

Musical Instruments from Recycled Materials:

A Case Study of Uthen Pialor

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Abstract

This research article focuses on two objectives: examining the design concepts and construction techniques of musical instruments made from recycled materials by Uthen Pialor and exploring the materials used and their associated benefits. The researcher utilized a case study research design, conducting qualitative research through semi-structured interviews. The interviews covered three key aspects: design concepts, construction techniques, materials used, and benefits derived from using recycled materials. Findings revealed innovative design concepts, prioritizing sturdy recycled materials and integrating natural elements. Uthen Pialor successfully created 15 instruments across four types using everyday materials. Benefits included addressing instrument scarcity, increasing waste material value, environmental contributions, improved accessibility, streamlined production, reduced costs, and applicability in teaching and learning. These findings demonstrate social benefits and potential for future instrument development.

Keywords *Musical Instruments, Recycled Materials, Uthen Pialor, Thailand*

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Introduction

Thai music is a captivating art form that evokes local identity and represents Thai cultural heritage. It is an expressive medium shaped by human creativity, conveying emotions through melodic compositions. The study of Thai music is integral to a rich legacy passed down through generations (Suwan, 2015; Arunrat, 2016). Each musical instrument in the Thai repertoire has unique techniques and is crafted with carefully selected materials, reflecting the value of Thai music. While solo performances were common initially, the growth of skilled musicians led to the development of ensemble music. However, specific instruments, such as the Pi Phat ensemble, maintain their traditional solo role, which combines instruments for particular occasions.

Uthen Pialor, also known as "Kru Ten," is a highly skilled educator in the art curriculum group at Singburi School located in the central region of Thailand. His exceptional ability to creatively work with a wide range of materials allows him to produce innovative creations that hold intrinsic value and capture the interest of young individuals intrigued by Thai music but have limited access to traditional instruments. His unwavering commitment centers around repurposing leftover materials to craft unique Thai musical instruments and explore unexplored possibilities within the realm of Thai music. His approach is guided by principles that prioritize astute resource selection and cost minimization, ensuring the practical utility of his creations while optimizing resource allocation and reducing costs. He utilizes milk cans, compressed wood, bamboo, tiles, pencil cases, tire rubber, water pipes, bowls, and cookie boxes. In his initial venture into designing and fabricating musical instruments from recycled materials, he successfully created a flute that served its intended purpose. Recognizing the untapped potential inherent in these materials, he continued to conceive and construct various types of Thai musical instruments, aiming to complete a comprehensive ensemble comprising string, percussion, wind, and brass instruments. Kru Ten's notable participation in the Recycle Music Competition held in Bangkok culminated in a momentous victory, as his inaugural musical instrument creation claimed the first-place prize. This achievement served as a catalyst, motivating him to diligently produce musical instruments for over two decades, accumulating a wealth of invaluable experiences and providing opportunities to showcase his recycled musical instruments through diverse media outlets that have generated significant public interest.

Led by Uthen Pialor, the initiative to create Thai musical instruments from recycled materials is driven by his recognition of their inherent value and potential for societal benefits. Rangsitsawat's research (2022) supports this approach, highlighting the creative development of environmentally friendly ceramic waste products. The study emphasizes three fundamental principles: 1) the 4R principles (Reduce, Reuse, Recycle, and Repair), 2) extending product and material lifespans and 3) adapting design and production to meet the specific needs of the target audience. Incorporating various recycled materials into the school's music program offers advantages such as waste reduction and the promotion of innovative craftsmanship, leading to the creation of comprehensive Thai musical instruments.

Through his innovative and creative efforts in developing musical instruments from recycled materials, Uthen Pialor has established himself as a leading Thai educator in repurposing discarded materials to create musical instruments. The public widely respects him and has garnered significant attention from various media outlets interested in his groundbreaking work. Furthermore, he has actively shared his knowledge of crafting Thai musical

instruments from recycled materials and provided these instruments to schools facing resource constraints and difficulties acquiring musical equipment. This admirable initiative enhances educational opportunities and access through alternative media platforms and demonstrates a steadfast commitment to exploration and the pursuit of future advancements. Moreover, it serves as an alternative avenue to promote access to Thai music while simultaneously upholding the preservation of traditional Thai musical instruments.

Research Objectives

This study aims to examine the design concepts and construction techniques utilized in developing musical instruments that incorporate recycled materials, guided by the expertise of Uthen Pialor. The primary objective of this investigation is to explore the intricate aspects of design and construction, shedding light on the innovative methods employed in creating these instruments. Furthermore, this research seeks to investigate the specific materials used in their structure and elucidate the potential advantages and benefits of using recycled materials in the production of musical instruments, all within the contextual framework of Uthen Pialor's scholarly contributions.

Theoretical Framework

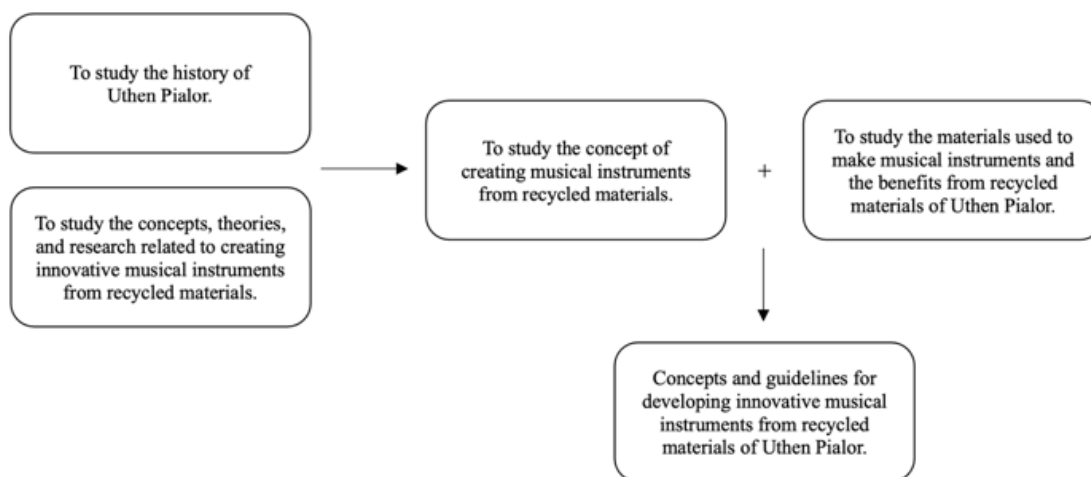


Figure 1. A study on the development of musical instruments from waste materials by Uthen Pialor. Source: Author, 2023.

Musical instruments go beyond their practical purpose as mere tools and surpass their role as lifeless objects. Instead, they embody significance and influence, profoundly shaping human artistic expression, performance technique, physical posture, social relationships, and various aspects of human-object interactions (Allen, 2013:795). Additionally, musical instruments are valuable artifacts rooted in a unique socio-cultural and historical context. They are carefully crafted from natural materials that possess intrinsic worth even before being transformed into musical instruments (Smith, 2018:2).

Literature Review

Musical Instruments

Unique artifacts such as musical instruments combine art and technology in specific ways.

They were created using a compass and a ruler and adhered to particular proportions until the end of the nineteenth century (Perez and Marconi, 2018:208). Musical instruments can be categorized into four main groups: 1) chordophones: instruments that transmit on mechanical vibrating string systems or string instruments, i.e., guitars, violins, and pianos 2) aerophones: instruments that create sound by vibrating an air column, i.e., bagpipes, flutes 3) membranophones: instruments that generate sound by stretching a vibrating membrane, i.e., drums 4) idiophones: instruments that vibrate themselves to make sound, i.e., xylophones (Damodaran et al., 2015; Fletcher, 2012; Kaselouris et al., 2022; Wachsmann et al., 1961).

Musical instruments and materials have a long historical relationship. Many instruments have evolved because of natural structures, specialized materials, players, or artisans. Wood and metal have been the only materials used to build numerous musical instruments. These are considered the preferred materials for creating musical instruments due to their unique mechanical and acoustic characteristics (Damodaran et al., 2015; Fletcher, 2012; Guitar et al., 1974). For instance, the animal gut has traditionally been utilized to make the strings used in the violin family, which significantly impacts tone quality. Synthetic polymers have less loss at high frequencies, provide a brighter sound, and are primarily used in modern violins. The higher strings are constructed of metal, which further lowers high-frequency losses (Fletcher, 2012:131).

In Thailand, musical instruments are categorized into 4 categories based on the method of playing. 1) string instruments refer to musical instruments that the player strums or pickups to make a sound such as the Ja Khae or the Krachappi (four-stringed lute), 2) string instruments refer to musical instruments that the player rubs the string with a bow to make a sound such as Sor or Salo (Thai fiddle), 3) percussion instruments refer to a musical instrument that uses hitting or striking to produce sound such as a xylophone, gong, or drum, and 4) wind instruments refer to musical instruments that are blown to produce sound, such as flutes. Thai musical instruments can be played in two main ways: playing in a band and solo. The band can be divided into 3 main types: the Piphat band, the string band, and the Mahoree band. The Piphat band is an ancient music band that Thailand has adapted directly from Indian music bands, and there has been a clear pattern and technique of playing since the Sukhothai period. In each period, the musical instruments have been added to the Piphat band. For instance, the Piphat band in the Sukhothai period, consist of 5 musical instruments namely Pi Nai (flute), Gong, Klong Tad (two-faced drum), Tapone (two-faced drum), and cymbals. Later in the Ayutthaya period, Ranat Ek, or soprano xylophone was added to the Piphat band (Thepsathit, 2021:12).

The creation of Thai musical instruments is unique and different such as the xylophone which has 17 steps and 37 pieces of equipment, each step is important and can influence the sound quality of the musical instrument. The steps of creating Ranat Ek or soprano xylophone are bamboo selection, segmentation, cutting, soaking, drying, size selecting, shaping bamboo into a bar, size modification, drawing pattern lines, drawing lines to prepare for drilling holes, drilling holes with nail, removing the head and bottom, drill a hole to be threaded, polish uneven bamboo keys, attach the lead to bamboo keys, sound tuning and polishing, and the last step is waxing (Phongkliang & Binson, 2023:115)

Due to environmental changes, wood and metal used to make musical instruments are now becoming more scarce, more expensive, and less desirable. In addition, the quality of the wood varies according to its geographical origins, which makes it difficult to control. Despite having extraordinary mechanical and acoustic qualities, wood has drawbacks such as inconsistent quality, drying, and cracking (Damodaran et al., 2015:2). The scarcity of materials essential for crafting traditional Thai musical instruments presents a significant challenge to instrument makers. This shortage not only impedes production but also threatens the authenticity and quality of these instruments (Chittep, 2019:111). Due to this, most producers of musical instruments are now looking for substitute materials for traditional musical instruments that provide more durability to environmental changes, less material variability, and reduced manufacturing processes (Damodaran et al., 2015; Fletcher, 2012). The requirements for selecting alternative materials are 1) to match the vibrational behavior of the target material and 2) to provide good mechanical strength and workability to match the properties of the existing materials (Damodaran et al., 2015:2).

Recycled Materials

To establish efficient and environmentally responsible waste management systems, increasing the recycling rate is an essential objective. Recycling entails replacing primary resources with secondary resources, which should lessen the environmental effects of the overall system for providing goods and services as determined by the life cycle assessment technique (Ragossnig & Schneider, 2019:2-4). Waste management or the practice of recycling would contribute to making cities clean and green, provide direct economic advantages, and raise awareness of environmental conservation among those involved. The additional socio-environmental benefits such as education, health, improved living standards, clean water and land, and breathable air could be reached, which are the primary goals of the United Nations Sustainable Development Goals (UN-SDGs) (Sharma et al., 2021; Yulianingsih et al., 2020).

A musical instrument was not considered necessary because it was more expensive than housing, transportation, or food. Children in the community had a low chance of being able to afford an instrument because of its high cost (Key, 2020:3). The selection of environmentally friendly materials should be a primary consideration for designers because the product market is becoming more competitive (Chen & Lo, 2019:77). Moreover, the Meanings of Material (MoM) supported that product designers can also use these principles to choose materials suitable for a particular product. Each material also has intangible qualities, such as its relationship to fashion trends, its importance to society, and the feelings a material arouses. These variables are crucial in assisting product designers in choosing suitable materials (Karana et al., 2010: 2932).

The concept of building instruments out of garbage, such as water pipes, kitchenware, and other everyday items from landfills, has developed (Key, 2020:4). Additionally, the construction of musical instruments from natural materials benefits children and people interested in playing music by having easy access because it can be constructed in the community (Kunastian et al., 2022:5)

Musical instruments (i.e., percussion, string instruments, etc.) can be made from recycled materials and craft materials with the use of a variety of techniques, tools, and materials

(i.e., newspapers, magazines, cardboard, plastic, steel, ropes, foam, cans, bottle caps, rubber, fabric, etc.) along with art materials (i.e., scissors, paints, hot glue, etc.) which help the producer define solutions to design challenges using recycled materials with a limited budget (Atkinson, 2020; Hagerman et al., 2022; Yulianingsih et al., 2020). However, as several producers have pointed out, using recycled and upcycled materials is unnecessary in the modern world. Factory-made instruments are now so widely accessible and come in various price ranges that most people probably could afford to acquire one if they wanted to. Producers can access mass-produced parts even while creating their instruments through physical stores or online retailers like eBay (Atkinson, 2020:9).

Design Concepts

The development of musical instruments takes place all over the world. It came from borrowing, adaptation, and inspiration, which affects the broader global musical culture (Magnusson, 2021:182). In the early design process, various aspects need to be taken into account, as shown in Figure 2. Moreover, the designer should also focus on appropriateness in function, ease of production, materials, cost, the number of constituent parts, sales, maintenance, disposal, and recycling (Azman et al., 2021:2).

Economic & ecological design (Eco-design) is a method of increasing production potential by concentrating on decreasing the impact on the environment by reducing waste and extending its lifespan. It takes into account the entire product cycle, from the initial process to the last step. The 4Rs principles are fundamental principles of eco-design and are used in every stage of the life cycle of a product consist of 1) Reduce is a design approach that involves using less material at every stage of the product life cycle, from the design and production phases to consumers who consider the product's durability as well as the end of its lifespan. It contributes to lowering the amount of waste that cannot be disposed of. 2) Reuse is the process of incorporating discarded materials or waste into the design of new items that have already been used or are intended for reuse to achieve new functional goals. 3) Recycled design involves using materials that remain from the manufacturing process to create new items. 4) Repair is the process of designing a product so that it can be easily maintained, which is thought to increase the product's lifespan and leave the least possible amount of environmental damage (Jitmunkongkul & Srithong, 2023:394).

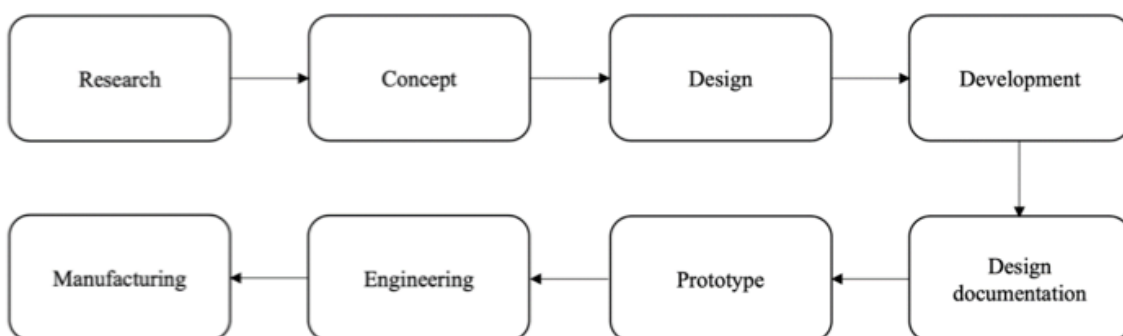


Figure 2. Design process flow. Source: Azman et al., 2021.

Design for Sustainability (DFS), which is defined based on the four pillars of ecological, social, economic, and institutional to promote sustainable products shown in Figure 3.

While considering the effects on human well-being, designers should practice sustainability by using the most effective technology, materials, and manufacturing techniques to produce final products with zero carbon emissions and the least amount of non-renewable resource use possible (Azman et al., 2021:7). Further, they focus on the user experience, which includes how people engage with things and the kinds of meanings and emotions that products arouse. Also make musical instruments better for users by enhancing usability and user understanding (Magnusson, 2021:182), which inspires creative individuals from other disciplines to participate and collaborate throughout the co-creation process to generate novel approaches to problems that will have a positive impact on society (Chen & Lo, 2019:79).

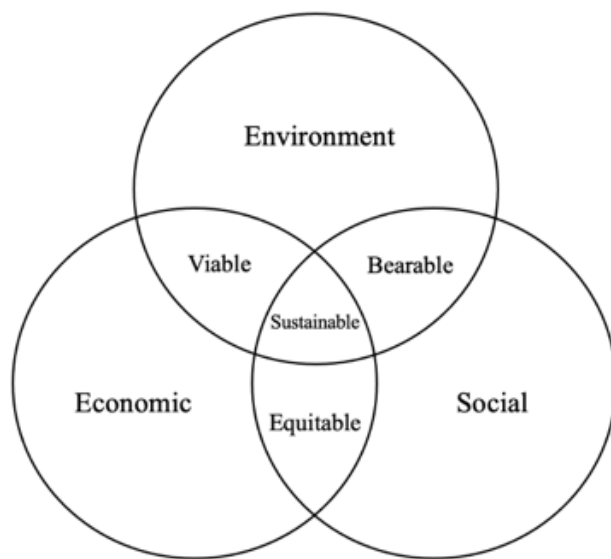


Figure 3. The pillars of sustainability. Source: Azman et al., 2021.

Product designers can employ materials in design concepts to present their work as eco-friendly. Still, they must be more attentive when picking suitable materials for a particular product (Azman et al., 2021:7). The quality of the raw materials used, and the craftsman's skill determine the sound quality of a specific instrument (Damodaran et al., 2015:118). Furthermore, to guarantee that the materials are safe for use, the choice of material frequently depends on the material that has already been used. However, this approach limits the range of materials available. An innovative product's creation depends significantly on the material choice. Designers must continually assess the direction of their design concept while simultaneously producing a variety of ideas from which to choose to avoid selecting the incorrect product design proposal, which may be highly expensive for the manufacturer in terms of money, time, and other precious resources—also preventing from low-quality musical instruments (Damodaran et al., 2015; Rodger et al., 2020).

Construction Techniques

The construction of innovative musical instruments is always a dialectic process that occurs through technological advances, architectural improvements, or new cultural forms (Magnusson, 2021:176). The spread of cultures leads to modifications in the tools, materials, and techniques utilized to create inexpensive, readily accessible musical instruments made from recycled materials (Duangbung, 2022:12)

The idiophones or maracas were made with boxes of milk and rice portion. An empty box was pierced with a wooden skewer stick, and rice was then placed inside. After inserting the skewer stick and fastening elastic bands, attach a second empty box to the top using silicone sealant. Moreover, the empty Styrofoam boxes were used to create chordophones by inserting rubber bands that were stretched and released to create oscillations that produced a range of sounds in an empty Styrofoam box. Eight rubber bands were used to effectively tune to an octave utilizing the Styrofoam instrument as a resonator. In addition, three sizes of handcrafted gongs were created using the six different-sized baking pans. Each pair of identical-sized pans was tied together with tie-ups to resemble a gong when viewed from both the front and the back. The gongs were secured to aluminum broom handles and suspended from a strong stand to form a large musical instrument that resembled a gong. When it strikes the pans, it makes both high-pitched and low-pitched noises. Further, empty Pringles chip containers, pins, rice, and glue were used to make acoustic instruments like rain sticks. These empty boxes' inside surfaces must have included several pins placed in various spots by the constructors. Additionally, hundreds of pins were put into a large cardboard tube to create a sound similar to rain pouring. Carefully placed pins were placed in multiple spots within the cardboard tube and boxes to create resistance in the rice that would be placed inside. The containers were assembled with the pins inside, then filled with rice and sealed with silicone sealant (Tsakiridou, 2022:75).

Phin is a type of stringed instrument with a distinctive sound group called a chordophone (Kammateerawit, 2019:20). Moreover, there were 5 Phin Phu-Tai created from waste materials with the same physical characteristics as follows: neck, headstock, a saddle made of Padauk wood, tuning keys used guitar tuning keys, fret made of flat bamboo ribs, and strings use guitar strings. As for the physical characteristics that are different, it is the body part. It is made from various types and shapes of materials consisting of square-shaped zinc cans, thinner rectangular-shaped cans, round-shaped zinc tin, tin cans, and cylindrical bamboo. The result of the creation showed that the Phin made from thinner rectangular-shaped cans and round-shaped zinc tin were appropriate at the highest level (Kulnasatian et al., 2022: 1). In addition, rubber bands, cardboard boxes, and wooden rods were also used to make stringed instruments by using rubber bands as strings and tied to the box. The rubber band's thickness produces a distinctive and unique sound. To provide a clearer pitch, the wooden rods are also employed as a bridge to lift the strings away from the box (Borsay & Page, 2016:57).

Recognizing that sound quality will influence and impose certain decisions is unavoidable when dealing with construction. Precise widths and masses must be used to create frequencies that fall within the range of human hearing. Sturdy constructions must be considered to maintain the tension of the materials (Tsakiridou, 2022:78).

Benefits

Current resource use is unsustainable. It pressures natural resources, pollutes the environment, and creates significant socio-economic impacts at local, regional, and global scales. The use of waste materials has been more popular over the past ten years due to rising environmental awareness, resource scarcity, high rates of waste generation, and the financial advantages of employing low-cost waste materials (Caldera et al., 2022:8). Waste materials allow people to create musical instruments or utilize materials with unique sound proper-

ties in a group setting. To put it another way, both environmental awareness and creative thinking will be realized and applied to achieve the goals of UN-SDG (Ozturk, 2012; Sharma et al., 2021).

Many micro and small-scale firms are now beginning to perceive it as a business opportunity and have engaged in this practice, which is usually considered a niche practice. The processes integrated into a circular economy (CE) plan are crucial (Caldera et al., 2022:3) and consist of three significant elements value creation, value transfer, and value capture (Centobelli et al., 2020:7). In addition, this strategy should be considered a mandatory approach for waste management (Bigdeloo et al., 2021:1) that promotes recovering value from waste material and achieving sustainability goals (Sharma et al., 2021:1803).

This shows a variety of advantages for society, the environment, and the economy, including increased material quality and life expectancy of materials and goods, lower energy use and greenhouse gas emission, employment creation, and promoting positive consumer behavior (Caldera et al., 2022:8). Moreover, the idea of CE helps to improve material efficiency, slows material flows, and minimizes the need for raw material extraction and the procurement of new products, enhancing environmental sustainability (Bigdeloo et al., 2021:2). Further, the innovators can add value to low-cost waste materials to produce items with a high market value due to their aesthetic appeal and ecological benefits (Bridgens et al., 2018; Caldera et al., 2022).

Finally, small or local businesses could initiate providing services such as waste resource distribution and collection, as well as equipment, training, and facilities to get the use out of waste materials. They may develop instruments for exchanging designs, offering opportunities for product differentiation and connected marketing of other goods intended to be inventively integrated (Bridgens et al., 2018:5)

Research Methodology

This study employs a qualitative research design to address the research objectives effectively. The study consists of two phases, each contributing to a comprehensive understanding of the topic. Phase 1 focuses on exploring the underlying concepts related to the use of recycled materials in the construction of musical instruments and investigating the diverse benefits associated with their incorporation of Uthen Pialor (informant) by using the interview method. In Phase 2, the researcher skillfully synthesized the intriguing findings obtained from the meticulous analysis conducted in Phase 1. This synthesis played a pivotal role in formulating comprehensive guidelines to facilitate the future development of musical instruments that creatively utilize recycled materials. The data was collected at Singburi School provided by Mr. Uthen Pialor, a professional music teacher at Singburi School in Singburi Province, Thailand. He won the first prize in the music band contest from waste materials and is also an expert in creating Thai musical instruments from waste materials. Further, he has knowledge and experience in making musical instruments from waste materials for over 20 years.

Research Instruments

The tool used in this research was a semi-structured interview to interview Uthen Pialor, an expert in musical instrument design and development from waste materials. The insights

gathered from these interviews undergo systematic collection, meticulous examination, comprehensive analysis, and skillful synthesis, resulting in substantial knowledge. This knowledge serves as a solid foundation for future endeavors in designing and developing musical instruments that ingeniously incorporate recycled materials. The researcher takes on the role of conducting interviews, collecting data, recording video, and recording audio. The questions in this in-depth interview allow the informant to explain and describe according to his understanding. The interview questions, presented as exemplars, encompass a wide range of topics, such as the creative ideas and inspirations guiding the design of various musical instruments, the financial aspects involved in instrument design and development, the critical factors to consider when designing instruments using recycled materials, and the differences between developing instruments with recycled materials and prevailing design practices, including the accompanying challenges. The primary objective of these interviews is to acquire invaluable insights and perspectives related to the design and development of musical instruments that effectively integrate recycled materials.

Data Collection

The researcher uses a qualitative research model to collect data and analyze results to meet the research objectives. The researcher divided the research into 2 phases: In phase 1, the researcher studied the development concept. Waste materials used to make musical instruments and the benefits of musical instruments from the waste materials Uthen Pialor (informant) by interviewing the informant. To ask for information and to be analyzed and separated into interesting issues and guidelines. In the second phase, the researcher brought exciting points from the first phase analysis to synthesize them as guidelines for the design and development of musical instruments from waste materials. These are as follows:

Phase 1: Study of the development concepts of waste materials used to make musical instruments and the benefits of those made from waste materials by Uthen Pialor. In the first phase, the researcher used a semi-structured interview form to study the following two issues: 1) Concepts of design and construction of musical instruments, 2) Materials used to create musical instruments, and the benefits of musical instruments made from waste materials of Uthen Pialor. The researchers analyzed the data obtained from interviews about the concept of design and construction of musical instruments, materials used to make musical instruments, and the benefits of musical instruments made from waste materials by Uthen Pialor by separating them into interesting issues and synthesizing the data to draw a qualitative conclusion in the second phase.

Phase 2: Synthesizes information to guide the design and development of musical instruments from waste materials. The second phase is data analysis and synthesis to answer research objective questions. When receiving complete information to answer the research objectives, the researcher analyzed the information obtained from interviews about making musical instruments. Materials used and benefits of musical instruments from Uthen Pialor waste materials by separating them into interesting issues and synthesizing them. Then the researcher summarized the results in an explanatory manner to understand the concept of designing and developing musical instruments from the waste materials of Uthen Pialor.

Data Analysis

The researcher used data analysis based on the concept of Colizzi, with the following data analysis steps:

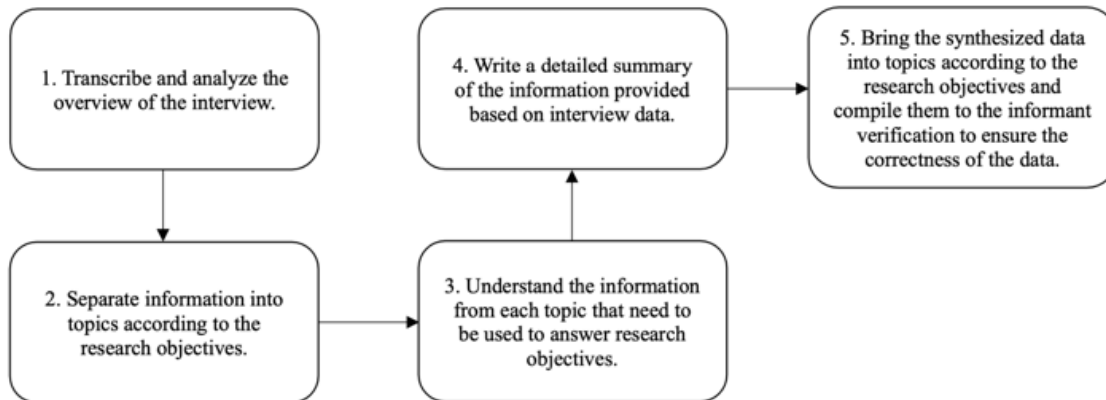


Figure 4. Data analysis procedures according to the concept of Colizzi. Source: Author, 2023.

Results and Discussion

The researcher has analyzed and summarized the musical instruments, material used, benefits, limitations, and budget of constructing musical instruments from waste materials by Uthen Pialor, as shown in the table below.


Instrument Name (With Illustrations)	Materials Used	Benefits	Limitations	Budget (USD)	Material Selection Techniques	Tuning Techniques
1. Ja khae (Thai zither) 	1. Plywood 2. Hardwood 3. Bamboo 4. Pencil case 5. Used PVC pipes or wood 6. Nuts and bolts 7. Strings 8. Wood paint	Reduce the details and the cost of production of the original instrument. (The actual price is about 233 USD)	The sound is quieter, and the quality is also different from the original zither.	17	The waste material such as plywood can be used to be assemble the body of the Thai zither because plywood is easy to shape and has similar characteristics to the original material. The creator can select an old pencil case that is the right size to create a zither bridge and tune the sound, which a pencil case can be installed without changing its material characteristics.	The sound quality can be adjusted by tuning with the original Thai zither or using a tuning application, in which the sound quality will be similar to the original zither, but it is different in loudness. The material used is different from the original instrument but the volume can be adjusted by changing the distance to the height of the bridges (The bamboo sheet that separates the cable from the wooden box).

Figure 5. Table listing the musical instruments, materials used, benefits, limitations, and budget for constructing musical instruments from waste materials by Uthen Pia Loh.



Instrument Name (With Illustrations)	Materials Used	Benefits	Limitations	Budget (USD)	Material Selection Techniques	Tuning Techniques
<p>2. Hai (Plucked string instrument)</p> 	<p>1. 2 jars (different sizes) 2. Motorcycle inner tubes</p>	<p>It can be used instead of drums. The sound is very resonant and able to tune.</p>	<p>The sound must be tuned before playing, and the rubber used may get damaged if exposed to sunlight for a long time.</p>	<p>-</p>	<p>The leftover materials from the household such as jars that are left over from fermenting food and old inner tubes can be used to create Hai because they are a highly flexible material, resistant to stretching, and can be easily adjusted to be tight and loose.</p>	<p>Hai can be tuned to the high or low pitch by tightening the rubber band. If the strings are tight, it will produce a higher pitch. If you slacken the string, it will make a low pitch. The water can be added to the jar to produce a higher pitch. There is no original instrument to compare and tune the sound with, so Mr. Uthen used the comparison of the sound of the Klong khaek (The drums that had the loud penetrating sound were labeled male and a drum with the gentler sound was female).</p>
<p>3. Sor au (Alto fiddle)</p> 	<p>1. Cookie tin 2. Bamboo 3. Hardwood 4. Strings 5. Fiddle strings</p>	<p>The sound quality is like an original alto fiddle.</p>	<p>Making the grooves for tuning cables requires a lot of precision.</p>	<p>6</p>	<p>The large leftover cans are commonly found as a replacement material for sound amplification, and string from the fishing hook to set the sound of the instrument.</p>	<p>The sound of the alto fiddle can be adjusted by using the tension of the strings. In addition to the Thai fiddle, it is possible to turn and adjust the tension of the string immediately for convenience in setting up strings. However, it has a lower sound than other types of fiddles because the can is used for amplifying sound to a large size which creates a low-pitched fiddle sound.</p>

Figure 5 cont. Table listing the musical instruments, materials used, benefits, limitations, and budget for constructing musical instruments from waste materials by Uthen Pia Loh.




Instrument Name (With Illustrations)	Materials Used	Benefits	Limitations	Budget (USD)	Material Selection Techniques	Tuning Techniques
4. Sor sam sai (Three-stringed fiddle) 	1. Cookie tin 2. Bamboo 3. Hardwood 4. Strings 5. Fiddle strings	The sound quality is like an original fiddle.	Making the grooves for tuning cables requires a lot of precision.	6	The creator can select strings based on the original fiddle, then measure the size of the cookie tin to be the same as the actual size of the fiddle and assemble it with a bamboo neck, fingerboard, and bow.	The sound of a three-stringed fiddle can be adjusted to high and low by using the tension of the strings. Also, the sound quality is similar to the original instrument because it uses the same type of fiddle strings.
5. Sor duang (Soprano fiddle) 	1. A can 2. Fishing line 3. Strings No. 0.25 4. Hardwood	The sound quality is like an original fiddle.	Making the grooves for tuning cables requires a lot of precision.	6	The technique is similar to a three-stringed fiddle.	The use of fishing line no.100 and no. 80 resulting in different sound levels and using fishing line number 0.25 to make the bow by measuring the length to be the same as the original instrument. The sound can be adjusted by using the tension of the strings. In addition to the Thai fiddle, it is possible to turn and adjust the tension of the string immediately for convenience in setting up strings.
6. Ranat ek (Soprano xylophone) 	1. Tiles 2. Plywood 3. Rubber air hose 4. Calico for making mallets 5. Hardwood	The sound level is stable, tuning before playing is not required.	The tiles may break if the player strikes too hard.	6	The creator can select materials left over from the construction such as tiles that can be struck and produce a resonating sound.	The sound can be tuned with the original soprano xylophone from the Piphat band, beginning with the Sol (S). The creator can also use an electric grinder to grind the tile to different sizes and thicknesses. For the high pitch, the creator can grind the tiles to be smaller and thinner but for the low pitch, the tiles must be bigger and thicker.

Figure 5 cont. Table listing the musical instruments, materials used, benefits, limitations, and budget for constructing musical instruments from waste materials by Uthen Pia Loh.




Instrument Name (With Illustrations)	Materials Used	Benefits	Limitations	Budget (USD)	Material Selection Techniques	Tuning Techniques
7. Ranat thum (Alto xylophone) 	1. Tiles 2. Plywood 3. Rubber air hose 4. Calico for making mallets 5. Hardwood	The sound level is stable, tuning before playing is not required.	The tiles may break if the player strikes too hard.	6	The technique is similar to soprano xylophone.	The sound can be tuned with the original alto xylophone from the Piphat band. The creator can also use an electric grinder to grind the tile to different sizes and thicknesses. For the high pitch, the creator can grind the tiles to be smaller and thinner but for the low pitch, the tiles must be bigger and thicker.
8. Khong wong yai (Large gong circle) 	1. 16 different size ceramic bowls 2. Plastic box 3. Plywood 4. Chopsticks for striking	It can be used as well as the original gong.	It is difficult to move and needs to be tuned every time. The sound is less resonant than the original gong and cannot strike too hard.	6	The material used to create this musical instrument has to be able to produce sound with different high and low pitches. Mr. Uthen has chosen to use various-sized ceramic plates and bowls that can be struck and produce a sound that resonates like a gong.	The sound level can be adjusted and tuned with the original gong by choosing different sizes of bowls and adjusting the amount of water in each bowl to create different sound levels. There are limitations in adjusting the sound, the amount of water must be adjusted every time the instrument is moved. This causes the sound to be easily distorted. The chopsticks are used instead of mallets because they are lightweight and commonly found.
9. Hmong (Gong) 	1. Aluminum box 2. Wood for the frame 3. Rope	Lightweight	The sound quality is also different from the actual gong and less resonant.	-	The creator can select waste materials that can be struck to produce a sound while still being durable and beautiful. Therefore, a round aluminum box was chosen to resemble the original musical instrument.	The sound can be adjusted by pounding the center of the aluminum box to create a raised shape using a stone pestle which creates a sound that similar to the original gong. The creator also can adjust the convexity and width of the convex point according to the preference.

Figure 5 cont. Table listing the musical instruments, materials used, benefits, limitations, and budget for constructing musical instruments from waste materials by Uthen Pia Loh.

Instrument Name (With Illustrations)	Materials Used	Benefits	Limitations	Budget (USD)	Material Selection Techniques	Tuning Techniques
10. Tapone (Two-faced drum) 	1. An old two-faced drum frame 2. Drumhead (snare drums, bass drums) 3. Plywood for the base	The drumheads are durable and easier to take care of than the leather. It can be used to practice instead of the two-faced drum.	The sound quality is different from the leather drumhead.	6	The material of the old Tapone that has been damaged and decayed, such as the drumhead can be used to create a new Tapone. However, Mr. Uthen has chosen waste materials to replace the drumhead of Tabon, by using the international bass drumhead that has been broken and stretched instead. It is the selection of waste materials to be useful again as a new musical instrument.	Tapone can adjust the pitch by tightening the drumhead by stringing the edge and using liquid glue to hold the edges of the drumhead with the frame.
11. Ching (Cup-shaped cymbal) 	1. 2 bicycle bells 2. Rope	It can be used as well as the original cymbals.	The sound quality is still very different from the original cymbals.	-	The material used to create a cup-shaped cymbal has to be durable and sound similar to the original instrument because it is a musical instrument that creates sound by percussion. It can be damaged if using fragile materials.	The volume cannot be adjusted, it depends on the size of the bicycle bell. A small size bicycle bell will produce a high-pitch sound while a larger size produces a low-pitch sound.
12. Ching (Cup-shaped cymbal) 	1. 2 gas stove heads 2. Rope	The sounds are similar to an original cymbal, very durable, and can be substituted.	Heavier than the original cymbal	-	The alternative material selection for cup-shaped cymbals such as gas stove heads made from brass. It creates a sound that similar to the original instrument.	The volume cannot be adjusted because a gas stove head is strung with rope. There are no customizations have been made.

Figure 5 cont. Table listing the musical instruments, materials used, benefits, limitations, and budget for constructing musical instruments from waste materials by Uthen Pia Loh.




Instrument Name (With Illustrations)	Materials Used	Benefits	Limitations	Budget (USD)	Material Selection Techniques	Tuning Techniques
13. Chab (Cymbal) 	1. Tin lid 2. Rope	Lightweight	The sound quality is still very different from the original cymbals.	-	The alternative material selection for the cymbal should be durable use which is the tin lid.	The volume cannot be adjusted. The creators created it to complete a set of musical instruments only, so the creators chose to use leftover materials that are durable and can make a sound when hitting. However, the sound quality is not very good.
14. Krap puang (Castanet) 	1. Bamboo 2. Tin lid 3. Strings	Lightweight and durable	-	-	To create a castanet, the creator must select durable materials to prevent damage when playing. Therefore, Mr. Uthen assembles a piece of tin lid with a piece of bamboo to create a sound.	The sound quality can be adjusted by increasing or decreasing the number of tins and bamboo sheets. The sound needs to be adjusted once during the creation of the instrument. It will be difficult to adjust the sound, loudness, or softness when it is built. Further, it depends on the number of records and the power of the player. The sound quality is not very good because the creator created it because they wanted to have a complete set of musical instruments only.
15. Khlui (Flute) 	1. PVC pipe 2. Teak	It sounds like an original flute and is durable.	The sound quality is slightly different from a wooden flute.	-	Waste materials such as PVC pipes that have the same diameter as the original flute can be used to create a new instrument by cutting to the same length as an actual size.	Adjust the sound quality by drilling a hole the size of a flute using a drill to decorate and trim the sound hole (mouthpiece) using teak wood. Adjust the sound by sharpening the width of the area through which the air flows by comparing the sound from the original instrument.

Figure 5 cont. Table listing the musical instruments, materials used, benefits, limitations, and budget for constructing musical instruments from waste materials by Uthen Pia Loh.

As illustrated in Figure 5's table, it can be concluded that Uthen Pialor has created 15 musical instruments from waste materials (i.e., wood, used tiles, PVC pipes, or cookie tins), and each instrument took about 2-4 days to construct. The concept of making musical instruments from waste materials of Uthen Pialor found that he had ideas about making musical instruments from waste materials, which would later become unwanted. Waste materials have been used to construct musical instruments, which makes Thai musical instruments more accessible and cheaper than the originals. For instance, a cymbal made from a bicycle bell, a cymbal made from a gas stove, a cymbal made from a tin lid, a flute made from PVC pipe, a xylophone made from tile scraps, and fiddle made from zinc can. It is a creative use of materials to solve the shortage of musical instruments, which teachers can apply in teaching or in groups of people interested in playing Thai music. A Musical instrument from waste materials such as water pipes, kitchenware, and others every day allows children in society to have more accessibility to musical instruments (Key, 2020:4). Moreover, musical instruments from waste materials can enhance the emotional development of the elderly also add value to environmentally friendly waste materials (Boonrod, 2022:150).

Likewise, Uthen Pialor mentioned the benefits of making musical instruments from waste materials that can solve the shortage of musical instruments, reduce waste, solve environmental problems, create musical instruments more accessible, and easier to play, reduce the complex details of the instrument, and less the cost of production. Environmentally friendly materials should be a key consideration due to environmental changes, materials scarcity, and inconsistent quality (Chen & Lo, 2019; Damodaran et al., 2015). This practice provides a variety of advantages for society, the environment, and the economy, which help to achieve sustainability goals (Caldera et al., 2022:1). However, his anticipate is further developing musical instruments from waste materials to have an appearance and sound quality comparable to traditional Thai instruments and can be applied to creating international musical instruments. Uthen Pialor is considered an innovator in the development and design of Thai musical instruments from waste materials by trying different materials to develop Thai musical instruments that have good tones or methods of playing that come out well and with the quality known as a “ครูผู้ผลิตเครื่องดนตรีจากวัสดุเหลือใช้ or a teacher who produces Thai musical instruments from waste materials.”

Conclusion and Recommendations

In conclusion, the journey of Uthen Pialor in creating musical instruments from waste materials showcases inspired from Siwasit Nilswan not only his innovative spirit but also the potential for sustainable creativity within the realm of traditional music. Over more than two decades, he has transformed discarded materials into functional musical instruments, demonstrating a commitment to environmental consciousness and cultural preservation. Through trial and error, Kru Ten has successfully crafted instruments such as the canned fiddle and the tile xylophone, which have not only garnered recognition in competitions but have also provided viable alternatives to traditional Thai instruments. His dedication to utilizing durable residual materials while avoiding hazardous substances underscores his commitment to safety and sustainability. Despite his achievements, there remain opportunities for further refinement and development. Kru Ten acknowledges the need for improvement in both the aesthetic appeal and sound quality of his instruments. With a vision to enhance the beauty and realism of his creations, he seeks to bridge the gap between traditional and recycled musical instruments, ensuring their continued relevance and utility

in contemporary settings. Moving forward, Kru Ten suggested that the creator can continue to explore innovative techniques and materials to enhance the quality and diversity of his instruments. Collaboration with experts in sound engineering and instrument design could provide valuable insights for achieving international standards in both craftsmanship and performance. Additionally, efforts to increase accessibility to these instruments within society, perhaps through educational initiatives or community workshops, would further amplify their impact and promote sustainable practices in the realm of music.

In essence, the pioneering work of Uthen Pialor serves as an inspiration for musicians, artisans, and environmentalists alike, and researchers can build upon the foundation established by Kru Ten, contributing to the ongoing advancement of sustainable and innovative practices in the field of instrument-making. Also, illustrates the transformative power of creativity and resourcefulness in preserving cultural heritage while embracing sustainable practices. Through continued dedication and collaboration, the realm of musical instrument making from waste materials can not only meet international standards but also contribute to a more harmonious relationship between art, nature, and society.

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