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Reimagining Indigenous Material Culture: Exploration and Utilizing Bamboo as a Sustainable Approach in Contemporary Costume Design – A Case Study on *Marik Empang* Beadwork

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Abstract

This study investigates the creation of bamboo beads for costume design, drawing inspiration from *Marik Empang* patterns, a traditional Sarawakian beadwork recognized for its symbolic and geometric motifs. Despite bamboo's sustainability and versatility, its application in bead design has been limited due to the challenge of aligning traditional aesthetics with eco-friendly practices. Using a studio-based, experimental methodology, the research evaluates four types of bamboo for their suitability in bead-making, with a focus on factors such as inner hole size, durability, and compatibility with stringing materials (cotton thread, nylon twine, and copper wire). Scanning Electron Microscopy (SEM) was utilized to examine the surface quality, cross-sections, and resistance to fungal growth. Findings revealed that bamboo treated with alum was the most suitable material, offering smooth surfaces, large inner diameters, and effective fungal resistance. Water soaking tests demonstrated the suitability of all three stringing materials, allowing the researchers to proceed with design prototyping. Additionally, a survey assessing the aesthetics, functionality, cultural value, quality, and pricing of the costume designs revealed strong positive feedback. The research conclusively demonstrates that the integration of bamboo beads into contemporary costume design not only enhances aesthetic appeal but also preserves and promotes the cultural heritage embedded in *Marik Empang* patterns.

Keywords: Bamboo beads, Contemporary costume design, Bamboo treatment, Material testing, Design innovation

Introduction and related literature

Today's designers ensure traditional creativity by emphasizing sustainable approaches and indigenous crafts. Prabhata et al. (2023) focused on transforming traditional art into a contemporary design that preserves cultural symbols while maintaining their native roots. Integrating traditional craftsmanship into contemporary design is often achieved by utilizing incredibly sustainable materials (Shaharudin et al., 2021). Several innovations in materials include composite knitting fabric, 3D printing, and textured textiles, as well as cutting-edge glossy finishes and a fashionable sense of straightness (Meng, 2020). Toino Abel introduced natural materials and traditionally dyed the reeds using natural plant-based dyes before undergoing traditional handcrafting techniques (Irma, 2018). These efforts enhance the close ties between innovation, tradition, and contemporary aesthetics.

Beading techniques create complicated designs and patterns, with beads as the primary medium. Multiple cultures and regions have been using these methods for generations. A ladder stitch is frequently used as the base row for brick and herringbone stitches, but it may also be used alone to create bands of beads (Hafez et al., 2018). Due to their solidity, 3D containers and wallets are popularly made with brick stitches. The most popular and valuable stitch is the herringbone stitch because the beads are arranged to resemble a fishbone (Hafez et al., 2018). The stitch requires less time since the beads are inserted in pairs (Hafez et al., 2018). According to Hector (1995), some beads are connected by a long, horizontal, continuous thread to create patterns, while other threads have multiple, separated parts in different directions, such as diagonal threads weaving or vertical thread weaves with open and closed variations. Notably, most pieces are constructed using a single method, but some are made by combining two or even three techniques (Hector, 1995).

A traditional part of the *Iban* women's costume, as one of the ethnic groups in Sarawak, Malaysia, is the *Marik Empang, also known as a tangu in the local language* (*a* beaded collar), made of multi-colored seed beads in a geometric design. Many industries utilize alternative raw materials when forest timber becomes rare. A good raw material should have properties comparable to those of wood, be readily accessible, grow rapidly, and be low-cost (Lee et al., 2023; Chaowana et al., 2021). Jalil (2025) explored the potential of bamboo fiber and hand-woven techniques as a sustainable approach for the textile and clothing industry. In Malaysia, bamboo is a common plant that grows quickly and is slowly replacing wood, as it meets all the above requirements. Textiles derived from bamboo are gaining market interest for their antibacterial properties, UV protection, moisture-wicking abilities, anti-static quality, and quick-drying nature (Rocky & Thompson, 2018).

Malaysia's natural resources, such as rattan and bamboo, are woven into intricate jewellery, baskets, hats, and rugs (Hospitality, 2019). According to Lias et al. (2020), bamboo is one of the natural resources that are easily found in our environment and widely used in the production of handicrafts and interior decorating products. There are 59 bamboo species in Malaysia, with 7 major species (National Forest, 2024). According to Luo et al. (2020), the size, functions, and materials of local bamboo crafts, as well as their marketing strategies, have been modified to adapt to new development trends. Weavers utilized various materials and colors to enhance the longevity and aesthetic appeal of their creations (Liufu et al., 2023). However, the spark of bamboo innovation in Sarawak was focused on furniture, paper production, and bamboo weaving products, but it was not even applied in costume design. The first challenge was that the innovative bamboo designs are rare (Sun & Liu, 2022). Secondly, the bamboo designs in Sarawak were primarily focused on furniture, decorative products, and craft designs. The bamboo designs were not applied in Sarawak's costume design, as Perumal et al. (2022) stated that bamboo was employed in agriculture, construction, arts and crafts, and furniture production, without mentioning its application in Sarawak's costume design.

Additionally, Sun and Shao (2021) noted that the gap between traditional craftsmanship and modern design requires further investigation. Therefore, with the challenges mentioned above, the purpose of this research was to design contemporary costume design with raw bamboo beading inspired by *Marik Empang* patterns in Sarawak. The modern development of traditional handicrafts has been well combined with the bamboo industry, contributing to the sustainability of crafted items (Luo et al., 2020). Bamboo beading provided a distinct aesthetic, and the lightweight bamboo beads make it comfortable to wear. This research advances sustainable bamboo materials by addressing the underutilization of bamboo and exploring its potential for beading applications. In addition to encouraging sustainability, this project redefines traditional craftsmanship for the next generation.

Materials and methods

A mixed-methods approach combining qualitative and quantitative research was employed, which included both experiments and surveys to explore the use of raw bamboo as a sustainable material in contemporary costume design, using *Marik Empang* patterns. Data were collected through observations, interviews, online surveys, and material testing. The research design ensured the integration of traditional cultural practices with modern design, aiming to create sustainable costume designs that are informed by the artistic aesthetic of the *Iban* ethnic group. The study focused on selecting the right type of bamboo for bead-making and its integration into costume designs, while testing materials and evaluating feedback from artisans and the public. The methodology further incorporated a studio-based approach, where creative work played a central role in generating new knowledge. This involved two phases, the data generation phase and the artwork phase, as follows.

Phase one: Data generation (Experimental process)

The data generation phase, which included literature review and material testing. The researcher utilized a range of materials and tools, including various types of bamboo, natural dyes, and seed beads, as well as tools for beading and stringing. Four types of aged, over one-year matured bamboo samples, collected from various locations in Kuching, Sarawak, were named Bamboo A, Bamboo B, Bamboo C, and Bamboo D, all of which belonged to the Bambusa Longissima type, which is the primary bamboo used to make handicrafts is Bambusa Longissima (Vu & Nguyen, 2020). Bamboo A, B, and C were collected in branches, while Bamboo D was sourced in the culm to test its suitability for beading (Figure 1a). Bamboo A collected from Batu Kawa was noted for its green, longest, and thickest culm wall, with the smallest internal hole compared with others. The second bamboo had light green skin and was also collected from Batu Kawa. It had the smallest size with a moderate culm length, featuring the thinnest culm wall and the largest internal hole. The thinner wall and larger hole formed naturally make it suitable for beading, as it allows the thread to pass through it. Bamboo C, collected from the Borneo Development Corporation (BDC), was characterized by its distinctive yellowish and green striped appearance. It had a moderate body size and culm length. With a thin culm wall and a large internal hole, it is suitable for beading since it allows the thread to flow through it. Bamboo D was collected from Serian in the culm. It was green with a large body size. As it was collected in a culm, it had a thinner culm wall and a larger internal hole, which was too big and not suitable for beading. The bamboo branches were thoroughly prepared, and some samples were prepared without the outer epidermis of the bamboo skin to test its durability and lifespan (Figure 1b). Various tools were utilized for cutting the bamboo. Stringing materials, including cotton thread, nylon twine, and copper wires (0.2mm, 0.5mm, and 0.6mm), were prepared for tests, as shown in Figure 1d. Alum and limestone were used as treatment agents. The skins of avocados, green grapes, and red onions are used for natural dyes, while green, red, and yellow food colorings are used as chemical dyes. Drawing from a previous study, Ji (2011) established an effective bamboo treatment solution. The researchers adapted this formula for alum and limestone treatment. The researchers also tested its durability and lifespan by removing the outer epidermis of the bamboo. To ensure quality and uniformity, the researchers prepared the bamboo samples without black spots or mite bites, as these imperfections could compromise durability. The SEM (Scanning Electron Microscope) was used to assess the suitability of bamboo for beading in phase one.

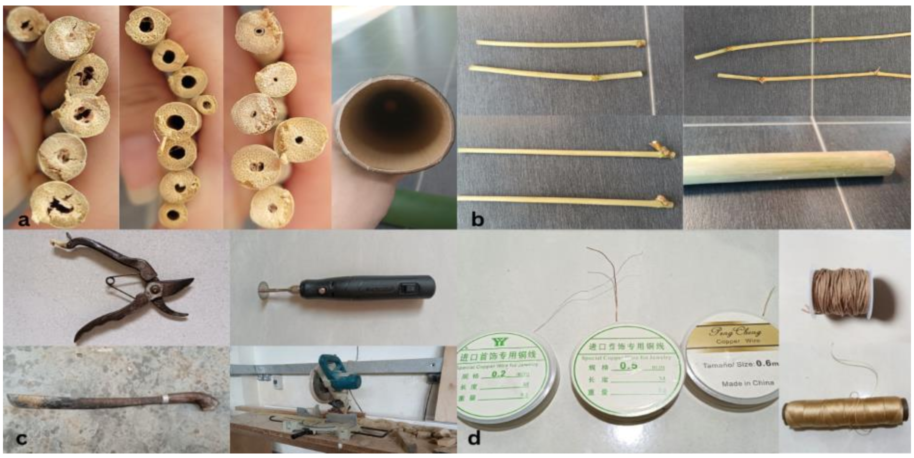

Figure 1 a) Internal hole size of four bamboos, b) bamboo without the epidermis, c) various cutting tools, and d) copper wires, cotton thread, and nylon twine

Phase two: Artwork phase and its analysis (Design process)

The artwork phase and its analysis (phase two), which focused on design prototyping, experimentation, and evaluation. After completing the final costume designs, the researchers conducted a survey using Google Forms to collect feedback in Kuching, Sarawak. The study utilized SPSS for analyzing survey data, which helped evaluate the designs' aesthetics, functionality, cultural significance, and market perception in phase two.

Results and discussion

Phase one: Bamboo treatment as a new eco-bead

According to Ji (2011), the solution for treating bamboo consists of 250g of alum dissolved in 1 liter of water at a temperature of 98°C for 15 minutes. The researchers experimented for 15 minutes, 30 minutes, and 1 hour with the above formula using alum and limestone. The bamboo became glossier and more yellowish after boiling with alum. This effect was not affected by the boiling durations. However, the limestone leaves a white residue on the bamboo. This treatment showed better efficacy of alum treatment. After treatment, the bamboo was dyed with natural and food coloring solutions, supplemented with alum and limestone. To observe the absorption of the dye solution, the bamboo was prepared both with and without the external epidermis. Figure 2a illustrates significant differences in the surface characteristics of bamboo treated with alum and limestone solutions. Bamboo treated with alum displays a smooth, uniform surface, free from visible cracks or residue, indicating that alum treatment effectively stabilizes the bamboo's surface and preserves its natural texture. Additionally, alum serves as a preservative, protecting the bamboo from fungal growth. In contrast, bamboo treated with a limestone solution has a rough, uneven surface with visible residue and surface irregularities, making it less suitable for applications that require precision and accuracy. Therefore, alum-treated bamboo is superior for beading designs, offering both aesthetic appeal and durability due to its smooth surface and resistance to fungal growth. Figure 2b highlights the differences in fungal growth between untreated and alum-treated bamboo surfaces. Fungal spores and mould structures are visible on untreated bamboo, indicating active fungal colonization. This suggests that untreated bamboo provides a conducive environment for fungal growth. On the other hand, alum-treated bamboo remains free from fungal structures, demonstrating its effectiveness in preventing fungal activity. Moreover, the absence of bamboo's epidermis results in uneven surfaces, which increases the risk of rot, as the epidermis acts as a protective moisture barrier. This finding aligns with previous studies, such as those by Chung and Wang (2017), who noted that removing the bamboo's epidermis weakens its mechanical properties by making it more susceptible to water absorption. Figure 2c further demonstrates that Bamboo B, with the most significant and most consistent inner hole, is the most suitable for bead-making. At the same time, Bamboo A is unsuitable due to its small and inconsistent hole size. Bamboo C, with a medium-sized hole, is viable for smaller beads or less intricate designs. Figure 2d shows that dyeing does not alter the bamboo's texture but results in uneven color absorption, which can affect its aesthetic quality for beading. The dyeing process also increases the risk of fungal growth due to the moisture involved. Lastly, Figure 2e compares cutting tools and reveals that the mini electric grinder provides the cleanest and smoothest cross-section, making it the most suitable tool for bamboo cutting, while the garden cutter and wood cutting machine are less efficient and cause uneven cuts. In conclusion, alum-treated bamboo (Bamboo B and C) and the mini electric grinder are optimal for beading. At the same time, dyeing should be avoided due to the risk of fungal growth and inconsistent color absorption. Based on the results, the treated bamboo without epidermis absorbed dyes more effectively but resulted in dull, darkened, and uneven surfaces, losing its natural texture. Bamboo with epidermis treated in an alum solution showed little visible color change and poor dye absorption. Treatment with limestone left a white residue, further diminishing appearance, and overall dyeing produced darker shades that obscured distinctions between samples. For cutting, the garden cutter was the fastest and easiest tool, while the knife was practical for length cutting and vertical splitting. The mini electric grinder provided the cleanest and smoothest cuts, whereas the wood-cutting machine, used only on Bamboo D, proved unsuitable as it left rough surfaces.

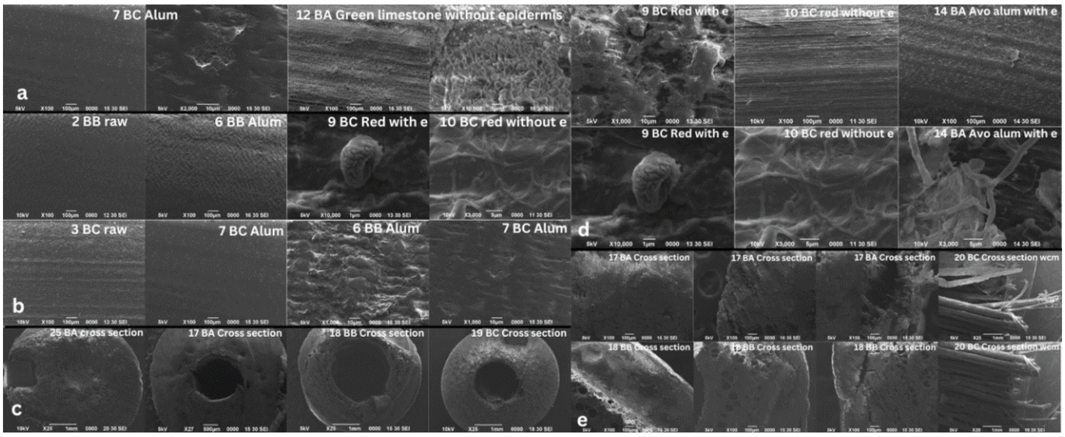

Figure 2 a) surface characteristics of bamboo treated with alum and limestone solutions, b) fungal growth between untreated and alum-treated bamboo surfaces, c) inner hole sizes of three bamboo samples, d) effect of dyeing on bamboo, and e) cross-section of bamboo using various cutting tools

Phase two: Beading design process

The researchers experimented with the *Marik Empang* beading patterns and analyzed the detailed patterns, color combinations, and beading techniques to reinterpret these designs. The researchers experimented with patterns in Figure 3 using a combination of bamboo beads and natural seed beads. In *Iban* culture, black symbolizes power, red represents blood and vitality, while yellow signifies light and good fortune. A combination of adlay, windmill palm seeds, red beans, and bamboo beads created intricate patterns, with adlay for black, palm seeds for white, red beans for red, and bamboo for yellow. Together, these natural colours reflect the basic traditional palette used in *Marik Empang*. *Marik Empang* means people holding hands in a circle in different motifs, including their size, material, meaning, and function. In terms of size, some were as large as cherries or blueberries, which may symbolize fertility. The long beads were believed to represent the carnelian spindles in old pieces. Women create motifs and patterns based on the *Iban* women’s dreams by the *Kumang* spirit (*Dayak Iban Goddess*). The patterns of *Marik Empang* are typically geometric in form, incorporating triangles (Figure 3e), squares (Figure 3a), and zigzags (Figure 3b and c). Motifs of fern and bamboo shoots are also utilised in Figures 3c and 3d, while the top and bottom edges are finished with the water droplet patterns. Beads are symbolically associated with fertility, protection, and coolness, while ensuring continuity of protection and symbolic value within the culture. Shapes like diamonds symbolize fertility and the rice fields, zigzags suggest lightning and divine power, spirals signify the life cycle and transformation, while interlocking patterns reflect unity and continuity across generations. Beyond their visual appeal, such designs are believed to offer protection against hostile forces, embody harmony and balance, and mark social identity, with specific motifs reserved for skilled weavers or individuals of higher status. Through these geometric abstractions, the *Iban* preserve cultural values and maintain a deep connection between the material world, the environment, and the spiritual realm.

The researchers tested cotton thread, nylon twine, and copper wires (0.2 mm, 0.5 mm, and 0.6 mm) for their suitability in stringing materials. Cotton thread is commonly used in *Marik Empang* beading due to its softness and flexibility. Nylon twine, known for its durability and mildew resistance, is particularly effective in moisture-prone areas, as it is "rot-proof" and can withstand varying weather conditions without damage. The team also explored combinations of string materials to assess their durability, flexibility, and resistance to environmental factors. For the beading pattern in Figure 3e, copper wire (0.2 mm) was initially selected to test the material’s ability to handle a complex structure involving multiple threads interlacing with beads. However, the wire proved unsuitable as it failed to securely hold the beads during the finishing process, as shown in Figure 4, particularly due to the small size of the 0.2 mm wire relative to the bead holes (Figure 4b and 4c).

Figure 3 *Marik Empang* and digital patterns created by researchers

Figure 4 Sample using 0.2 mm wire (a) gaps between beads, b) and c) weak support and (c) finishing

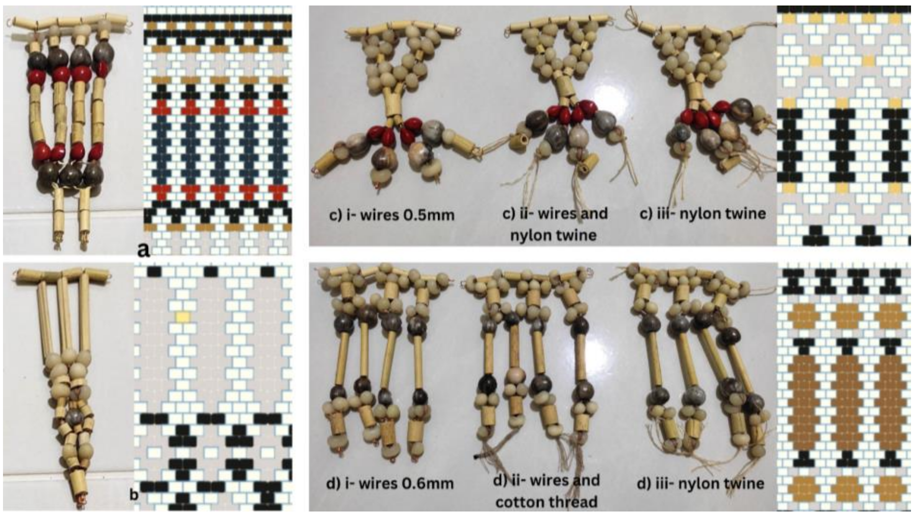

Figure 5 a) Sample with 0.5mm wire, b) sample with 0.6mm wire, c) and d) samples with combined materials

To overcome this, thicker wires (0.5 mm and 0.6 mm) were tested, and they provided better structural support, reduced gaps, and maintained the beads in place (Figures 5a and 5b). These thicker wires proved to be stronger, more durable, and better suited for beadwork requiring structural integrity. A combination of 0.5 mm copper wire and nylon twine (Figure 5c(ii)) successfully balanced strength, enhancing alignment and securing finishes for beadwork. This combination was particularly effective in humid or challenging environments, as nylon twine provided resistance to mold, while copper wire ensured stability. Similarly, combining 0.6 mm copper wire and cotton thread (Figure 5d(ii)) provided flexibility and strength; however, the cotton thread's ply tended to split more easily, making it more challenging to achieve a smooth finish. Despite these issues, the combination remained suitable for intricate designs. The optimal stringing material varies based on the design's needs and environmental conditions. Thicker wires are ideal for rigid, durable designs, while nylon twine excels in intricate patterns, offering ease of use and resistance to mold. Therefore, the material selection should align with the specific requirements of the design and its intended environment.

The patterns in Figure 6 were selected and tested using natural beads to evaluate their structural stability and flexibility. These patterns utilized stringing techniques, such as threading one bead with two or more strands of copper wire, cotton thread, nylon twine, or their combinations, resulting in excellent support. These contrasting properties enabled the researchers to select between wires and threads based on the requirements of the beading project, thereby achieving the desired outcome. Patterns a and b in Figure 5, which included three to four strands of string materials, produced greater tension and caused difficulties for thicker materials. The bamboo's inner hole was too narrow to fit four strands of 0.5mm copper wire and was less suitable due to the higher chance of breakage caused by the extra pressure applied to the beads. As a result, the prototypes in Figure 6 performed better after some minor adjustments to the arrangement of beads, which helped balance the durability, flexibility, and stringing ease of various materials. Finally, nylon twine was used for the patterns in Figure 6a, cotton thread for the patterns in Figure 6b, and copper wire for the patterns in Figure 6c.

As shown in Table 1, the characteristics of bamboo, especially the internal hole size, significantly influence its suitability for beading. Bamboo A, with the smallest internal hole, presents challenges in threading, making it less suitable for beadwork. In contrast, Bamboo B and C's naturally thinner walls and larger holes make them ideal for beading, allowing threads to pass through effortlessly. The substantial internal hole of Bamboo D's culm renders it unsuitable for beading application, compromising the structural integrity required for precise beadwork.

The researchers conducted a water soaking test to evaluate the durability, strength, and water resistance of various stringing materials. Water soaking test to test the absorbency, durability, tensile strength, resistance to rot, and mildew (Textile American Publishing Company, 1912; Verma, 2011). In this soaking test, the soaking materials included copper wire, cotton thread, and nylon twine. Each type of string was submerged in pure tap water for three different durations: one day, three days, and seven days, to simulate exposure to moisture over varying periods of time. The results indicated that there were no visible changes or significant deterioration in any of the materials after soaking. All three materials demonstrated good water resistance, maintaining their visual appearance, structural integrity, and strength even after a week of immersion. The string materials retained their shape, texture, and tensile strength, with no signs of fraying, corrosion, swelling, or weakening. Based on these findings, the selection of stringing material can be made according to the intended function of the beadwork or the researcher's preference, as all materials tested performed reliably under wet conditions.

Marik Empang new look

After conducting experimental and design ideation, the researchers began by creating patterns based on the cultural uniqueness of the *Marik Empang* motif and colours, which have been mentioned in the previous section. The details of the pattern that was created followed the digital patterns. The V-shaped motif in prototypes symbolizes growth and cultural continuity, often associated with bamboo or fern shoots. The diamond shape, inspired by a shield, represents harmony and protection. The long and zig-zag patterns were believed to symbolize the flow of life, healing, or reflecting the journey of resilience through challenges. The nine strings on the male waistband carried meaning as an auspicious number.

Following the pattern drafting, the toile was assembled using calico to create a test garment. The initial toile was then fitted onto an M-sized mannequin, allowing the researchers to assess the general fit, drape, and balance of the garment. The researchers focused on the neckline and collar shapes for the female top, as well as the overall proportion of panels, to ensure optimal integration of *Marik Empang* patterns. After fitting, the pattern was transferred onto the final fabric, and the beadwork was then carefully fitted onto the toile, with precise attention given to the arrangement, alignment, and positioning of each pattern segment. Special attention was given to wearability, particularly regarding the weight of the bamboo beads, the flexibility of the materials, and the movement of the garment when worn. The researchers ensured that the beading did not restrict mobility or cause discomfort, especially in areas such as the shoulders, neckline, and waist. After finalizing, the researchers transfer the final patterns onto the velvet fabric, cut them out, and sew them together according to the design. The beads were then carefully sewn onto the top of the velvet fabric before the lining was added, ensuring the beadwork was securely integrated and allowing for a clean and perfect finish. A lining was added to both the top and bottom pieces to distribute the weight of the beadwork, prevent distortion of the velvet, and contribute to a more comfortable and professional finish. The interface was added to both female and male waistbands to provide structure, shape, and prevent rolling. Finally, the costume designs were successfully brought to life, as shown in Figure 7. The costumes reflected a harmonious blend of traditional *Marik Empang*, sustainable materials, and contemporary design, showcasing the researchers' commitment to both heritage preservation and innovative craftsmanship.

Figure 6 Beading pattern prototypes

Table 1 Four Bamboo types with their characteristics from Bambusa Longissima

Bamboo type	Color	Inner hole size	Challenges in bead making	Bead making suitability	Usage
Bamboo A	Green	Small, inconsistent	Hard to string	Low	Unsuitable for beading
Bamboo B	Light green	Big, uniform	No significant challenges	Ideal	Beads or fine crafting
Bamboo C	Yellow and green strips	Medium, uniform	Avoid thicker threads	High	Decorative craft of beads
Bamboo D	**Green**	**Large**	**Loose stringing result**	**Not suitable**	**Unsuitable for beading**

Respondent's feedback

The researchers surveyed 102 participants in Kuching, Sarawak, with diverse backgrounds and professions, with most participants (58.82%) being between 21 and 30 years old, indicating that the survey attracted a young adult audience. Female respondents were recorded in greater numbers (74.51%) compared to male respondents (25.49%). Ethnically, the survey reached a diverse range of respondents, Chinese (37.25%), followed by *Bidayuh* (19.61%), *Iban* (16.67%), and other ethnicities, as shown in Table 2. Regarding professional background, the survey recorded the most responses from students, who represented 46.08% of the participants, followed by private sector employees at 24.51%. 85.29% of respondents reported having no experience in textile or fashion. Overall, the designs received positive feedback, with mean scores ranging from 4.17 to 4.25 and relatively low standard deviations (0.891 to 1.060). Participants rated the designs as visually appealing. The colors and patterns also received favorable feedback, indicating that they enhanced the overall visual appeal of the design. The texture and natural look of the bamboo and beads reflected a strong agreement that these elements added uniqueness to the designs. Additionally, the balance between contemporary and traditional styles was well-received. Regarding functionality, the designs received a positive evaluation with a mean score of 3.90, indicating that the designs successfully integrated aesthetic appeal with practicality. The practicality of the designs was rated the highest, suggesting the designs were perceived as functional. Respondents also demonstrated a balanced view on the design's quality and price. They showed appreciation for craftsmanship while being price sensitive. A mean score of 4.23 indicated strong support for handmade, sustainable, and culturally meaningful products. The lowest standard deviation of 0.904 showed consensus on the designs' quality. In terms of cultural value, the designs received a favorable response, with a mean score of 3.62, indicating that the bamboo beads effectively reflected the *Marik Empang* cultural tradition. The respondents also agreed that wearing these designs connected them to the *Marik Empang* culture. The designs were seen as genuinely authentic, reflecting a high level of agreement with some variability. Finally, the highest mean score of 4.22 demonstrated that the respondents felt the designs contributed to the preservation and promotion of *Marik Empang*'s cultural identity. Overall, the survey revealed strong positive feedback, with participants expressing significant interest in contemporary costume designs that integrate bamboo.

Discussion

Bamboo treatment and dyeing process: The analysis of bamboo treatment reveals important insights for this study. Alum-treated bamboo presents a significantly smoother and more uniform surface compared to bamboo treated with limestone. The alum treatment not only enhances the aesthetic appeal by providing a soft surface but also acts as a preservative, preventing fungal growth and surface decay, which is crucial for applications like beading. In contrast, bamboo treated with limestone exhibits a rough, uneven surface due to mineral deposits from the calcium carbonate, making it less suitable for fine craftsmanship. This finding is consistent with research by Hjelmar et al. (2022), which suggests that limestone treatment results in rough, insoluble residues. Alum-treated bamboo's resistance to fungal growth ensures its durability, while untreated bamboo surfaces provide an environment conducive to fungal colonization, thereby compromising the material's longevity. Additionally, the removal of bamboo's epidermis, which serves as a protective barrier against moisture, compromises its mechanical properties, making the bamboo more susceptible to water absorption and fungal growth, as confirmed by studies (Chung & Wang, 2017; Nkeuwa et al., 2022).

Bamboo's inner hole size and dyeing effects: The analysis of inner hole sizes in different bamboo samples demonstrates their suitability for bead-making. Bamboo A, with its small and inconsistent inner hole, proves unsuitable for beadwork due to threading difficulties and compromised structural integrity. Bamboo B, exhibiting the most significant and most consistent inner hole size, is ideal for bead-making, facilitating easy threading and providing ample space for stringing materials. Bamboo C, with a medium-sized inner hole, is less optimal but still suitable for smaller beads or less intricate designs. Bamboo D, sourced from the culm, is not recommended for bead-making due to its overly large hole size. The dyeing process introduces challenges, as it creates uneven color absorption and increases moisture, which can foster fungal growth. Studies by Perry (2009) indicate that dyeing with reactive colors using an alkaline technique can damage the bamboo's protein fibers, thereby promoting further fungal colonization. Thus, maintaining bamboo's natural color and treating it with alum offers a more sustainable and durable solution for bead-making, avoiding the risks associated with dyeing.

Cutting tools and stringing materials: The study of cutting tools emphasizes the importance of precision in preparing bamboo adequately. The mini electric grinder was identified as the most efficient tool, delivering clean and accurate cuts, which are essential for detailed beadwork. The garden cutter, although suitable for cutting bamboo branches, proved less efficient for making precise cuts, resulting in uneven edges. The wood-cutting machine was found to be unsuitable due to its aggressive nature, which caused damage to the fibers. Sandpaper was used to finish the bamboo beads, ensuring a polished surface. Regarding stringing materials, cotton thread, nylon twine, and copper wire were tested for durability, strength, and water resistance. Cotton thread, while flexible and easy to knot, is less resistant to moisture and prone to fraying. Nylon twine proved to be the most durable and water-resistant option, making it ideal for designs exposed to moisture. Copper wire, with its rigidity, provided excellent support for structured bead designs, ensuring that the beads remained in place and the design maintained its shape. Each material offers unique advantages, and the choice depends on the specific application. Nylon twine is suitable for intricate designs, cotton for comfort, and copper wire for structured, durable beadwork.

Prototype development and material selection: The development of costume prototypes highlights the importance of material selection in achieving both aesthetic and functional outcomes. Bamboo B and C were selected for their ideal physical characteristics, which enhanced the creative and cultural aesthetic of the designs. Velvet fabric was chosen for both the top (red) and bottom (black) garments, emphasizing the refined aesthetic of the designs. The costume construction involved transferring patterns from the toile to the velvet fabric, followed by precise cutting, sewing, and the addition of a lining to ensure durability and comfort. The beadwork was carefully integrated before the lining to achieve a seamless, professional finish. This research highlights broader applications in sustainable design, where the integration of natural resources and traditional techniques fosters innovative fashion development that bridges cultural heritage with contemporary aesthetics.

Bamboo beadwork compared with other eco-materials: The result of this research showed that using natural beads that do not contain harmful chemicals can be safer for both the community and the environment. In addition, using bamboo beads was lighter compared with wooden beads, as previously investigated by Marco (2025); henceforth, bamboo beads can be replaced with wooden jewellery since they are much heavier. In addition, the wooden beads are easily drilled and harder compared to bamboo beads, which are fragile as they may break when they are strung with thicker string materials due to the limited inner hole size, which is in line with the findings of Theresa Flores Geary (2008). The natural oval shape and the natural inner hole also make it easy to string without the need for polishing, which is in line with previous studies that say the adlay has a complex and oval structure, making it often used in prayer beads (Yoon, 2023; Dev et al., 2025). Based on the results, the natural textures of bamboo add uniqueness to the beadwork, as noted in previous research by Raichaudhuri (2010), making the bamboo product both unique and visually appealing, rather than other plant- based and natural accessories. Overall feedback from the process and evaluation showed that the final products received strong positive feedback, with participants expressing significant interest in contemporary costume designs that integrate bamboo beads with *Marik Empang* patterns. However, this study was applied to 102 young respondents, who, if applicable to a larger population, may have different feedback. Still, the primary focus of this research is sustainable and nature- based jewelry and costume design. This study was conducted in Kuching, but its approach can also be applied in other states, where perceptions and feedback on this integration may differ.

Figure 7 *Marik Empang* new look

Table 2 Descriptive analysis of data

Question	M	S.D.
Q1 The designs are visually appealing.	4.23	1.001
Q2 The choice of colors and patterns enhances the overall visual appeal.	4.19	1.060
Q3 The textures and natural looks of bamboo and other natural beads add uniqueness to the designs.	4.25	0.961
Q4 The designs incorporate modern elements while retaining their unique character.	4.17	0.891
Q5 The designs combine both style and usability.	3.90	0.928
Q6 The designs are easy to use.	3.89	0.932
Q7 The designs are practical.	4.00	0.912
Q8 The slight variations in size and color are acceptable as they are natural materials and seeds, giving each piece a unique character.	4.17	1.025
Q9 If the quality is good and the price of this design is reasonable, then it is worth buying.	4.13	1.002
Q10 A higher price is acceptable if the design is handmade and supports sustainable and cultural craftsmanship.	4.23	0.953
Q11 The designs and quality offer good value for money.	4.12	0.904
Q12 The use of bamboo beads in the design reflects cultural traditions *(Marik Empang)* creatively and effectively.	3.62	0.890
Q13 Wearing these designs makes me feel more connected to the *Marik Empang* culture.	3.85	0.837
Q14 The cultural features in this design feel authentic.	4.08	0.909
Q15 These designs help preserve and promote the cultural identity of *Marik Empang*.	4.22	0.991

Conclusion

This study examines bamboo as a sustainable material for beading design, drawing inspiration from *Marik Empang* patterns, and presents eco- friendly alternatives that align with contemporary costume design trends. The findings identify Bamboo B and C from the Bambusa longissima species as ideal for bead-making due to their naturally larger internal holes, thinner walls, and easy stringing. These bamboo types offer a renewable solution that combines traditional craftsmanship with contemporary aesthetics, appealing to environmentally conscious audiences. Alum treatment enhanced the surface smoothness of bamboo and its fungal resistance, thereby increasing durability. However, challenges such as reduced dye absorption and potential moisture retention, which may lead to rot, underscore the importance of proper drying and storage techniques. Nylon twine emerged as the versatile stringing material, particularly for designs exposed to wet conditions, while cotton thread and copper wire offer alternatives for delicate and structured applications. The combination of sustainable bamboo beads and durable threads allowed for diverse design possibilities across both costumes. This approach ensured functionality without sacrificing aesthetic appeal. This research outlines the process of developing costume designs based on traditional *Marik Empang* patterns and analyzes the audience's feedback on these designs. Furthermore, the researchers used survey feedback to collect opinions from the audience through a Google Forms survey, gathering insights on cultural authenticity, material choices, and the overall success of the final costume designs. This survey feedback provided valuable insights into how the costumes were received, helping to assess the balance between traditional elements and contemporary adaptation. The balance between traditional and modern is also achieved by using sustainable and contemporary materials as alternatives to *Marik Empang* patterns in costume design. Through this process, the researchers successfully merged heritage and contemporary design, producing a costume that reflected the cultural significance of *Marik Empang* patterns while embracing sustainable fashion practices. Overall, the research highlights the potential of bamboo bead- making to promote sustainable crafting practices while addressing material fragility, fungal resistance, and limitations in dyeing. By advancing traditional *Marik Empang* patterns through innovative material testing and techniques, this study contributes to preserving cultural heritage while meeting the evolving demands of contemporary design. Future research may examine other bamboo bead forms utilising mechanical instruments or digital fabrication methods like 3D cutting or laser cutting to increase the utilisation of bamboo beads. This would increase their potential uses in interior design, accessories, and fashion, in addition to improving their visual attractiveness. Beyond technological improvements, cooperation with jewellery companies, fashion houses, and textile designers may facilitate the use of bamboo beads in fashionable design collections, blending traditional craftsmanship with contemporary designs. These collaborations would also open doors for exhibiting bamboo-based inventions on global stages like fashion weeks and design shows, establishing bamboo beads as a sustainable substitute material in the worldwide marketplace. Furthermore, studies might investigate a larger variety of bamboo species to find different types of surface texture, colour, and performance that are appropriate for beadmaking. Trying out geometric or modular design may lead to more adaptable uses, from architectural interiors to haute couture clothing. Future studies can help bamboo beads become an essential element of the sustainable design industry by fusing traditional craftsmanship or co-designing with the craft makers, with or without innovative technology and global marketing techniques. This will inspire both traditional craftspeople and the international creative industries.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Credit authorship contribution statement

Chee, Q. H. K. : Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization, Resources. Jalil, M. H. : Writing – review & editing, Formal analysis, Conceptualization, Supervision, Validation, Investigation.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author used ChatGPT as a language assistant to rephrase and refine the text. After using this tool, the author reviewed and edited the content as necessary, taking full responsibility for the accuracy and content of the publication.

References

Chaowana, K., Wisadsatorn, S., & Chaowana, P. (2021). Bamboo as a sustainable building material—Culm characteristics and properties. *Sustainability*, *13*(13), 7376.

Chung, M. J., & Wang, S. Y. (2017). Effects of peeling and steam-heating treatment on fundamental properties of two types of bamboo culms (Phyllostachys makinoi and Phyllostachys pubescens). *Crossmark*, *63*(5), 473-482.

Dev, D., Pandey, S., Nandni, S., Mishra, S., & Chourasia, K. N. (2025). *Millets*. Burlington, Canada: Apple Academic Press.

Hafez, N. M., Qureshi, W. A. R., & Ahmed, A. R. M. (2018). Design innovative clothing using bead weaving techniques. *Architecture and Arts Magazine*, *10*(p1), 683-706.

Harris, L. (2024). *Sustainable Fabrics*. Toronto, Canada: Marcelo Marins Rodrigues.

Hector, V. (1995). Prosperity, reverence and protection: An introduction to Asian beadwork. *Beads (Ottawa. Online)/Beads*, *7*(1), 3-36.

Hjelmar, O., Hyks, J., Korpisjärvi, K., Wahlström, M., & Grönholm, R. (2022). *BAT for combustion and incineration residues in a Circular Economy*. Copenhagen, Denmark: Nordic Council of Ministers.

Hospitality, K. (2019). *Famous handicrafts and arts of Malaysia*. Retrieved from https://www.kualalumpurhospitality.com/blog/famous-handicrafts-and-arts-of-malaysia

Irma. (2018). *Five reasons why this new, sustainable must have bag by Toino Abel makes sense*.

Retrieved https://www.irmasworld.com/five-reasons-why-this-new-sustainable-must-have-bag-by-toino-abel-makes-sense-0315613

Jalil, M. H. (2025). Weaving a greener tomorrow: A mini review of bamboo fiber, textiles and hand-woven techniques for sustainable innovation. *Pertanika Journal of Science and Technology*, *33*(3), JST-5735-2025.

Ji, L. J. (2011). *Mould-proof technology of bamboo products*. Retrieved from https://patentimages.storage.googleapis.com/08/5c/9d/746b94813130c1/CN102862200A.pdf

Lee, S. H., Al-Edrus, S. S. O., & Tahir, P. M. (2023). Multifaceted bamboo. In M. K. A. Uyup (Ed.), *Springer* (1st ed.). Bugis, Singapore: Springer.

Lias, H., Ismail, A. R., & Hamid, H. A. (2020). Malaysia textile craft industry: Innovation inspired by bamboo for batik block contemporary design. *IOP Conference Series: Earth and Environmental Science*, *549*(2), 012087.

Liufu, Y., Hu, R., Fu, Q., & Luo, B. (2023). Bobai Hakka weaving: plant diversity, traditional culture, and a model for rural revitalization. *Springer Nature*, *26*, 17335-17352

Luo, B., Ahmed, S., & Long, C. (2020). Bamboos for weaving and relevant traditional knowledge in Sansui, Southwest China. *Journal of Ethnobiology and Ethnomedicine*, *16*(1), 63.

Marco, P. D. (2025). *Secrets of beading: Exquisite jewelry designs with a twist*. Manhattan, New York: Union Square & Co.

National Forest. (2024). *Perkhidmatan atas talian*. Www.forestry.gov.my. Retrieved from www.forestry.gov.my website: https://www.forestry.gov.my/en/soalan-lazim/94-uncategorised/448-khidmat-online

Nkeuwa, W. N., Zhang, J., Semple, K. E., Chen, M., Xia, Y., & Dai, C. (2022). Bamboo-based composites: A review on fundamentals and processes of bamboo bonding. *Composites Part B: Engineering*, *235*, 109776.

Perry, B. (2009). *Teach yourself visually hand-dyeing*. Jersey, United States: Wiley Publishing.

Perumal, M., Hassan, N. H. B. M., Abdullah, N., Ismail, Z., & Omar, L. (2022). Towards bamboo industry development in Sarawak: Evaluation on survivorship and field growth attributes of four selected bamboo species. *International Conference on Food and Industrial Crops 2022 (ICFIC2022).* Sarawak, Malaysia: Universiti Putra Malaysia Bintulu Sarawak Campus.

Prabhata, T., Susanto, I. A., Savira, P., & Murwonugroho, W. (2023). Local culture synchronization in global contemporary fashion style breakthroughs. *Mudra*, *38*(3), 288-289.

Raichaudhuri, A. (2010). *Managing new ventures*. Delhi, India: PHI Learning.

Rocky, B. P., & Thompson, A. J. (2018). Production of natural bamboo fibers-1: experimental approaches to different processes and analyses. *The Journal of the Textile Institute*, *109*(10), 1381-1391.

Shaharudin, S. S., Jalil, M. H., & Moghadasi, K. (2021). Study of mechanical properties and characteristics of eco-fibres for sustainable children’s clothing. *Journal of Metals, Materials and Minerals*, *31*(2), 19-26.

Sun, Y., & Liu, X. (2022). How design technology improves the sustainability of intangible cultural heritage products: A practical study on bamboo basketry craft. *Sustainability*, *14*(19), 12058.

Sun, Z., & Shao, J. (2021). Preliminary study on innovative design of bamboo furniture based on users’ big data. *Journal of Physics: Conference Series*, *1774*(1), 012017.

Textile American Publishing Company. (1912). The textile American. *Textile Fabric*, *3*(1), *17-18*.

Theresa Flores Geary. (2008). *The illustrated bead bible: terms, tips & techniques*. New York: Sterling Pub.

Verma, N. K. (2011). *Comprehensive Chemistry Activities Vol.I XI* (Vol. 1). Delhi, India: Laxmi Publications.

Vu, T. P., & Nguyen, V. X. (2020). Technical paper life cycle assessment for key bamboo products in Viet Nam. *Creative Commons*, *1*(1), 1-58.

Williams, B. (2025). *Ethical fashion design: A practical guide for aspiring designers* (1st ed.). New York: Barrett Williams.

Yoon, G. (2023). *The Korean herbal apothecary*. United States: Fair Winds Press (MA).