

Research Paper

# Integrating Sustainable Design with Bio-composites in Development of Education: A Pathway towards a Sustainable Future

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**Abstract:** The world is currently grappling with interconnected issues such as climate change, rapid urbanization, and recurring financial crises. The recognition of these challenges has led to a growing understanding of the necessity for sustainable development (SD). Achieving SD requires a careful balance among all the institutions. The three pillars—social, economic, and environmental—are at the core of the SD concept and require effective institutional arrangements to translate the SD agenda into reality. Higher education, as a crucial institution, plays a vital role in enhancing understanding and promoting the practical application of SD within communities up to the ground level. Universities have the potential to contribute significantly to addressing the major challenges of the 21st century by sharing the principles of sustainable development with the upcoming generations. This research article highlights the importance of SD by incorporating natural fibers for making bio-composites which was presented by university students to educate school students about the importance of SD. By sharing the concept of SD universities can educate and shape the mindset of future decision-makers, equipping them with the knowledge and skills needed to address sustainability challenges effectively. This research paper also serves as a valuable example of how educating the school students by university students about SD can have a lasting impact on their mindset, fostering a sense of responsibility and enabling them to become catalysts for positive change.

**Keywords:** Sustainable development, Conceptual design, higher education, bio composites

## 1. Introduction

The effects of climate change, hunger and malnutrition, wealth inequality, rising urbanization, and the recurrence of financial crises are just a few of the interconnected problems the globe is currently dealing with [1]. These problems have made it clear how important sustainable development (SD) is. When making decisions today, it is important to balance the relationship between social, economic, and environmental aims or demands, as indicated by the worries about comprehending SD. To make the SD agenda attainable, the three main pillars of the SD concept—social, economic, and environmental—need to be supported by suitable institutional frameworks. One of the other crucial institutions in the arrangement for improving SD comprehension and applicability across communities is education. Since it is considered that SD education can spread worries for the future of the earth and local communities around the world, it actually becomes a phenomenon. With the advent of the digital era, education has witnessed significant improvements through the integration of technology, coupled with a focus on raising awareness about the Sustainable Development Goals (SDGs). A blended curriculum approach has emerged,

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incorporating diverse strategies that leverage the latest technological advancements. This integration aims to provide students and educators with a wider array of experiences in teaching and learning, specifically tailored for sustainable development. The incorporation of technology in education has revolutionized the learning process. It has enabled interactive and immersive learning experiences with digital tools and platforms. This technology empowers students to engage with SDGs in dynamic ways, allowing them to explore real-world challenges, analyze data, develop solutions, and collaborate with peers from various backgrounds, transcending physical boundaries [2]. Sustainable development is a crucial outcome of using bio-composites. Most natural fibers are readily biodegradable in environmental settings, and they also have other significant benefits like being abundant, affordable, light in weight, strong, and non-abrasive, which makes them an excellent alternative to synthetic fibers for reinforcement. They therefore aid in SD due to the aforementioned qualities [3][4].

The article explains the importance of sustainable development and highlights the role of higher education centers to carry it further. It also gives an example on blending the theory information with the practical impartation of that knowledge. The paper describes the group of university undergrads who made a product (portable standing desk) by using natural fibers and conceptual design method. The students then arranged a presentation session followed by exhibition for their product. The sole reason was to educate the school students on the importance of sustainable development.

## **2. Concept of sustainable design and sustainable development in education**

The United Nations Education, Scientific and Cultural Organization (UNESCO) introduced the concept of environmental education (EE) in 1977 (UNESCO 1978) and in 1992 developed a new concept called Education for Sustainable Development (ESD) (UNESCO). Which has been defined as: Every person can get the knowledge, skills, attitudes, and values essential to sculpt a sustainable future through education for sustainable development. The duration of 2005–2014 was designated by UNESCO as the UN Decade of Education for Sustainable Development. Teaching and learning about important sustainable development topics, such as climate change, disaster risk reduction, biodiversity, poverty alleviation, and sustainable consumerism, is known as education for sustainable development. Additionally, it calls for active learning and teaching strategies that inspire and equip students to alter their behavior and take initiative for sustainable development. As a result, education for sustainable development encourages skills like critical thinking, picturing possible futures, and group decision-making. The method that education is currently frequently done must undergo significant adjustment to support sustainable development [5].

Concept of sustainability in education can be integrated into various fields in education, such as in the areas of social sciences, environmental sciences, and technology.

On the other hand, the terminology of “design for sustainability” (DfS) or sustainable design has often been related to technical applications of sustainability toward developing products and processes. DfS implementation involves three aspects in product development, which are environment, people, and profit [6]. Nevertheless, both terminologies complement each other closely in the context of sustainability, whereby DfS is an approach toward achieving SD. Both terminologies are based on the whole development life cycle, starting from the birth (or design) stage to the end-of-life stage of any activities. The holistic approach is a massive improvement compared to the traditional development approach, which addresses the issue of sustainability only at certain stages in the development process. Furthermore, both sustainable development and DfS include the objective of simultaneously care of the environment as well as the well-being of living things in the same ecosystem in terms of their social and economic needs [7].

### **3. Sustainable design: teaching methods and approaches in education**

With the belief that education can serve as a key component of a strategy for sustainable development, sustainability has become a fundamental focus of higher education institutions over the past ten years [8][9]. Universities are entrusted with the essential roles of conducting research, imparting knowledge through teaching, and providing valuable services. They bear the obligation to acknowledge their responsibility and actively participate in advancing SD [10]. Over 600 universities worldwide have developed diverse educational programs focused on sustainability and sustainable development. Notably, a wide array of fields has tried to incorporate ESD into academic areas, such as economics, environment, engineering, and the arts. Along with these trends, planning-related disciplines have increasingly embraced the concept of sustainability, which is also emerging as a new planning stream [11]. (Sandell et al., 2005)[12] have developed an approach that provides a useful tool for interpreting the goals outlined in school curricula regarding environmental education. Their framework identifies and distinguishes between three levels of environmental education approaches. This framework can be applied to analyze and understand the objectives set in educational programs related to the environment. By utilizing this approach, educators and curriculum developers can gain insights into the progression and depth of environmental education within different educational contexts.

- a. The first level involves a basic approach where environmental education focuses solely on acquiring scientific knowledge. Environmental issues are viewed as unforeseen consequences of production and exploitation.
- b. The second level encompasses environmental education that not only emphasizes scientific knowledge but also aims to cultivate values and attitudes that promote environmental friendliness.
- c. The third approach involves education about sustainable development. This level recognizes the interplay between the environment and society, viewing environmental

issues because of conflicts arising from diverse human goals. Education in this context emphasizes the need for democratic political processes to address these challenges and transform society towards sustainability.

The establishment of the "International Sustainable Campus Network (ISCN)" signifies the recognition and dedication of prestigious universities to assume a leadership role in shaping the concept of SD. Comprising renowned institutions from America, Europe, Asia, and Australia, the ISCN adopts a comprehensive approach to sustainability. It emphasizes the equal integration of the economic, ecological, and social dimensions within the realms of research, teaching, and operations at universities. As outlined in the ISCN-GULF Sustainable Campus Charter, member universities are committed to setting specific sustainability goals and providing transparent and regular reporting on their progress. This collective effort by universities can significantly contribute to the realization of their sustainability commitments and foster the advancement of sustainable practices. The "Association for the Advancement of Sustainability in Higher Education (AASHE)" is dedicated to promoting SD through an integrated approach that encompasses the ecological, social, and economic dimensions within universities. With a membership of 859 schools, AASHE provides its member institutions with the "Sustainability Tracking Assessment & Rating System (STARS)". This system serves as a tool for tracking and assessing sustainability efforts at universities, enabling them to measure their progress and make informed decisions. By utilizing STARS, AASHE empowers universities to enhance their sustainability practices and contribute to the broader goals of SD [13]. Following the influential Brundtland Report in 1987, which emphasized the need to address the interconnectedness of social, economic, and ecological aspects, the concept of "sustainability" has gained significant global recognition. In response, numerous projects and initiatives have emerged at local and global levels, aiming to promote a better quality of life and contribute to sustainability efforts. Within this context, education has been identified as a vital policy tool to foster community involvement and participation in SD. Recognizing the pivotal role of education, higher institutions and schools have incorporated the study of SD into their curricula. By integrating sustainability as a subject of study, educational institutions aim to equip students with the knowledge, skills, and values necessary to contribute to the SD process. This integration allows students to engage actively in sustainability agendas, becoming informed social actors who can make meaningful contributions to their communities and the broader global sustainability movement [7]. In addition to generating knowledge, universities have a crucial responsibility to transfer that knowledge to both the scientific community and the broader non-scientific audience. Alongside Education for Sustainable Development (ESD), universities serve as educational institutions tasked with equipping individuals with the necessary knowledge and skills to actively contribute to shaping a sustainable future that encompasses economic, ecological, and social dimensions. To fulfil this role effectively, there is a pressing need for progress across all fields of expertise to ensure that future leaders are well-prepared and inclined to integrate sustainability into their professional

activities. In addition to raising awareness, the concept of "shaping competence" emphasizes the acquisition of essential skills and competencies [14]. This includes developing abilities outlined by Organization for Economic Co-operation and Development (OECD) in Table 1.

**Table 1.** Assignment of skills to the competence categories source

Competence categories defined by OECD	Sub-skills for shaping the future
Interactively use media and tools	Open minded and able to integrate new perspectives in learning
	Foresighted thinking and actions
	Ability to gain and apply interdisciplinary insights
Ability to gain and apply interdisciplinary insights	Ability to plan and work with others
	Ability to participate in decision making processes
	Ability to motivate others to act
Independent work	Self-principled and ability to reflect on principles of others
	Ability to plan and work independently
	Ability to show empathy and solidarity for the disadvantaged
	Ability for self-motivation and action



**Figure 1.** Poster prepared by students to showcase collaboration between university and school

Based on the activities conducted by the lecturers and students at Universiti Putra Malaysia (UPM), examples of teaching and learning designs that contain both DfS and the SD idea are shown in the below section of this paper. Figure 1 shows the banner used by the university students to show the collaboration between university and school. Interactive talks on bio composites with a focus on SD was organized by UPM undergrad students for school students. The purpose was to inform and interest young groups on the value of sustainable practices. The students use multimedia tools, graphic visuals, and interactive activities to offer captivating presentation. They talk about importance of sustainability like using natural resources and the dangers of plastics. They motivate the younger generation to take an active role in creating a sustainable future by using real-life examples to highlight the palpable effects of sustainable acts. Pictures of the presentation session is shown in Figure 2. University students also set up vibrant and informative exhibition within school premises to showcase their product. The exhibition serves as interactive platforms where students demonstrate practical applications of sustainable practices. Displays include prototypes, models, and informative posters that address various sustainability topics such as recycling, and utilization of natural resources as shown in Figure 3. Through the exhibit, university students engage with school students, explaining the importance of sustainable practices and answering their questions. The displays aim to spark curiosity, inspire creativity, and encourage students to adopt sustainable behaviors in their daily lives.



**Figure 2.** University students giving presentation to school students.



**Figure 3.** University students explaining the poster to school students.

#### **4. Experiential learning of design for sustainability concept into education: Product Development (Portable Standing Desk)**

Undergrads students from Bachelor in technology, mechanical engineering, UPM made a Portable Standing Desk from using natural resources under the heading of sustainable design. They used pineapple leaf fibers (PALF), bamboo, and epoxy to fabricate the portable standing desk (Figure 4). The detail of the work is described in this section.

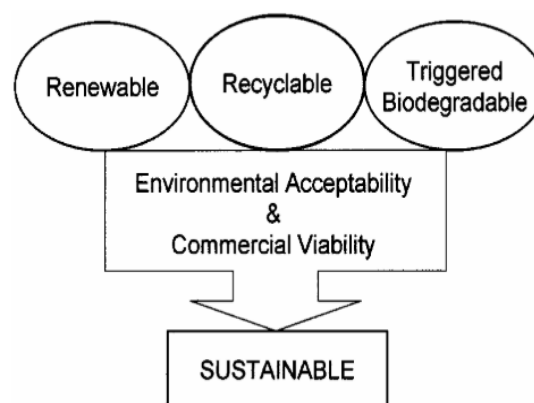


**Figure 4.** Portable standing desk made by university students

Eco design, also referred to as sustainable design, has emerged in contemporary industry and is swiftly gaining popularity. Because of this, product designers now consider the environmental effects of their products and employ Sustainable Design to lessen these effects through better design choices. In every way, research into products made from

natural fibers has increased. The cause for this is the expanding environmental consciousness and the ongoing loss of natural resources. In general, natural fiber composites are essential to establishing a sustainable and environmentally friendly future. As the product base grows, natural fiber composite production is increasing globally. Products made from natural fibers are gradually replacing synthetic fibers and high-energy items. The trend is being driven by natural fibers because of their exceptional qualities, such as their light weight and inexpensive price, as well as the growing awareness of the environment. [15]. A "sustainable" bio-based product is one that is created from natural resources that biodegrade naturally and are accepted by the market (schematic representation in Figure 5). Bio-composites, also referred to as "green composites," are constructed of biofiber and bioplastic that are generated from renewable sources and biodegrade after usage, as opposed to plastic that may not disintegrate over time. Thermoplastic has a bigger environmental impact than thermosets since it may be recycled. [16].

The desired project's goal was to design a sustainable lightweight, long-lasting standing desk that can be readily carried and set up in a variety of settings. The desk should solve the issue of present heavy and large desks that are difficult to move around by creating a desk with light and durable composite material which is comfortable for either standing use or sitting use and can be moved around with ease. The design of the desk has a multi-layered composite panel that is robust and solid enough to withstand the weight of a laptop or monitor. The legs of the desk are similarly composed of composite materials, providing flexibility, stability, and stress absorption. To create a product that is both practical and visually aesthetic, innovative composite materials and processes are used in the production process. The product is a portable standing desk that can be used in a range of situations, including the home, business, and outdoors. The product's potential benefits include improved posture, increased productivity, and reduced back pain.



**Figure 5.** Sustainable bio-based product model [16]

## 5. Conceptual design

Conceptual design is utilized to choose the best material for the least amount of money. The initial cost of adjustments is cheap, but the prospective cost savings are substantial when using the strategies, as shown in Figure 6. "Pre concept generation," "concept generation," and "concept evaluation" are the three main parts of conceptual design. Conceptual design seeks to minimize the quantity of trash produced during disposal while simultaneously having a positive effect on the environment. Therefore, whether designing a product or a material, recycling should be taken into account [17][18].

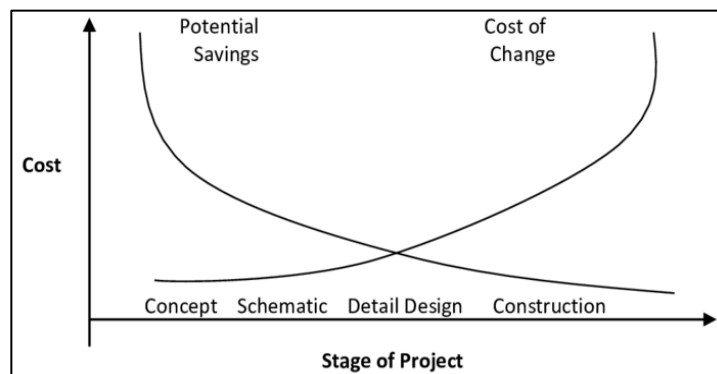


Figure 6. Stages of project and saving potential [19]

### 5.1 Material selection

Material selection is done by keeping four parameters in mind [20].

- Translation: express design requirements as constraints and objectives
- Screening: removal of material which is incapable in carrying out the task
- Ranking: using best suited materials for the job
- Supporting Info: brochures, expert advice etc.

#### 5.1.1 Fiber selection and method

The selection of appropriate fibers for composite materials has been found to be a complex undertaking, as evidenced by numerous research studies. The composite material is being utilized in this project for the purpose of fabricating the top layer of a standing desk. The initial stage involves the identification of the performance requisites of the composite material. This encompasses the essential characteristics such as strength, stiffness, toughness, and additional properties that are necessary. The requisite level of performance will be dependent upon the intended application of the composite material which is for a standing desk for students in schools. The selection of fiber depends upon the processing technique employed in the production of the composite. Certain types of fibers are better suited to specific processing methods than others. Woven textiles may exhibit superior compatibility with specific fibers in comparison to non-woven mats. The strength depends mainly on fiber structure [21]. The cost factor holds significant importance when choosing a fiber. The cost of certain fibers is contingent upon various factors, including but not limited to availability, production volume, and processing

requirements but then also they are cheaper than other man-made fibers [22]. As such, certain fibers may be more costly than others. The utilization of this composite material is intended for educational institutions, and given the limited production scale of the project, it is more plausible that a cost-effective fiber will be used [18].

The performance of the composite will be influenced by the properties of the fiber. Certain types of fibers exhibit varying degrees of strength, flexibility, and moisture resistance. The properties of the fiber must be taken into consideration in relation to the requirements of the composite [23]. The employment of a standing desk within the educational setting is anticipated, with the composite material being fabricated in conjunction with epoxy. The application of epoxy resin has the potential to effectively mitigate moisture absorption by sealing the fibers. Upon completion of the curing process, the resin undergoes a transformation into a solid state, creating a robust barrier that envelops the fibers, thereby impeding the penetration of moisture into the composite structure [24]. The moisture absorption property is not a significant factor to consider when selecting the fiber for the standing desk. In addition, it is imperative to consider the impact on the environmental ramifications of the fiber. Certain types of fibers may exhibit greater sustainability or possess a reduced carbon footprint in comparison to others. It is imperative to assess the sourcing, production, and disposal of the fiber. It is imperative that the chosen fiber is both environmentally sustainable and ecologically friendly. The selection process for composite fibers is contingent upon multiple factors, such as performance and processing requirements, cost, fiber properties, and environmental impact. The Pugh method was used to compare Kenaf, Pineapple, Coconut, and Sugar Palm fibers based on their mechanical properties.. Assuming higher values of tensile strength, elastic modulus, and elongation at break are better, while lower values of density are better. Using the Pugh method, the weight of each criterion can be assigned based on its importance. For this comparison, assuming that each criterion has equal importance.

### 5.1.2 Pineapple Leaf Fiber (PALF)

After citrus and bananas, pineapple (*Ananas comosus*) is one of the most popular tropical fruits in the world. PALF can be used to build reinforced polymer composites since it has good mechanical qualities [25][26]. It is a silk-like, smooth, and lustrous white fiber with a medium length and good tensile strength. Compared to other natural fibers, it has a smoother surface and is better at absorbing and keeping colour. Utilising a decorticator and a crushing mechanism, the leaves are mechanically removed. The impact of fiber orientation along the composite's length is investigated for longitudinal, transverse, and random fiber orientation. In terms of mechanical properties, the longitudinal orientation performs better than the transverse and random orientations. The effect of fiber content and length on PALF reinforced in Poly Propylene (PP) and low-density polyethylene (LDPE) was investigated using PALF reinforced in PP and LDPE. The fibers vary in length from short to long. From 0% to 25%, the fiber loading percentage

has grown. Researchers looked at the mechanical characteristics and stress transfer effectiveness of composites made with PP and LDPE resins [27].

### 5.1.3 Bamboo

A perennial plant known as bambusa is also used to refer to bamboo fibers. It can reach a maximum height of 30 m and matures to its full size in 6–8 months. A grass with a rapid rate of growth, bamboo has a vast array of species. It is a fast-growing grass because of how quickly it grows. By incorporating the use of raw materials like bamboo fiber, which is stronger and can be used to produce high end, sustainable industrial products, researchers have increased their competence in product design. The starchy pulp of bamboo plants is used to separate the fibers. It's used by several automakers, like Toyota, for speakers, floor mats, and baggage compartments [28][29]. In the building sector, it is also used as a structural material as a concrete reinforcement. Developers have been forced to support long-term growth and create new technology based on renewable feedstock as a result of consumer awareness and environmental legislation [30][31].


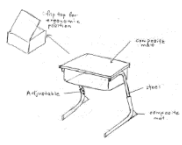
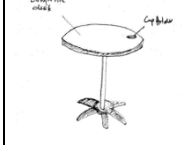
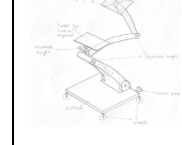
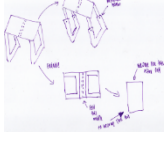
### 5.1.4 Polymer Matrix Composite

Different types of matrix exist, including ceramic and polymeric ones. There are two types of polymeric matrix: thermosetting and thermoplastic. Cross-links in thermosetting materials including epoxy, polyurethane, unsaturated polyesters, phenolics, and silicones create a three-dimensional structure that results in exceptional strength and rigidity. Long-chain polymers are used to make thermoplastics. When heated, it can be easily bent, reshaped, or braked, as with acrylics, polyethylene, polypropylene, and polystyrene [32].

## 5.2. Concept screening

The selection criteria used in design screening as shown in the Table 2 below refers to the design criteria that has been determined based on the technical requirement of the project. Table 2 below shows the concept screening for Design B, C, D and E with Design A as the reference design based on the selection criteria [18]. The current product's design is selected as "datum" and is one of several concepts listed. To ensure that each concept satisfied the design's requirements, each concept design is compared it to the datum. A concept is marked with the legend "+" if it meets a condition better than the datum, "" if it does so worse, and "S" if it does so the same as the datum. The final design concept, in this case concept C, is chosen as it has the greatest favorable difference after adding "+" and "-" Based on the scores in Table 2 by considering these factors, the design is selected to produce standing desk.

**Table 2.** Shows the Pugh method used in design selection

Concept					
	A	B	C	D	E
Durability	D A T U M	-	+	-	-
Economic		+	+	-	+
Feasibility		S	+	-	-
Feature		-	-	+	-
Safety		-	-	-	-
Eco friendly		+	+	S	-
Ergonomics		-	S	+	-
Manufacturability		+	+	+	+
Maintenance		-	+	-	S
Results		5- 3+	6+ 2-	3+ 5-	2+ 6-

### 5.3 Method

Composites are materials made by combining two or more different materials to create a new material. They are widely used in various industries, including aerospace, automotive, construction, and sports. This section will discuss how to make a composite using epoxy resin, hardener, and fiber, including the necessary calculations. First, the mold dimension given is 2400 cm<sup>3</sup>. This information is essential to determining the amount of resin, hardener, and fiber required to make the composite. To calculate the required amount of resin and hardener, the ratio of epoxy and hardener must be determined first, which has been decided to be 71:29. This means that for every 71 parts of epoxy, 29 parts of hardener are needed. Since the volume of the mold is 2400cm<sup>3</sup>, the total volume of resin required is  $(71/100) \times 1920 = 1363.2 \text{ cm}^3$ , and the total volume of hardener required is  $(29/100) \times 1920 = 556.8 \text{ cm}^3$ . Next, we need to determine the fiber ratio. The fiber ratio is the amount of fiber required relative to the total weight of the composite. The fiber ratio has been decided to be 20%, which means that the weight of the fiber should be 20% of the total weight of the composite. Substituting the values, we get the weight of the fiber required as 480 cm<sup>3</sup>. To make the composite, mix the resin and hardener in the correct ratio and then add the fiber. The mixing ratio of the resin and hardener is given as 79:21, which means that 80 parts of resin must be mixed with 20 parts of hardener. Once the resin and hardener have been mixed, the fiber can be added and

mix thoroughly. The composite can then be poured into the mold and left to cure for several hours.

#### 5.4 Target market

The target market for standing portable desks is broad and diverse, as the health benefits of standing desks appeal to a wide range of users. However, there are some specific segments of the population that are particularly likely to benefit from standing portable desks, including:

##### *Teachers:*

Teachers often spend long hours on their feet in front of a classroom, which can cause fatigue and discomfort [33][34]. Standing portable desks allow teachers to alternate between standing and sitting positions throughout the day, helping to reduce fatigue and improve focus and energy levels. In addition to the physical benefits, standing portable desks can also provide a practical solution for teachers who need to move around the classroom during lessons. With a portable standing desk, teachers can easily move their workspace to wherever they need it in the classroom, whether it's next to a student who needs extra help or in the center of the room for a group activity[35].

##### *Students:*

Standing portable desks are also popular among students, especially those in college or school who spend a lot of time studying or working on assignments. These desks can help students stay focused and alert, as well as reduce the risk of health problems associated with sitting for extended periods. Office workers: People who work in offices are one of the primary target markets for standing portable desks. These workers often spend long hours sitting at a desk, which can lead to health problems such as back pain, obesity, and cardiovascular disease. Standing portable desks provide an alternative that can improve posture, increase energy levels, and reduce the risk of these health problems. People with health issues: Standing portable desks can also be beneficial for people with health issues such as back pain, arthritis, or other conditions that make sitting for long periods uncomfortable. By allowing users to stand and change positions as needed, these desks can help alleviate discomfort and reduce the risk of further health problems. Overall, the target market for standing portable desks is anyone who is looking for a healthier, more active work style that can improve their overall well-being [36].

Considering these design criteria during the conceptual design phase of the project can help ensure that the final product meets the needs of the user and performs well in a variety of environments.

### 5.5 Design selection & specification

When designing a standing portable desk, several design criteria should be considered to ensure that the final product meets the needs of the user and performs well. Some of the essential design criteria for a standing portable desk are shown in Table 3.

**Table 3.** Concept screening process

Criteria	Description
Durability	The standing portable desk is able to support a load of 50 kg.
Economic	The standing portable desk should be affordable to most people.
Feasibility	The standing portable desk can be folded into a small form factor to be stored easily.
Feature	Some extra features like cup holder, adjustable height, and wheels are needed.
Safety	The standing portable desk must be safe for the people when using it.
Environmentally friendly	Constructed from materials that are environmentally friendly
Ergonomics	The height of the desk should be adjustable to accommodate users of different heights.
Manufacturability	The standing portable desk is designed must be easily produced. without any complicated technology.
Maintenance	Should not need any extra maintenance work to the electrical or transmission system.

### 6. Fabrication equipment & material

There are a few pieces of equipment and materials that are used for the fabrication of the final design. The equipment are scissors, a weight scale, a ruler, a drill, disposable gloves, a scraper, a chopstick, and a mold. Each of these tools plays a unique role in the fabrication process, enabling the group members to achieve precise measurements and smooth, polished surfaces. Scissors are used to cut the pineapple fiber into the size that has been measured. Next, the other equipment that has been used is the weight scale. The weight scale is used to measure the weight of pineapple fiber that has been decided. Furthermore, the ruler is also one of the pieces of equipment that have been used in the process of fabrication. The ruler is used to measure the length of pineapple fiber that must be cut with scissors. Then, the other equipment is drills. The drills are used to make a hole in the bamboo. The hole in the bamboo is to make the length of the portable standing desk adjustable. These tools are essential for cutting and measuring the materials, as well as drilling holes to connect different parts of the table and to make sure the fabrication of the portable standing desk is successful. Meanwhile, the disposable gloves provide a protective barrier for hands from direct contact with the epoxy and hardener, which are

necessary to create a strong bond between the different components of the table. The scraper and chopstick, finally, aid in the smoothing out of any rough edges, achieving a polished and refined appearance, where scraper is used to remove mixed epoxy and hardener while the chopstick is used to mix the epoxy and hardener together and help in pour and spread the epoxy resin. Finally, the mold plays a crucial role in shaping the table into the desired form. The materials needed for this project include pineapple fiber, epoxy, hardener, bamboo, and bearings. Natural fiber produced from pineapple plant leaves. It is utilized as a reinforcement material in composites because it is lightweight, robust, and long-lasting. Besides, epoxy, a two-part adhesive, is employed to join the various materials [37]. It is a strong, long-lasting adhesive that is renowned for its versatility and resilience to heat, chemicals, and moisture. A catalyst called a hardener is added to epoxy to hasten the curing process. Together, they react to create a solid, long-lasting bond that is rigid and robust [38].

Epoxy and hardener are essential components of the adhesive that will hold the table together. These materials create a strong, waterproof bond between the pineapple fiber and bamboo, ensuring that the table can withstand everyday use [39]. The table's structure is made of bamboo, which grows quickly and is renewable. It is the perfect material for the table frame because it is robust, lightweight, and flexible and easy to work with, making it an ideal choice for the legs of the table. The bearing is a device that is utilized to support the revolving tabletop and other components. It aids in lowering friction and ensuring effortless spinning. These components allow the table to move smoothly and prevent unnecessary wear and tear.

## 6.1 Fabrication process

Based on the final design, there are a few steps involved to build a portable standing desk. The first step is cutting and shaping the materials. Based on our research, the mass of composite fiber should be 20% of the volume of a portable desk which is equal to 480 grams of pineapple fiber. The pineapple strands were in thick pieces, so it was separated and split into thin strands. The pineapple fiber should have a specific length depending on the design. The fiber length that was decided to use is 40mm. To begin this process, the strands were split and separated to be multiple thin strands that were measured to 40mm using a ruler and were cut using scissors. Besides, the epoxy resin and hardener has been used to ensure that the desired shape is achieved. The total volume of epoxy and hardener should be 80% of the volume of a portable desk which is equal to 1920ml. The role of the epoxy is to bond the fibers together and transfer loads between them while the hardener initiates the chemical reaction that causes the epoxy to cure and harden. In this project, the ratio of the epoxy to the hardener is 80% to 20% (Figure 7). Then, the wax was applied on the mold so that when the epoxy is poured on the mold, it does not stick. Next, the pineapple fiber strands were equally distributed on the mold and the epoxy was poured (Figure 8). It was then compacted so that the epoxy is distributed equally and there are no bubbles. Multiple layers of composite and epoxy are made until the desired depth is

achieved according to the design [40][41]. The composite was consolidated and left at room temperature for 24 hours for curing [42]. The composite is then removed from the mold and is placed in the oven for post curing process which increases ultimate tensile strength (Figure 9) [43][44].



**Figure 7.** Cut and shape materials (PALF)



**Figure 8.** Repeat layering until desired depth obtained



**Figure 9.** Composite sheet out of mold



**Figure 10.** Final product

## 7. Conclusion

The focus of sustainable education is on developing both the hard and soft skills necessary to create a sustainable future. Educators are key players in achieving sustainable education. This is so because teachers are the ones who interact most frequently with students. To date, a variety of teaching and learning strategies, including experiential learning, community involvement, and problem-solving, have been employed to ensure sustainable education. These instances demonstrate how modern

instruction is increasingly focused on student-centered learning, in which both students and teachers actively engage in discussions about certain subjects. With this strategy, students not only obtain information but also a variety of soft skills, like leadership, cooperation, and communication, and are able to design procedures and products that will benefit larger populations to achieve the SDGs. A good example of sustainable education has been shown by the university students in the above example. They fabricated, presented and exhibition their product (standing desk) which was made by bio composites, it was also adjustable and mobile. The potential benefits of using the portable standing desk included improved posture, increased productivity, and reduced back pain. Moreover, the desk's portability allows for its use in various environments. As the demand for ergonomic furniture continues to rise, the development of innovative products such as the portable standing desk is crucial. The integration of composite materials in furniture design has the potential to revolutionize the industry and provide solutions for individuals seeking to improve their health and well-being while working. They used their product to share the vitality of sustainable development among the coming generation which will enlighten the young minds to ponder on future of the planet.

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