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Portable Modular Pool Prototyping for Military Training and Testing in Remote Environment

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Abstract: Military training and periodical assessment are essential in preparing a well-built soldier physically and mentally for the Malaysian Army Forces. One of them is the water survival training test. The test consists of a series of aquatic tasks conducted in a remote area. As a matter of fact, it requires a water-pool facility which is durable and portable. Therefore, this research aims to design and prototype a modular portable swimming pool for floating exercises and assessment for military personnel. The study is conducted in partnership with the Royal Army Engineers Regiment, with the objectives being to design, simulate, prototype, and build the modular portable swimming pool for military uses. The study output was tested, evaluated, and appraised on the swimming pool workability on site. The methodology is divided into 4 phases; (i) Content Studies and Design Profiling, (ii) Digital Prototyping, Evaluation and Testing, (iii) Physical Prototyping - Materials and Method; and (iv) Application and Measurement. The study seeks to maximise the training of military personnel and reduce the transportation time and resource costs of building a permanent pool by placing it with a modular portable swimming pool, which is more cost-efficient and user-friendly. The findings of Phase 1 prototyping required improvement on design structure where it indicated disadvantages in sustaining water volume ability at targeted level due to structural integrity. Upon improvement of Phase 2 prototyping using metal with bracing frame the pool are able to sustain the desired water volume at 5200 l^3. Moreover, this study, also responds to the approaches of the Sustainable Development Goals (SDGs) 9, 16 and 17 towards harmonizing and interconnecting the three core elements of sustainability, economic growth, social inclusion, and environmental protection for human well-being.

Keywords: Mobile modular pool, prototyping, military training, remote environment

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1. Introduction

Military training and fitness tests are continuing procedures and routines throughout all three branches of Malaysian Army Forces. Apart from combatant exercises and other military taskings, the fitness test is one of the most critical measures in assessing physical abilities and readiness of the soldiers for any duty calls while serving. Currently, training is conducted at remote bases and fields using portable water-pool for aquatic-based physical training and testing. However, this existing facility needs a better system to optimise its use in terms of lifespan, cost, and ability to mobilise without damaging it. The main issue in handling this physical training and test is the limitation of military bases with water-pool facilities in the country in addition to being only available at the main Military Bases. The problems are associated with the high cost of building and maintaining the water pool. Furthermore, the location of the military unit or training ground is remote and far away from the main bases with such facilities. Thus, the requirement of regular aquatic-based fitness ability tests makes it not viable to build a permanent pool which incur such a huge cost.

The importance of defence substantially coincides with national security and defence [1]. Malaysia is located at a strategic maritime crossroad between the east and west of South East Asia; thus, it must be prepared for security and defence. With The Straits of Malacca as a chokepoint in maritime trade, the preparedness of the military personnel is of the utmost importance in guarding the country's security. Military training must prepare individuals to enter harm's way and perform physically and mentally demanding tasks at the highest possible proficiency levels. This requirement may be the defining characteristic of military training as it is a matter of life and death situation [2]. Other than various physical training and periodic fitness tests, one of them is water-based swimming and floating training. These exercises and tests require a water body facility such as a swimming pool. The problem with the swimming pool is that it is very costly to build and maintain [3]. The pool also requires specialised systems for a periodical chemical treatment to maintain hygiene and safety [4].

Nearly all military organisations throughout history have formed and maintained programmes that, in other contexts, would very much resemble basic education, in addition to the requirements for combat skill training. The Romans made sure that all troops could read and write Latin in addition to teaching them how to swim. [5]. Looking at the current military training module, the ability to swim to a certain extent for navy or marine personnel is required to pass floating test as part of requirement. According to Fletcher and Chatelier (2022), it is challenging to have a cogent discussion about military training given its scope and diversity. Thus, General Paul Gorman proposed a strong segmentation of military training, which continues to be widely used [6]. According to Table 1, Gorman's matrix separates military training into four cells, each of which is keyed to the type of trainees (individuals or "collectives") and the location of the training (in residence or in operational units). This structure appears to change almost inexorably within US Department of Defence organisations as roles and responsibilities for overall administration and conduct of training change. For this study, the foci are on Operational Units of Royal Army Engineers Regiment, Bridge Division trained individuals, and the collective skills to swim and to float as compulsory requirements to be considered as 'forward employment' (FE) in continuing delivering the assigned task.

Table 1 - Gorman's Matrix: Components of Military Training

	Where Training Takes Place	
Who is Trained	**Residence**	**Operational Units**
Individuals	Training conducted by training organizations to develop individual skills and knowledge in formally convened centralized settings	Training conducted by operational units to develop individual skills and knowledge in distributed settings
Collectives	Training to achieve crew, team, and unit performance standards in formally convened, centralized settings	Training to achieve crew, team, and unit performance standards in operational units and other distributed settings

The military field of work requires honour, loyalty, courage, and pride [7]. Working in such conditions demands well-developed physical and psychological qualities. During fleet specialists' training, great attention to physical culture lessons is paid to general physical training and special professionally applied physical training [8]. Military training mainly consists of prolonged physical activities and training performed at low intensities, which may interfere with optimal muscle strength as well as the development of maximal strength, power, and aerobic capacity. Training programs should be well periodised so that the total training load increases progressively and includes sufficient recovery periods [9]. Therefore, this study was conducted by a collaboration between Universiti Teknologi MARA (UiTM) and the Royal Army Engineers Regiment, Malaysian Armed Forces at Kem Syed Sirajjudin, Gemas, Negeri Sembilan, Malaysia. This collaboration aimed to provide a solution to the constraints of the Royal Army Engineers Regiment to provide an efficient system of modular portable swimming pool equipped with a pool structural and filtration system.

This aspiration was also in line with the Malaysia Chief of Army's emphasis through the 2nd Pillar Army values, which is "practising creativity and innovation in order to optimize limited resources in line with the task". Military training and periodical assessment are important in preparing a well-built soldier physically and mentally. Hence, supporting facilities and equipment is necessary in implementing the aforementioned exercises and tests. The gap in this study would be the lack of water-pool facilities at medium or small military units in the country. Thus, this research aimed to design and prototype a modular mobile pool for floating exercise and test for military personnel. The objectives of the study were to design, simulate, prototype and built the modular mobile pool for military uses. The output of the study would be tested, evaluated, and appraised on the workability on-site. The methodology of the study was divided into 4 phases; 1. Content Studies & Design Profiling, 2. Digital Prototyping, Evaluation & Testing, 3. Physical Prototyping - Materials & Method, and 4. Application & Measurement. The study was significant in maximising the training of military personnel, reducing transportation time and resources to permanent pool at main military bases and budget expenditure saving to build permanent pool. Besides, the study aimed to achieve SDG 17 Partnership for the Goal by bridging the gap between civilian academia researchers with Malaysia Army Forces. In addition to combatant exercises and others military tasking, fitness test is one of the most important measures in assessing level of physical abilities and readiness towards any duty calls while serving. Since trainings are carried out at bases and remote field, the requirement for water-pool in conducting aquatic-based physical training and testing became high in demand. The main issue in handling this physical training and test would be the limitation of military bases that have water-pool facilities in the country besides main Military Bases. The conundrums were further supported with the high building costs and water pool maintenance, the remote location of the military unit or training from such facilities, and the periodical testing of the aquatic-based fitness ability test in building a permanent pool. Therefore, this paper discusses the improvement of the developed prototyping modular portable swimming pool which has undergone two phases of prototype processes.

2. Materials and Methods

There were three phases conducted in this study; (i) Phase 1: content study and design profiling, (ii) Phase 2: digital prototyping, evaluation, and testing, and (iii) Phase 3: modular mobile group prototypes. This paper presented Phase 2 progress which focused on the design prototyping of the modular portable swimming pool. In Phase 1, the design ideation process of the pool had been developed by considering significant established factors; the ability of the pool to perform the specified purposes while maintaining the structural integrity, modularity, and construction method. Then, to achieve the Phase 2 objective, prototyping was developed and tested twice as in Phase 1 Prototyping (Figure 1 and Table 2) and Phase 2 Prototyping process (Figure 1 and Table 2). The following section explains the evaluation result of the prototype design for future improvement.

a b

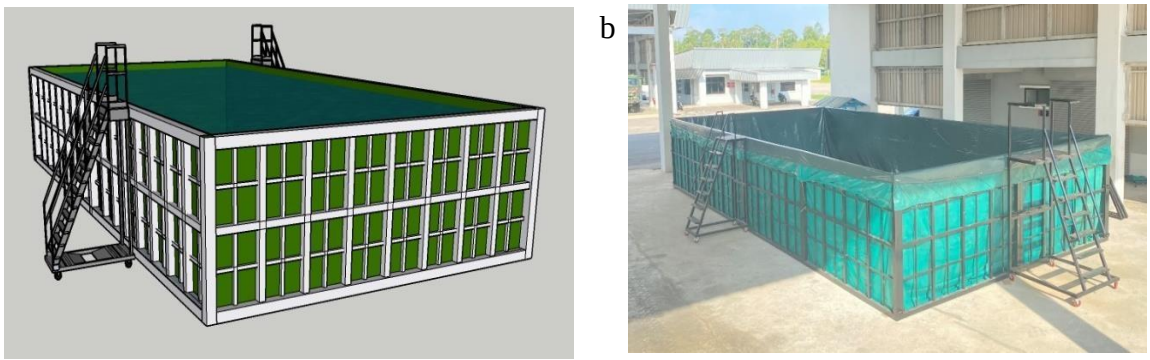

Fig. 1 - Phase 1 Prototyping (a) 3D View; (b) Physical Prototype

Table 2 - Phase 1 Prototyping

Item	Description	Improvement
Design	Pool was constructed using metal without bracing frame	Needed
Size	Pool size 40'x20'x7'	None
Advantages	Location mobility Water depth could be administered. Did not require monthly maintenance. Utilized durable and highly strength canvas fabric and had high puncture sustainability	None

Disadvantages	Did Not Able to Sustain Water Capacity Exceeded 3 Ft. Height (2400 l^3) of The Pool Wall and Began to Tear Up	Needed

a b

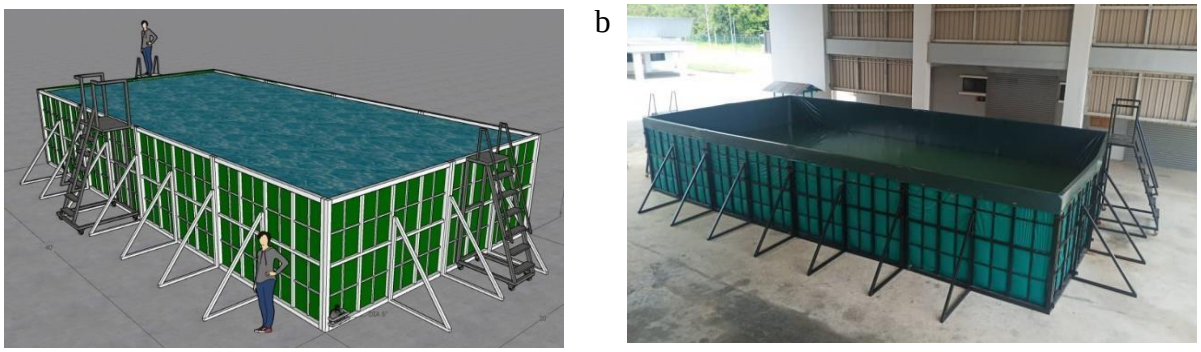

Fig. 2 - Phase 2 Prototyping (a) 3D View; (b) Physical Prototype

Table 3 - Phase 2 Prototyping

Item	Description	Improvement
Design	Pool was constructed	None
Size	Pool size 40'x20'x7'	None
Advantages	Location mobility Water depth could be administered. Did not require monthly maintenance. Utilized durable and highly strength canvas fabric and had high sustainability to puncture. Water capacity levelled up to 6.5'	None
Disadvantages	Lower pool wall was not parallel to upper wall when the water capacity was up to 6' 5" level (5200 l^3)	Needed

3. Timeline of Project Processes

3.1 Prototype Improvement

The findings from Phase 1 Prototyping suggested improvements for item number 1 (Design) and number 4 (Disadvantages), item no. 1; 'Design' and item no. 4; 'Disadvantages'. Regarding design factors, the Phase 1 prototype required improvement on the structural integrity where all side panels of the pool were constructed without the bracing space frame. The lack of structural integrity has compromised the sheer strength of the side panels once the pool capacity reached three feet height (2400 cubic litres) from the plane of floor level. The lateral side horizontal load of the water pushed the middle part of the unbraced structure and began to tear up the canvas fabric skin due to fluidity pressures. Thus, Table 4 suggests improvements for items 1 and 2 of Phase 1 Prototyping.

Table 4 - Phase 1 and Phase 2 Comparison

Description	Required Improvement				
Phase 1 Prototyping	1.Design √	2.Size X	3.Adv X	4.Disadv √	Structural Design & Volume Capacity
Phase 2 Prototyping	Ẋ	X	X	√	Structural Design & Volume Capacity

Meanwhile, the results from Phase 2 Prototyping indicated only one area of improvement required for item no. 4, which was the Disadvantages factor. Attention should be given to the volume of water. Even though it reached 6' 5" height (5200 cubic litres) of water level and served the purpose of a physical fitness test floating routine, the upper part of the poolside panel expanded slightly compared to the pool base dimension. The outcome of the evaluation suggested that improvement was needed to strengthen the upper panel by adding a bracing frame interval at the calculated point. Comparatively, only one area was required to be improved from the Phase 1 Prototype to the Phase 2 Prototype.

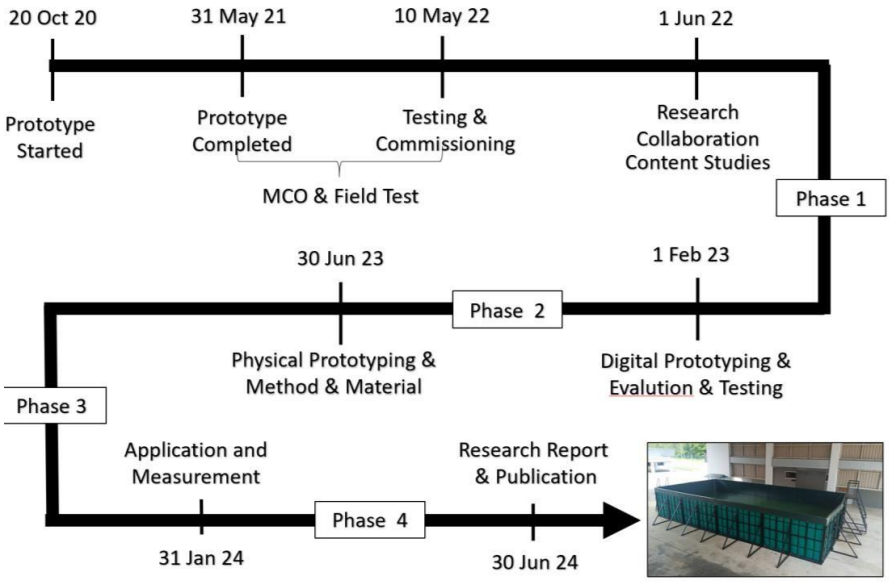

Fig. 3 - Project Research and Prototyping Research Flow

A further process of Phase 2 was conducted to improve the tested prototype through digital prototyping, followed by the evaluation and simulation of pool structural strength and sturdiness in achieving a maximum 7' height water level (5600 l3). A maximum water level was required for the next prototype to create a water overflow channel for the filtration system. The overflow channel was crucial in channelling pool body water to filtration instead of creating an overflow hole on the poolside panel. It would create a structural weak point and the possibility of termination leak joint between materials components. Figure 3 of the Project Design and Prototyping research flow indicated the subsequent processes of Phase 3. After digital design and simulation, the optimum digital design prototype would be physically constructed for application and measurement by the end-users, which is the Royal Army Engineers Regiment team.

3.2 Approaches to Sustainable Development Goals

In general, this study addressed three SDG's, particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 16 (Peace, Justice, and Strong Institutions) and SDG 17 (Partnerships for The Goals). SDG 17 addressed these needs and calls for actions to increase capacity for implementing the SDGs at all levels. As such, meeting the targets and ambitions of SDG 17 is absolutely essential for successfully advancing the entire SDG agenda [10]. Besides, this study included a number of targets from SDG 16 on peace, justice and strong institutions [9], and from SDG 9 on industry, innovation and infrastructure [11, 12]. It has also encouraged sustainable management via environment, social and economic factors throughout this project development [13]. These encompass:

- Enhancing scientific research, upgrade the technological capabilities of industrial sectors in the country by encouraging innovation and substantially increasing the number of research and development through academia and military research and development spending (SDG 9)
- Facilitating sustainable and resilient infrastructure development in the country through enhanced financial, technological, and technical support (SDG 9)
- Supporting domestic technology development, research, and innovation in the country (SDG 9)
- Substantially reducing infrastructures/facilities development expenditure, corruption, and bribery in all their forms (SDG 16)

- Developing effective, accountable, and transparent institutions at all levels (SDG 16), and
- Encouraging and promoting effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships (SDG 17).

4. Conclusions

Overall, this study emphasised the need for the Malaysian Army Forces to have a modular portable swimming pool for military personnel training and fitness assessment. These periodic aquatic exercises are crucial for military survival training, which enhance swimming and floating skill, and also support the general health of the military community. This study was carried out through a partnership with the Royal Army Engineers Regiment, Kem Syed Sirajjudin, Gemas, Negeri Sembilan, Malaysia. This partnership also supported the approaches of the Sustainable Development Goals (SDGs) 9, 16 and 17.

Likewise, this paper presented the preliminary output of the study: Phase 1 Prototyping, and Phase 2 Prototyping Process of the modular portable swimming pool for the military periodical physical fitness test facility. This mobile swimming pool was significant in maximising the training of military personnel and reducing transportation time and resources cost. Moreover, this project encouraged sustainable management via environmental, social, and economic factors. The preliminary study's outcomes indicated some important achievable factors that were required to design and prototype a modular portable pool based on its findings:

i. Flexible and movable: easy to assemble and dismantle.
ii. Material: durable and locally available.
iii. Cost-effective: cost was much lower compared to the construction of an on-site swimming pool.
iv. Less manpower: required 5 personnel to assemble the unit.
v. Reduced installation time: 2 hours of assembly time.
vi. Transportation: reduced cost for transportation as it only required 2 x 3-ton trucks.

Hence, the implementation of this project as a pilot study at Kem Syed Sirajjudin, Gemas, Negeri Sembilan, Malaysia will embark new possibilities for the implementation of a modular portable swimming pool throughout military establishment in Malaysia, particularly in remote military units or divisions with limited access to permanent swimming pools, which are normally located at larger camps or headquarters. Therefore, a future recommendation is to implement this project at a military establishment which requires specific needs for personnel to pass swimming and floating test for FE (floating exercises). The limitations and future research of this study at phase 1 in implementing a filtration system and further strengthening the modular pool structure integrity are significant in ensuring a more hygienic water quality and a robust application.

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