit is connected to the transfer unit of the seat, and a backboard is installed at another end of the supporting unit. The backboard has at least two plate bodies and a hoop attached to the other end of the supporting unit. The seat, supporting unit, and backboard installation allow the foldable basketball stand to be assembled quickly and detached easily. Therefore, the foldable basketball stand's volume is small, contributing to an easy, quick and convenient storage process [6].

In addition, there is an almost similar project by Politeknik Jambi to develop portable badminton posts for personal training and commercial tournaments, as shown below in Fig. 2(b). This portable badminton post comes with a load and tyres on the side. The existence of load prevents the post from falling and stabilizes it, while the existence of tyres makes it easier to move it to a particular place. The limitation of this innovation is that it must be on a flat surface [7].



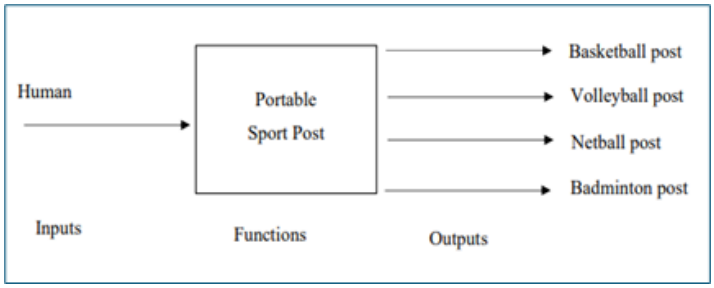
(a) **(b)**

Fig. 2 *Portable Sports Post (a) Patented product; (b) Product developed by Politeknik Jambi*

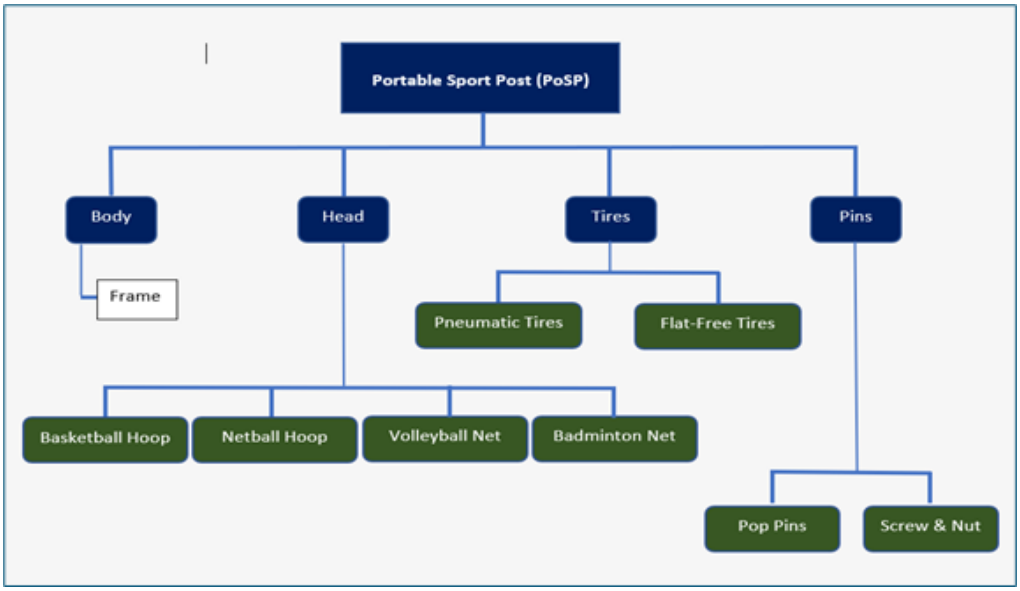
2. Methodology

2.1 Project Methodology

Problem Formulation is the first step in this project's implementation. Knowing the user's problem and root cause can help solve it effectively. Secondly, the product design specifications are developed to summarise the design requirements and plan suitable solutions through the design and development process. This project continued with the Concept Design stage, in which the Black Box Model and Product Component Decomposition are identified, as shown in Fig. 3(a) and Fig. 3(b) below.



(a)



(b)

Fig. 3 *Portable Sports Post (a) Product Component Decomposition; (b) Black Box Model*

According to the Product Component Decomposition structure, the tyres and pins sub-assembly have several component alternatives. These alternatives must be finalized, and only one alternative for each structure must be selected using the Weighted Rating Method. Assessment using the weighted rating method uses weighting per cent for each criterion desired, and then rates will be given to all three alternatives for one element. The value of the rate is then multiplied by the importance of the weight. Finally, each alternative's total amount for the 'rate × weight' will be compared.

The alternative with the highest amount is the best alternative to Portable Sports Post and will be chosen. The best options will be brought to the stage of design configuration, which is product architecture, parts configuration, and the initial three-dimensional product development. SolidWorks software is used to visualize the 3D drawing. At the final stage, the prototype is manufactured, tested, and analyzed to ensure the final product developed is functional as expected, safe, and easy to use for the user.

2.2 Material Selection

Mild steel, also known as plain carbon steel, has been selected as the primary material as it can withstand a higher load than plastic or other materials. It also weighs more and can provide better stability for the post. Six of the seven parts will use plain carbon steel, as shown in Fig. 4 below. The remaining part, a hex screw-pin, will use steel material.

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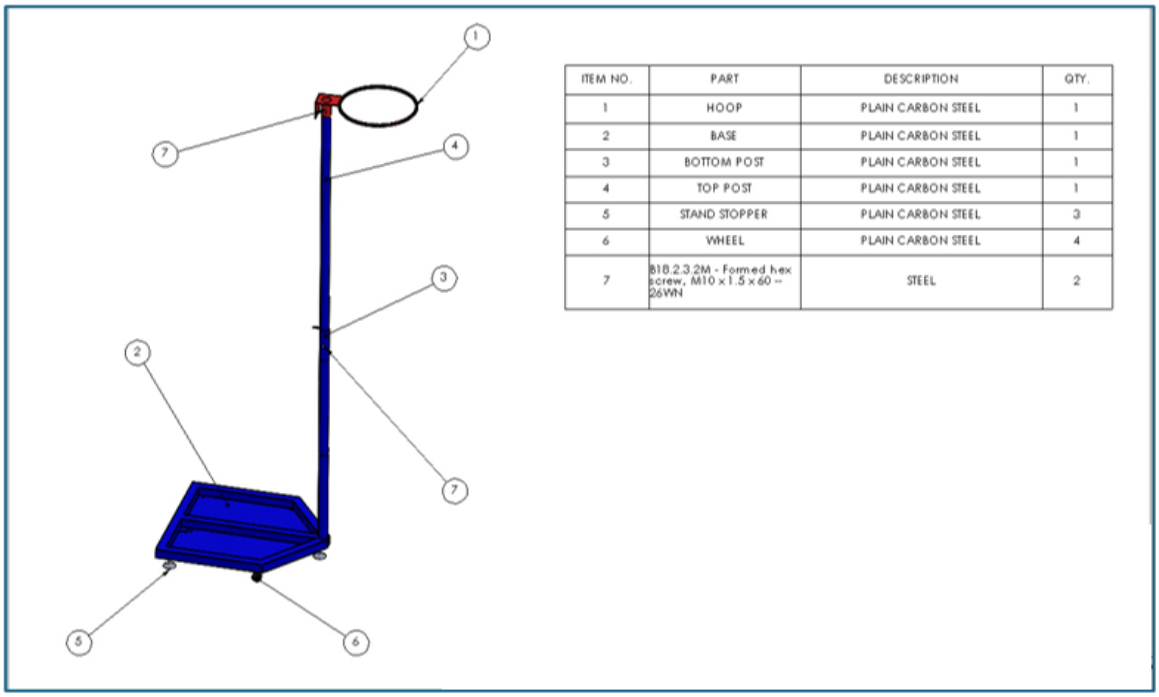
This hex screw-pin is a hole stopper between the top and bottom posts to adjust the desired height. Using steel materials can improve the toughness and lessen the bending when a load is present on the hoop from dunking. Regarding environmental sustainability, steel usage is better than plastic because steel is more easily disposed of when the components are not used anymore. It can be reusable, but plastics are not.



ITEM NO.	PART	DESCRIPTION	QTY.
1	HOOP	PLAIN CARBON STEEL	1
2	BASE	PLAIN CARBON STEEL	1
3	BOTTOM POST	PLAIN CARBON STEEL	1
4	TOP POST	PLAIN CARBON STEEL	1
5	STAND STOPPER	PLAIN CARBON STEEL	3
6	WHEEL	PLAIN CARBON STEEL	4
7	B18.2.3.2M - Formed hex screw, M10 x 1.5 x 60 -- 26WN	STEEL	2

Fig. 4 *Drawing of Portable Sports Post with BOM (Bill of Materials)*

2.3 Engineering Analysis

Engineering analysis uses scientific principles, mathematical models, and computational tools to evaluate and understand engineering systems and components' behaviour, performance, and characteristics. It involves breaking down complex systems into simpler parts to study their interactions and predict their responses under various conditions. In this project, several mathematical equations were used to analyze the criteria below:-

i. Structure performance-stability analysis

$$F = ma \tag{1}$$

Where:-
F = Force (N)
m = mass (kg)
a = acceleration (m/s²)

$$M = Fd \tag{2}$$

Where:-
M = Moment (N.m)
F = Force (N)
d = distance (m)

ii. Structure strength-bending analysis

$$\sigma_b = \frac{My}{I} \tag{3}$$

Where:-
σ_b= bending stress
M= the internal bending moment of the section's neutral axis
y = the perpendicular distance from the neutral axis to a point on the section
I = the moment of inertia of the section area about the neutral axis

3. Results and Discussion

3.1 Product Specification

The Portable Sports Post has undergone several meticulous manufacturing processes to produce a high-quality product. These duties include measuring, cutting, machining, welding and spraying process. These processes start with precise measuring, where accurate dimensions of raw materials and components are ensured using precision tools like measuring tape and callipers. The raw materials are cut to the specified sizes using various cutting tools and machines such as band, rotary, and jig saws.

The next step is machining, which involves shaping the raw material into the final form through drilling and grinding to create necessary features for assembly and functionality. Welding then joins the metal components, using techniques like MIG, TIG, or arc welding to develop strong and durable joints that ensure the structural integrity of the sports post.

Finally, the paint spraying applies a protective and aesthetic coating to enhance appearance and protect the surface from corrosion, wear, and environmental factors. These manufacturing steps ensure that the Portable Sports Post meets the required performance, durability, and safety standards.

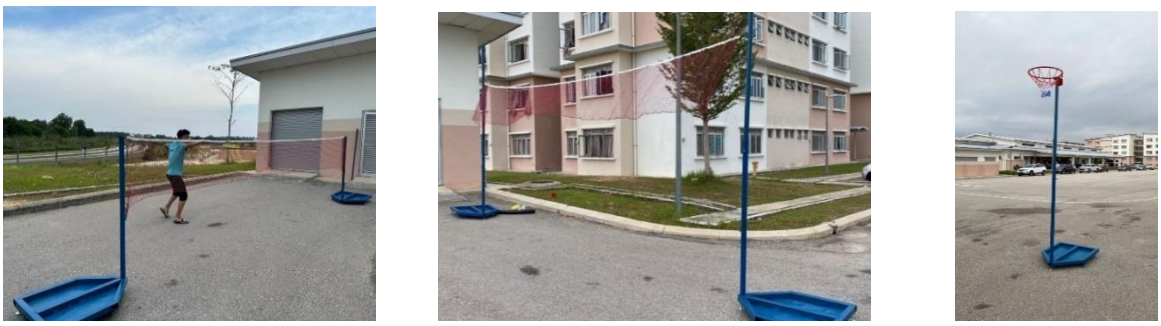
Table 1 *Portable Sports Post Specification*

No.	Details	Specification
1	Base size	90cm x 80cm x 5cm
2	Max counterweight load	40kg
3	Tires (W x H)	26mm x 75mm and can support 70kg of load each tire
4	Max Adjustable Levelling Stand	0mm until 100mm
5	Adjustable height	1.55m, 2.43m and 3.05m
6	Transportation (movement)	Pushing or pull-through tyres
7	Total Cost	RM413.40
8	Number of posts in one set	Two posts (left and right)

According to Table 1 above, the Portable Sports Post is designed with several key specifications to ensure its functionality and user-friendliness. It features a robust base size of 90 cm in length, 80 cm in width, and 5 cm in height, providing stability during use. The post can accommodate a maximum counterweight load of 40 kg, ensuring it remains secure even during vigorous sports activities. Equipped with tyres measuring 26 mm in width and 75 mm in height, each capable of supporting up to 70 kg, the post is designed for easy mobility, allowing it to be effortlessly pushed or pulled from one location to another.

The maximum adjustable levelling stand ranges from 0 mm to 100 mm, which is particularly beneficial for setting up on uneven surfaces, ensuring the post remains perfectly vertical. Additionally, users can adjust the height of the sports post to three levels—1.55 meters, 2.43 meters, and 3.05 meters—making it versatile for various sports requiring different heights for nets or goals. These three levels are based on the standard height of the post for each sport subsequently.

Lastly, the total cost of the Portable Sports Post is RM413.40, representing a reasonable investment for a multifunctional sports solution that combines stability, adaptability, and ease of transport. As shown by Fig. 5(a), Fig. 5(b), and Fig. 5(c), below is the final prototype of a Portable Sports Post, which can be convertible to 3 types of sports posts, which are badminton, volleyball, and netball posts.



(a) **(b)** **(c)**

Fig. 5 *Portable Sports Post (a) Badminton posts; (b) Volleyball posts; (c) Netball post*

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3.2 Operating Procedure

The operating procedure for Portable Sports Post (Badminton/Volleyball) could be explained below:

1. Start with the first post. Adjust the bottom stopper to a suitable height to make it more stable.
2. Insert the frame into the base slot and ensure the user's feet stay away from the slot area.
3. Insert the extended frame through the frame before.
4. Adjust the frame height (1.55 meters for badminton/ 2.43 meters for volleyball) using the hex screw-pin, and be careful when extending the frame to avoid finger stuck.
5. Repeat steps 1-4 for another second post.
6. Position both posts at a suitable distance at the left and right middle-end according to the court width.
7. Install the net on the top of both posts.
8. Tie the net rope at the side of the post and make sure it is tight.
9. The Portable Sports Post is ready to use.

The operating procedure for Portable Sports Post (Netball) could be explained below:

1. Start with the first post. Adjust the bottom stopper to a suitable height to make it more stable.
2. Insert the frame into the base slot and ensure the user's feet stay away from the slot area.
3. Insert the extended frame through the frame before.
4. Install the hoop and net at the top of the frame.
5. Adjust the frame height (3.05 meters) using the hex screw-pin, and be careful when extending the frame to avoid finger stuck.
6. Repeat steps 1 to 5 for another second post.
7. Position both posts at a suitable distance according to the netball court size.
8. The Portable Sports Post for netball is ready to use.

3.3 Verification and Validation

Verification involves evaluating whether a product, service, or system complies with a regulation, requirement, specification, or imposed condition and is often conducted as an internal process. On the other hand, validation assures that a product, service, or system meets the needs of the customer and other identified stakeholders, typically involving acceptance and suitability assessments with external customers.

Prototype Testing verifies that the machine components and systems meet the design requirements and are safe and reliable for operation. Three tests were performed: the Structure Performance Test, the Structure Stability Test and the Component Functionality Test. Fig. 6(a) below shows that the Structure Performance Test was done by putting several bricks (mass = 2kg) as a loading force in the Y-axis on the Portable Sports Post. The Structure Stability Test is done by throwing a basketball through the hoops to see its stability as a netball post, as depicted in Fig. 6(b). As a result, the Portable Sports Post can withstand the applied forces and maintain stability to give a better playing experience when a maximum height of 3.05 m.

During the Component Functionality Test, all the components are tested to ensure they are functional. Examples of the functionality test are the testing of the functionality of the wheel with brakes, the stopper that can be adjustable, the connection between two posts and the slot for the pop pin on the post. Fig. 6(c) below shows the functional test for an adjustable stopper.

At the end of the project, the final prototype was presented to the Residential College Principal, UTHM Pagoh Campus, as shown in Fig. 6(d). Through this validation process, this project has positive feedback due to this product's prospect of being portable, convertible, easy to install, and easy to store. Some recommendations for future development were also received.

(a) **(b)** **(c)** **(d)**

Fig. 6 *Verification and Validation Activities (a) Structure Performance Test; (b) Structure Stability Test; (c) Component Functionality Test; (d) Presentation to the Residential College Principal, Ts.Hj. Suhairi*

4. Conclusion and Recommendations

In conclusion, the objectives of this project have been achieved. The design and development of the Portable Sports Post has demonstrated its potential as a valuable facility for sports activity usage within the university. This product is considered 3 in 1 post, which can be converted into badminton, volleyball and netball posts. Also, the solutions of this product, being portable, convertible, easy to install, and easy to store, provide the best solution for university management to provide temporary sports courts as long as there are empty and suitable spaces. For future recommendations, this project can expand usage to a broader range of sports, such as basketball and futsal, because these sports require a more stable and robust structure.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: ***Problem, conception and design study:*** *Mohd Najib Janon, Mohd Afiq Iskandar Mohd Affaidi, Mohd Adib Mohd Yani, Muhamad Haris Danial Mohamad Hikmal;* ***Prototype Manufacturing and Data collection:*** *Mohd Afiq Iskandar Mohd Affaidi, Mohd Adib Mohd Yani, Muhamad Haris Danial Mohamad Hikmal;* ***Analysis and interpretation of results:*** *Mohd Afiq Iskandar Mohd Affaidi, Mohd Adib Mohd Yani, Muhamad Haris Danial Mohamad Hikmal;* ***Draft manuscript preparation:*** *Mohd Najib Janon, Mohd Shahir Yahya, Hafsa Mohammad Noor. All authors reviewed the results and approved the final version of the manuscript.*

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