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Red Clay Mini Bricks with Nano-Bentonite (Clamib-Naben): Materials in Early Learning

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ABSTRACT

The Ministry of Energy, Science, Technology, Environment, and Climate Change (MESTECC) is concerned about a downward trend (from 48 % in 2012 to 44 % in 2019) of students in schools pursuing Science, Technology, Engineering, and Mathematics (STEM) subjects in schools and higher education institutions. This downward trend may be related to the thinking of the younger generation, who consider engineering courses quite challenging due to the nature of the courses, which are considered "difficult courses". Therefore, the purpose of this research is to explore the effect of implementing red Clay Mini Bricks with Nano-Bentonite (ClaMiB-NaBen) materials on anxiety towards engineering among students at the preschool level. A cooperative learning method was utilised among students in developing building models using ClaMiB-NaBen. In order to achieve the objectives of the study, a total of 50 students from pre-school were selected. Observations and pre- and final tests were used to collect empirical data based on practical activities in the class. The data were described using frequency, mean, and standard deviation. The pre-test showed that the majority of students were not interested in the field of engineering. However, the post-test results revealed a significant increase in interest in this field. Therefore, ClaMiB-NaBen is expected to be able to change the perception *of the younger generation to be more interested in engineering, which is in line with the Sustainable Development Goals (SDG) of Malaysia that are to be achieved by 2030, as all countries are racing to produce new science and technology that is sustainable, affordable, and safe.*

Keywords: STEM; Bricks; Clay; Bentonite; Sustainable

INTRODUCTION

The Ministry of Energy, Science, Technology, Environment, and Climate Change (MESTECC) recorded a decline from 48 % of students in schools choosing Science, Technology, Engineering, and Mathematics (STEM) fields in 2012 to 44 % in 2019 [1]. This gradual decline will ultimately result in a lack of talent in STEM-related industries. In addition, MESTECC's goal is to achieve a 60:40 ratio, with 60 % of students majoring in STEM. However, this ratio is difficult to achieve when the number of students enrolled in science, math, computers, engineering, manufacturing, and construction at the institutions of higher learning in Malaysia in 2017 totaled 334,742. This was significantly lower than the 570,858 students studying arts and humanities, education, social sciences, business, and law. MESTECC established the Energy, Science, Technology, Environment, and Climate Change (ESTECC) education programme to expose students to science and pique their interest in pursuing a career in the field. MESTECC discovered that one of the reasons fewer students were interested in STEM was that younger generations preferred subjects that were easier to understand or were unable to see how science could play a role in daily life. Meanwhile, the Sustainable Development Goals (SDGs) 2015–2030 in Malaysia under SDG 4 are Quality Education and Empowering Human Capital. In line with this goal, an approach to early education from the early stages of pre-school education is critical to raising human capital.

STEM education equips children and young adults with transferable skills which will aid them in their future endeavours [2]. These skills transcend the ability to solve an equation or design a building. By highlighting the importance of these transferable skills, students will realise the value of STEM education and how this can help them in engineering careers. STEM education requires students to think for themselves. Tasks often involve problem-solving, and this encourages critical thinking. Not only is this skill highly important in STEM careers, but it is also a well-respected transferable skill. Finally, STEM education requires management skills, from overseeing a project to delegating tasks. This is particularly beneficial for careers in business, as well as any engineering role. In the United Kingdom, due to the development of STEM education programmes, there is a shortage of 173,000 workers in the UK's STEM industries, and 49 % of engineering businesses find it challenging to discover skilled workers [3]. Overall, the United Kingdom is taking the necessary steps to encourage the younger generation into STEM careers. This can start as early as childhood, with the toys they play with to the subjects at primary school. The Institute of Engineering and Technology provides free lesson plans and educational videos for kids between the ages of 5 and 11. This effort gives educators the resources to motivate the next generation. Children can also start their STEM education outside of the classroom. Parents can teach their kids to ask questions in order to promote this. Children are enriched with life skills as well as the tools to flourish in STEM disciplines through educational toys like coding robots. In Malaysia, Science, Technology, and Innovation (MOSTI) is concerned about the percentage of students in STEM because the STEM talent will be the catalyst for the development of a country [4]. Furthermore, MESTECC established the Energy, Science, Technology, Environment, and Climate Change (ESTECC) education programme to expose students to science and pique their interest in pursuing a career in the field. In Malaysia, Lego has been used as a game tool in schools at the primary and secondary school levels in STEM projects [5]. With regard to the state of STEM education in Malaysia, the review reflects that it still faces some issues such as insufficient localised STEM learning materials and weak interest of students in continuing STEM related studies at secondary and tertiary levels [6]. Conclusion can be drawn that the goal of STEM education in the UK and Malaysia is to increase the number of engineers in the future to make the developed countries competitive. On the contrary, there are differences in terms of STEM exposure applied in Malaysia compared to the UK. First, STEM has been introduced from the pre-school level in the UK, whereas in Malaysia it is only in the secondary and tertiary schools. Second, STEM exposure to parents, including in terms of materials, has been applied in the UK. Compared to Malaysia, STEM is only implemented at the school level.

In that regard, the implementation of Clay Mini Bricks with Nano-Bentonite (ClaMiB-NaBen-NaBen at the pre-school level is expected to give a clear picture of how building structures are made using bricks. It also piques the interest of the younger generation to venture into the field of engineering in the future. ClaMiB-NaBen has been created and is suitable for children because it is made from natural materials that are safe to use for children. Next, ClaMiB-NaBen has been created with a smaller size (1.5 x 0.5 inches) compared to the actual size of the brick, which is suitable to be used as a building design tool. ClaMiB-NaBen is very practical because to show how building construction is done practically, cassava glue made from natural materials is used to replace cement. Therefore, students can develop strong and unique building structure design ideas through the use of ClaMiB-NaBen.

Therefore, research is needed to study the general perception and level of interest of students at the preschool level in employment in engineering. There are three (3) research questions that will be answered through this study, which are:

i. What is the student's perception of engineering careers?
ii. What is the student's level of interest in a career in engineering prior to the ClaMiB-NaBen approach?
iii. What is the level of student interest in a career in engineering prior to the ClaMiB-NaBen approach?

Characteristic of Red Clay

Red clay is the main component of ClaMiB-NaBen. The red clay is made up of a mixture of natural minerals known as "clay minerals" (quartz, feldspars, iron oxide, oxidised titanium, earthy oxide, etc.) as stated in [7]. Clay minerals with higher concentrations include silica (quartz, cristobalite, tridymite), aluminium oxides and hydroxides (corundum, gibbsite, diaspore, boehmite, etc.), carbonates (dolomite, diobertite, siderite, calcite, aragonite, etc.), and iron minerals (lepidocrocite, maghemite, etc.). Red clay is used in the construction industry as a raw material (as a catalyst, bricks, etc.). Its applications are heavily reliant on their structure, composition, and physical characteristics.

Characteristic of Bentonite

Bentonite is the admixture in ClaMiB-NaBen that ensures it is safe for children to play with. Bentonite clay is also known as montmorillonite clay [8]. Accordingly, the use of bentonite in a moisturising cream has been shown to improve chronic hand dermatitis in the vast majority of people who previously had uncontrolled dermatitis. It has the potential to sorb the pesticide endrin in laboratory conditions due to a combination of hydrophobic and charge-dipole interactions. Bentonite may act as a barrier for the transfer of toxic organophosphorous compounds across the skin, implying that it has a physical protective effect on the skin. Aflatoxin is a cancer-causing substance produced by certain moulds that primarily affects the liver. Bentonite can reduce water aflatoxin to 66 % of its primary concentration, indicating bentonite's adsorption capacity for aflatoxin [9]. Additionally, adding clay to aflatoxin-contaminated corn partially restored pig liver function [10]. Pesticides containing organochlorine are among the most persistent organic pollutants in the environment. They are highly toxic, chemically and biologically stable, and accumulate in organisms. Bentonite is said to be capable of absorbing pesticides because of its cationic nature [11].

Therapeutic Benefits of Bentonite

Bentonite is also used for therapeutic benefits [12]. It has been used and consumed since ancient times. Furthermore, the combination of bentonite and water forms a paste that has been used both externally and internally. In some countries, including Iran, it has long been used as a hair cleanser. The findings of scientific studies show that this clay has many benefits in terms of being cheap, abundant, and natural. Bentonite has long been used externally on the skin to overcome allergic skin problems [13,14]. The use of bentonite in a moisturising cream has been shown to improve chronic hand dermatitis in the vast majority of people who previously had uncontrolled dermatitis [15]. Bentonite is believed to work better and faster than calendula in treating diaper dermatitis, one of the most common skin disorders in children [16,17].

METHODOLOGY

A cooperative learning method is defined as small groups being used during instruction so that students can collaborate and maximise both their own and each other's learning [18]. Utilising this approach, principles and techniques are used to help students engage more effectively [19]. Hence, in this research, a cooperative learning method was used among 50 students in pre-school to test the effectiveness of ClaMiB-NaBen as a tool to encourage them to pursue engineering careers in the future. Cooperative learning involves students working together to achieve common goals, and this sense of interdependence motivates group members to assist and support one another [20]. When students collaborate, they learn to listen to others, to give and receive help, to reconcile differences, and to solve problems democratically. Natural glue made from cassava is used as an adhesive between mini bricks as a replacement for cement, which is applied in the reality of the construction world. The theme of the product focused on engineering by creating a building. Some examples of pictures, such as bridges, pyramids, houses, and so on, are given to each group to assist the students in building structures. Next, each group should select one structure to serve as a model. Each team consists of 4–5 members. The teacher's role in establishing cooperative learning in the classroom during the activity is critical to its success. This includes understanding how to structure cooperative learning in groups, including their size and composition, the type of task assigned, student behaviour expectations, individual and group responsibilities, and the teacher's role in monitoring both the process and the outcomes of the group experience. Figure 1 shows the six stages used to obtain data.

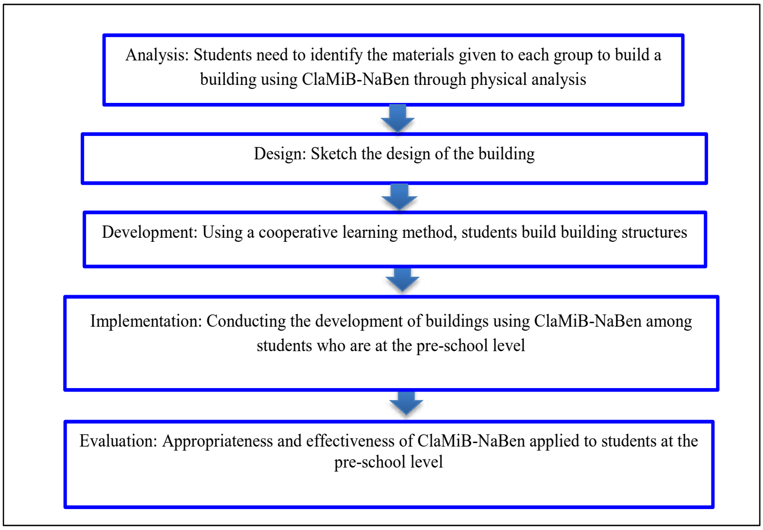

Figure 1: Flow of Research Methodology

ClaMiB-NaBen Design Details

The Red Clay Mini Bricks with Nano-Bentonite Material (ClaMiB-NaBen) were built towards the mission and vision of the increasing interest of the younger generation in the engineering field. ClaMiB-NaBen is a new invention developed from the concept of Lego. Lego is made of plastic material, while ClaMiB-NaBen is made of natural and sustainable materials (mixture of clay and bentonite) that are safe for use by children and very relevant to describing the real world in the aspect of building engineering. Bentonite is a natural component of soil that also does not have a negative effect on the environment [21]. A water quality test was conducted to make sure ClaMiB-Naben was safe before being distributed to students during the building process. ClaMiB-NaBen, a mixture of bentonite and clay, showed a water quality read (220 RPM) that is acceptable marginally using TDS metres.

The brick size is mostly used on 9x4-inch bricks that are usually used to build the structural portion of the building. This size of brick is usually used and applied in laboratories in higher education (university or college level). For this current research, the size of ClaMiB-NaBen was created and processed to a smaller size and shape compared to the original brick size, which is very practical in schools for learning purposes (a practically built replica of buildings) and because it is very easy to install by children (pre-school level). The dimensions are 1.5 by 0.5 inches. Figure 2 shows the prototype of ClaMiB-Naben.

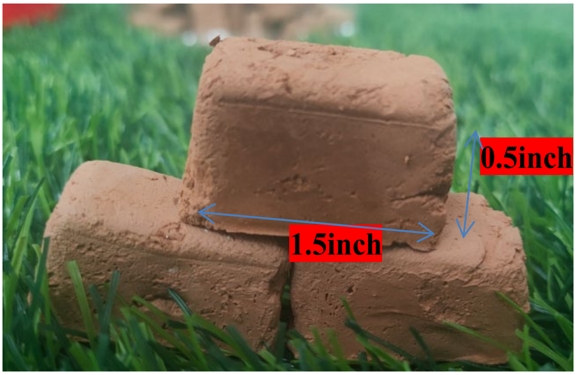

Figure 2: ClaMiB-NaBen

Red clay is the main admixture in ClaMiB-NaBen. The red clay is made up of a mixture of natural minerals known as "clay minerals" [22]. Bentonite is the admixture in ClaMiB-NaBen that ensures it is safe for children to play with. In addition, the price of ClaMiB-NaBen is very economical compared to Lego. In that regard, the implementation of ClaMiB-NaBen at the pre-school level is expected to give a clear picture of how building structures are made using bricks. It also piques the interest of the younger generation to venture into the field of engineering in the future. ClaMiB-NaBen has been created and is suitable for children because it is made from natural materials that are safe to use for children.

The Production of ClaMiB-NaBen

In a cooperative learning method among students in pre-school, ClaMiB-NaBen is used as a tool to encourage them to pursue engineering careers in the future. Natural glue is used as an adhesive between mini bricks as a replacement for cement, which is applied in the reality of the construction world. The natural glue (cassava) is a mixture of tapioca flour and water, which is then boiled at a temperature of 100 degrees Celsius for 10 minutes. The theme of the product focused on engineering by creating a building. Some examples of pictures, such as bridges, pyramids, houses, and so on, are given to each group to assist the students in building structures. Next, each group should select one structure to serve as a model. Each team consists of 4–5 members. The teacher's role in establishing cooperative learning in the classroom during the activity is critical to its success. This includes understanding how to structure cooperative learning in groups, including their size and composition, the type of task assigned, student behaviour expectations, individual and group responsibilities, and the teacher's role in monitoring both the process and the outcomes of the group experience. Figure 3 shows the flow diagram of the production of ClaMiB-NaBen and its application among students at the pre-school level.

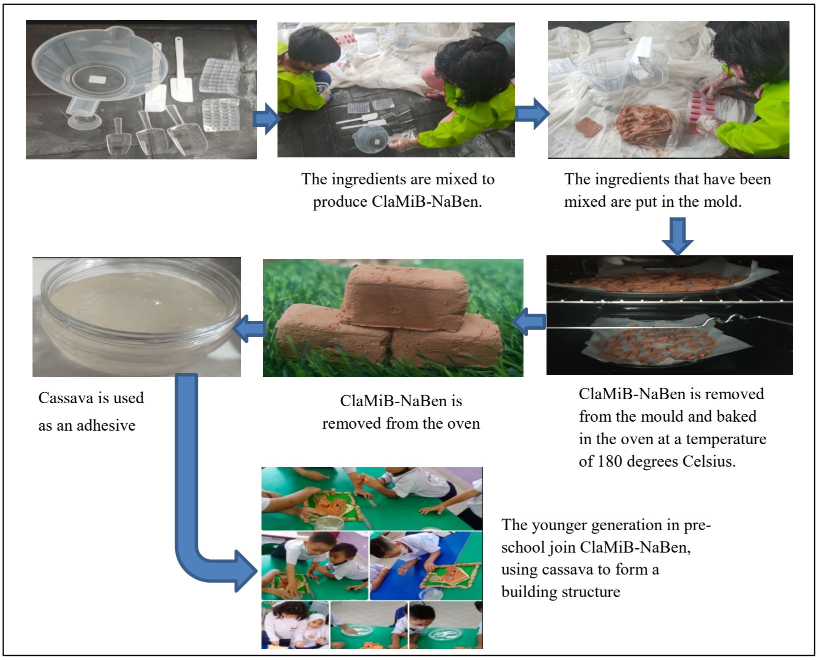

Figure 3: Flow diagram of the production of ClaMiB-NaBen and its application among students at the pre-school level

RESULTS AND DISCUSSION

A cooperative learning method was used among 50 pre-school students. The data were described using frequency analysis. The pre-test showed that the majority (92 %) of students were not interested in the engineering field. The pre-test showed that the majority (92 %) of students were not interested in the engineering field. However, the final results (see Figure 4) revealed a significant increase in the interest of students, from 92 % not interested in this field to 96.08 % interested in the engineering field after playing with ClaMiB-NaBen.

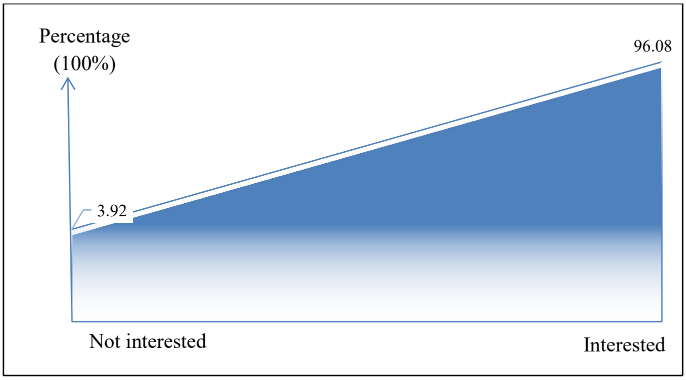

Figure 4: Final Results After Application of ClaMiB-NaBen

ClaMiB-NaBen showed no full (100%) impact on the interest of a few students in choosing a career in engineering. Improvements can be made to future studies using approaches such as playback like an engineer (such as a safety helmet or safety boot) during activities. Besides, exposure like these exciting videos can be used to encourage students to pursue careers in engineering. It is hoped that ClaMiB-Naben can be one of the future learning materials that can be applied in schools in Malaysia to increase the number of engineers who can drive the construction of Malaysia in the future.

CONCLUSION

A programme using ClaMiB-NaBen has been conducted at the preschool level and has shown effectiveness in increasing confidence, ranging from 92 % not interested in involvement in engineering fields (construction) before the activity is conducted to 96.08 % interested in involvement in these fields after the programme is finished. However, there are still a number of students who do not show interest in the engineering field. The study suggests improvements to the forthcoming study to identify factors that prevent students from pursuing careers in engineering in terms of interests, family history, gender, and a shortage of engineering-based game materials at the school level. In addition, the study is limited to only 50 students at the preschool level. It is recommended to increase the number of students in the study by making comparisons in several countries in Malaysia. Furthermore, the suggestion to extend the research to students at the primary and secondary levels is well-founded. Expanding the study to different age groups would provide a more comprehensive understanding of the long-term impact of the ClaMiB-NaBen program.

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