

CERAMIC PUZZLE DESIGN: EDUCATING THE NOBLE VALUES OF BUDDHA GAUTAMA'S TEACHINGS FROM THE RELIEFS OF BOROBUDUR TEMPLE

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Abstract. This study explores the development of a practice-based educational tool - Ceramic Puzzle Design - inspired by the narrative reliefs of Borobudur Temple. As access to the temple's upper levels becomes increasingly restricted to preserve the structure, alternative learning models are essential to ensure sustained engagement with its rich cultural and spiritual heritage. The puzzle integrates traditional ceramic craftsmanship with interactive digital components, including QR-coded guides that facilitate the interpretation of key Buddhist philosophical themes. Employing a practice-based research methodology, the project involved material experimentation, visual abstraction of reliefs and iterative prototyping through collaboration with ceramic artisans and designers. The production phase yielded three distinct ceramic puzzle prototypes, each representing a curated narrative sequence from Borobudur's relief panels. A simulation and evaluation framework was also designed to incorporate qualitative observations and thematic analysis to assess user engagement and interpretive understanding. This project demonstrates how hybrid craft-digital approaches can reframe complex religious narratives into accessible educational tools, thereby contributing to heritage preservation and spiritual literacy.

Keywords: *Ceramic puzzle design, Borobudur Temple relief, noble teachings of buddha, digital learning.*

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1. Introduction

Borobudur Temple is an architectural and cultural marvel in Central Java, Indonesia. Constructed in the 8th and 9th centuries under the rule of the Sailendra Dynasty, it is the largest Buddhist monument in the world (Prasetyo, 1993). This temple, with its intricate carvings and grand structure, serves as a place of religious significance and an important source of knowledge and historical narrative. The temple comprises nine stacked platforms, a large central dome surrounded by seventy-two Buddha statues, each seated within a perforated stupa. The walls of Borobudur are adorned with intricate bas-reliefs that narrate stories from Buddhist teachings, including the life of Buddha, karma and moral values. Each relief panel carries a story from when it was created, forming an extensive visual scripture reflecting Buddhist teachings. The reliefs at Borobudur Temple include Karmawibhangga, Lalitavistara, Jatakamala-Jataka, Awadana, Gandawyuha and Bhadrachari (Heraty, 1985).

One essential aspect of Borobudur's reliefs is their ability to convey philosophical teachings through symbolism and visual narrative. Each carved panel represents a deeper meaning, encompassing depictions of daily life, moral lessons and cosmic interpretations of existence. The temple itself is designed as a mandala, guiding visitors on a symbolic pilgrimage from the earthly realm (kamadhatu) through the transitional world (rupadhatu) to the realm of enlightenment (arupadhatu). This architectural and artistic integration provides a unique way to experience Buddhist philosophy, allowing visitors to engage in a structured meditative journey while ascending the monument.

Recognizing its cultural and historical significance, UNESCO designated Borobudur Temple as a World Heritage Site in 1991 (Susilo & Suroso, 2014). As one of Indonesia's most treasured landmarks, the temple attracts millions of visitors annually and is an important site for cultural education and historical exploration. However, in recent years, conservation efforts have restricted visitor access to the temple's upper levels. These restrictions aim to preserve the structural integrity of the temple but have inadvertently limited the direct interaction that visitors, especially younger generations, can have with the reliefs. This limitation raises concerns regarding how Borobudur's artistic and philosophical legacy can be effectively disseminated and preserved for future generations despite restricted physical access.

To address these challenges, this study explores the development of an innovative educational tool - the Ceramic Puzzle Design - which integrates traditional ceramic craftsmanship with modern digital elements. This project seeks to create interactive ceramic puzzles replicating Borobudur's reliefs, providing an engaging and tactile learning experience. By bridging traditional artistry with digital learning, this educational tool aims to enhance the public understanding of Borobudur's artistic and historical narratives in an interactive and accessible manner.

The significance of this research lies in its contribution to the intersection of traditional craftsmanship, cultural heritage and contemporary educational methodologies. By incorporating historical narratives into interactive ceramic puzzle pieces, the project presents an alternative medium for cultural education that transcends the limitations of physical site visits. Through this approach, the study aims to foster a greater appreciation of Borobudur's heritage while ensuring its cultural and philosophical teachings remain accessible to future generations. The following sections will comprehensively explore relevant literature, methodological approaches and theoretical frameworks to establish the foundation for the Ceramic Puzzle Design. This educational craft product merges traditional ceramic art with digital learning tools for interactive cultural engagement.

2. Literature Review and Theoretical Framework

2.1. Learning Theories and Interactive Educational Media

Contemporary educational research supports the effectiveness of physical interaction in learning. Experiential learning theory (Kolb & Kolb, 2017) emphasizes that knowledge construction is most effective when learners use direct, tactile experiences, reflecting on concrete interactions, to form abstract concepts. Experiential learning aligns with modern constructivist approaches (Hmelo-Silver *et al.*, 2018), highlighting how learners actively build understanding through hands-on exploration and social collaboration, updating Piaget's (1970) foundational work with recent empirical evidence.

In cultural heritage education, interactive tools have been shown to enhance engagement and knowledge retention significantly. Falk and Dierking's (2016) Contextual Model of Learning demonstrates that multisensory experiences - combining physical interaction with digital narratives - strengthen cognitive and emotional connections to historical artifacts. Recent museum education studies further validated that tactile, gamified exhibits (e.g., puzzle-based interfaces) improve recall and empathy toward cultural content (Rahaman *et al.*, 2019).

The Ceramic Puzzle Design project operationalized these principles by transforming Borobudur's reliefs into a tangible, reconstructible narrative. This approach leverages embodied cognition theory (Johnson-Glenberg, 2018), which proposes that the physical manipulation of objects enhances conceptual learning. By integrating barcode-scanned digital content, the design bridges Kolb and Kolb's experiential cycles (2017) with contemporary digital storytelling methods, fostering active participation rather than passive observation.

2.2. The Intersection of Traditional Craft and Digital Learning

Ceramic craftsmanship has historically been a powerful medium for cultural storytelling and experiential education. The reliefs of Borobudur exemplify this tradition in which ceramic art is used to encode religious and moral narratives in tactile forms (Tanudirdjo, 2012). Contemporary studies affirm that ceramic-based educational tools - with their durability, aesthetic richness and haptic engagement - enhance memory retention and emotional connection to cultural content (Lackovic, 2020; UNESCO, 2022; Malinverni *et al.*, 2022). For example, Malinverni *et al.* (2022) found that children interacting with ceramic puzzles showed a 1.5x greater emotional connection cultural narratives than those using digital tablets. Similarly, UNESCO (2022) documented a 35% increase in story retention among Indonesian students using ceramic replicas in museum workshops.

Fusing traditional craft with digital tools aligns with tangible computing frameworks (Resnick, 2017) and embodied interaction theories (Dourish, 2021), which posit that physical manipulation of objects paired with digital feedback deepens cognitive engagement. Recent case studies have highlighted how augmented reality (AR) and QR codes can contextualize ceramic artifacts by layering animations, oral narratives or gamified quizzes (He *et al.*, 2018; Ghouaiel *et al.*, 2017). For example, Recent implementations demonstrate how digital tools enhance ceramic heritage engagement: 1) The use of Augmented Reality (AR) significantly enhances visitor engagement and satisfaction when experiencing art exhibitions (He *et al.*, 2018); 2) The implementation of an AR prototype at the Louver demonstrated a 40% increase in interaction time with artifacts, 25% higher information retention in post-visit tests and 78% of visitors reported that AR made their visit more meaningful (Ghouaiel *et al.*, 2017).

This project operationalized hybrid learning by embedding scannable barcodes in ceramic puzzles, creating a “phygital” (physical + digital) interface. The approach addresses two critical gaps in heritage education: 1) Accessibility: Digital layers compensate for restricted physical access to Borobudur (e.g., preservation policies). 2) Multisensory Learning: This approach combines the tactile benefits of ceramics with the dynamic storytelling capacity of digital media (Malinverni *et al.*, 2022). By merging craft traditions with interactive technologies, the design preserves cultural heritage and aligns with 21st-century pedagogical trends (OECD, 2023) that prioritize multimodal, student-centered learning.

2.3. Conceptual Framework and Previous Research

To establish a structured approach to this study, a conceptual model is developed, linking key elements: (1) Borobudur reliefs as narrative and educational artifacts, (2) interactive learning theories that support engagement through tactile media and (3) hybrid educational tools that integrate traditional craft with digital enhancements.

a. Several previous research initiatives have explored interactive cultural education tools:

b. Augmented Reality for Cultural Heritage (Ghouaiel *et al.*, 2017): Demonstrates how mobile AR applications enhance museum experiences by providing interactive learning through contextualized content delivery at the Louvre Museum.

c. Tangible Heritage Education (Bonsignore *et al.*, 2013): The effectiveness of hands-on models in fostering engagement with historical artifacts is highlighted.

d. Craft-based Learning (Gauntlett, 2018): Explores how traditional crafts can be adapted for contemporary educational contexts.

3. Method

This study adopts a practice-based research approach that integrates creative practice as an essential part of the research process. This approach is aligned with the methodology developed by the Empirica Research Group at Aalto University, which emphasizes the interaction between artistic practice and academic inquiry to generate new knowledge (Nimkulrat, 2012; Mäkelä & Routarinne, 2006). In this context, the development of Ceramic Puzzle Design is intended both as an educational tool and a research medium to explore the intersection of traditional crafts, digital technology and interactive learning experiences.

3.1. Practice-Based Research Approach

As a practice-based study, this research focuses on material exploration, production techniques and user interaction within the context of cultural and historical education. This approach enables a deeper understanding of how physical artifacts such as ceramic relief puzzles can be practical educational tools. According to Scrivener (2000), practice-based research generates knowledge embedded in the process of making itself, making it particularly relevant for studying tangible learning media. In the context of ceramic puzzle design, this involves the following:

a) Reflective practices in which design and production processes inform theoretical insights.

b) Iterative experimentation testing different materials and digital integration methods.

c) Engagement with craft and technology, ensuring a balance between traditional techniques and modern interactivity.

3.2. Development of the Ceramic Puzzle Design

The development of Ceramic Puzzle Design follows an iterative design process consisting of the following stages:

3.2.1. Design Exploration

Literature review of Borobudur reliefs and their visual representation in interactive formats (Fontein, 1990). Experimentation with puzzle shapes that optimize user engagement and cognitive learning (Kolb, 1984; Packer, 2008). The design process involved sketching, modeling and prototyping, carefully maintaining the aesthetic and symbolic integrity of the original reliefs.

3.2.2. Material and Production Techniques

Testing various types of clay and relief casting techniques to ensure that intricate details remain visible in ceramic form (Clark, 2012). Developing color application and finishing techniques to replicate the aesthetic of Borobudur's reliefs while maintaining durability.

3.2.3. Digital Integration and Interactivity

Digital game-based learning improves educational outcomes (Hwang *et al.*, 2014), suggesting the potential for QR code integration as a supplementary tool. We conducted usability tests to evaluate user responses to integrating interactive features.

3.3. Planned Evaluation and Evaluation Strategy

Although direct user testing of the Ceramic Puzzle Design has not yet been conducted, a comprehensive simulation and evaluation plan has been prepared to assess its educational effectiveness and user engagement in future stages. This simulation will be implemented in a controlled educational setting, such as a classroom or museum learning workshop, where participants, consisting of students, teachers and cultural learners, will engage with the ceramic puzzle sets.

The simulated activity involves assembling a set of ceramic puzzle tiles representing selected narrative reliefs from Borobudur Temple. Participants will be encouraged to interpret the imagery, interact with the embedded QR codes or digital guides and reflect on the philosophical meanings embedded in the reliefs. The simulation follows a structured scenario, including a brief introduction, hands-on assembly and guided discussion or reflection to assess learning and engagement. This plan aims to simulate authentic interactions while ensuring that data on learning outcomes and user responses can be effectively captured through observation and dialogue.

3.4. Anticipated Data Analysis and Evaluation

This study adopts a qualitative, practice-based research approach. The simulation analysis will focus on the interpretive understanding of user experience. Data will be collected through observation protocols, semi-structured interviews and participant feedback forms. Thematic analysis will examine the narratives and patterns that emerge from participants' interactions with the puzzle.

This analytic process will involve coding interview transcripts and observational notes to identify key themes such as engagement behavior, perceived cultural relevance, understanding of Buddhist values and ease of use. The analysis will draw from the Braun and Clarke (2006) framework for thematic analysis, which allows for rich, contextual interpretation of qualitative data. Through this approach, the study aims to generate insights about the educational potential of ceramic puzzle design and how users engage

with cultural artifacts in interactive formats. These findings will inform future design iterations and contribute to the broader discourse on experiential learning and heritage-based education.

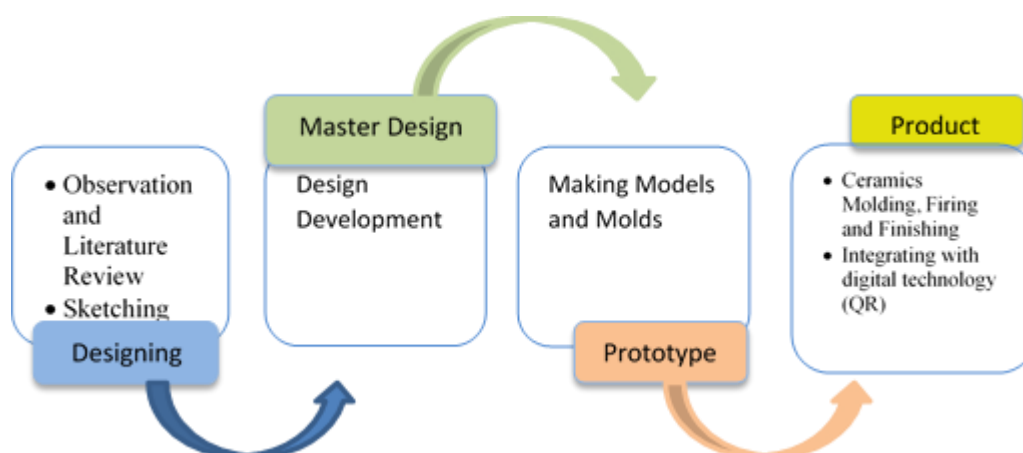


Figure 1. Research stage

4. Result and Discussion

4.1. The Process of Puzzle Creation

4.1.1. Observation and Identification of Borobudur Temple Reliefs

The first stage of this process involved direct observation of Borobudur Temple's reliefs and an in-depth study of its philosophical and symbolic meanings. Observations were made by visiting the temple, photographing and taking notes on the details of the reliefs, especially those depicting noble Buddhist values such as *dāna* (generosity), *śīla* (morality) and *prajñā* (wisdom). In addition, a literature review is conducted to explain the academic interpretation of the reliefs. At this stage, scientific books and articles on the art and architecture of Borobudur Temple (Miksic, 2021; Larisa, 2001; Fontein, 1990; Soekmono, 1981) and studies on Buddhism (Cowell, 2000; Huntington, 1985) became the primary references. This study aims to determine which relief panels are most suitable for adaptation into educational media through the creation of ceramic puzzles.



Figure 2. Observation and documentation
Source: Researcher (2024)

In addition, interviews were conducted with professional tour guides certified by the Borobudur Conservation Office (Balai Konservasi Borobudur) under the Indonesian Ministry of Culture. These guides typically hold educational backgrounds in archaeology or history, having completed specialized training programs that cover Borobudur's art history, Buddhist philosophy and heritage interpretation techniques approved by the Ministry. Their academic training and field experience enables them to provide scholarly and practical perspectives on how the reliefs communicate Buddhist values. This approach aligns with the temple's status as a UNESCO World Heritage Site and requires accurate dissemination of its cultural significance. The guides' insights were particularly valuable in understanding how abstract philosophical concepts from the reliefs can be made accessible to modern audiences. This combination of direct observation, interviews and literature review provided a strong foundation for understanding the noble Buddhist values expressed in the reliefs. It ensured that these messages could be effectively translated into the ceramic puzzle designs to be created.

After looking at and studying the various reliefs found at Borobudur Temple, we chose the reliefs that will be used as a source of ideas for doing ceramic puzzles. In Table 1, we can see the image and description of the relief.

Table 1. Selected relief

No	Figure	Discription
1		This relief comes from the Jatakamala story when King Sakra (king of the gods) asked for an eyeball from King Siwi, who was known to have good character and was very generous. Then, King Sakra intended to test how generous King Siwi was. Raja Sakra disguised himself as an old and blind Brahmin who asked Raja Siwi for an eye to be donated to him. King Siwi, known to be kind and generous, did not think twice and fulfilled the Brahmin's request. One eye was given to the Brahmin and immediately, the eye that had been given to the Brahmin returned to King Siwi and the Brahmin turned into King Sakra and believed that King Siwi was indeed noble and generous (Cowell, 2000).
2		This relief is taken from the Jataka relief story carved in the candi Borobudur, which instructs humans always to do good to all creatures, be it humans, animals or plants. The Jataka reliefs carved in several relief panels bear high ethical values (Cowell, 2000).

4.1.2. Design Process

The interpretive process involves systematically distilling the didactic content of Borobudur's narrative reliefs into simplified visual schemata while preserving their doctrinal essence. This representational strategy consciously avoids direct replication by employing selective abstraction to foreground the core soteriological messages of the panels. As established by Fontein (1990) and further developed by Miksic (1990), each relief constitutes a sophisticated visual exegesis of Buddhist ethical principles, with particular emphasis on the *pāramitās* (perfections) including *dāna* (generosity), *śīla* (morality) and *prajñā* (wisdom). Our visual translation methodology follows Kemp's (1998) “intelligent simplification” principles whereby complex iconographic programs are reduced to their essential formal and semantic components without compromising doctrinal fidelity. The resultant schematic representations maintain what Huntington (1985) identifies as the “visual rhetoric” of Buddhist pedagogical art while achieving greater accessibility for contemporary audiences.

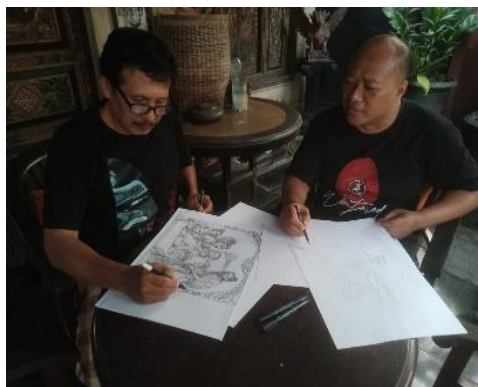


Figure 3. Sketching
Source: Researcher (2024)

The final designs are not copies of the original reliefs but thoughtful reinterpretations that distill their essential symbolism. Each composition was first developed as a complete visual narrative, consciously maintaining the integrity of the Buddhist teachings before being divided into puzzle elements. This approach requires a nuanced understanding of the spiritual concepts embedded in the reliefs: their depictions of compassion, moral discipline and enlightenment. The resulting designs serve a dual purpose: they preserve the aesthetic beauty of Borobudur's art while making its profound messages accessible to contemporary audiences. Through careful simplification, visual language can retain artistic power and its capacity to convey ancient wisdom.

In design, as shown in Figure 4, a message of kindness emphasizes the importance of generosity or charity without distinguishing ethnic background, class or social status. This design is inspired by Relief No.1, in which the king, through all his kindness, gives his eyes to a Brahmin who needs them. The following symbolic interpretation is developed by the author as part of a reflective design process within the framework of practice-based research. It aims to translate the narrative and moral values of the original Borobudur relief into a contemporary visual form that supports educational engagement, particularly for younger audiences unfamiliar with Buddhist iconography.



Figure 4. Design 1 (left), Design 2 (middle) and Design 3 (right)
Source: Researcher (2024)

1) Elderly Figure: The elderly figure, a Brahmin carrying prayer beads in front of the young figures, depicts wisdom and generosity. In this context, the prayer beads are interpreted by the author as a symbol of spirituality and morality, representing wisdom and guidance conveyed from the older to the younger generation. This demonstrates that goodness is material and can also be in the form of knowledge and virtues bestowed upon others.

2) Young Figures Sitting with a Calm Attitude: The seated position of the young figures in the picture exudes an attitude of acceptance and humility. They receive with respect, symbolizing the importance of being open to whomever the others is, whether young or old. This portrayal makes us feel included in the overall cycle of kindness, emphasizing that acceptance with a sincere heart is a crucial part of it.

3) Lotus Flower with Clouds and Eyes: Lotus flower, a powerful symbol of purity of heart and wisdom in the Buddhist tradition, is held by one of the characters. The lotus often symbolizes spiritual enlightenment and the eye on top can be interpreted as the gift of eyes from the young to the old. This portrayal inspires us that the good we do is not only seen by others but also by God, who will reward us, either in this world or in Nirvana (heaven).

4) Differences in Age and Social Status: In this image, there is a difference in age and display of social status between old and young characters. This reinforces the message that kindness should be given regardless of differences in status, age or background. All beings, regardless of their circumstances, deserve help and generosity.

The narrative of these symbols is that any good we give, be it in material form, such as physical assistance or spiritual, such as wisdom, will return to us in the form of multiple rewards, both in this world and in the hereafter. The Almighty God always notices and appreciates every good deed done and will reward us accordingly, either immediately or in the realm of Nirvana.

The second and third designs, as shown in Figures 4 (middle) and Figure 4 (right), are illustrations depicting kindness in the form of giving and receiving, symbolizing the noble values in Buddhism and the humanitarian tradition in general. In the context of this visual message, the message of kindness that can be taken is that humans must always do good to fellow creatures created by God, be it fellow humans, animals, plants or other creatures around us.

The kindness given to other creatures will return to us through peace, love and harmony in life. This teaching reflects the Buddhist principle of karma, where every good

deed one does will result in a positive impact in the future. It also reminds us that a spiritually and materially give-and-take relationship is the essence of harmonious living. Both designs reinforce the universal value of sharing and caring for others. This message is not only relevant in the context of religious teachings but also in everyday life, where empathy and generosity can be the foundation for a more peaceful and respectful society.

Here are some symbols of Designs 2 and 3 that visually reinforce the narrative of kindness and compassion between God's creatures:

1) Giving and Receiving Gestures: The hands giving each other containers or vessels symbolizes generosity and magnanimity. In Buddhism, giving without expectation of reward (dana) is one of the noble deeds. This image shows that kindness can take simple forms, such as giving to those in need and that such actions will flow back as peace.

2) Container or Vessel: The vessel the people in the picture hold can be interpreted as a symbol of fortune or happiness resulting from good deeds. It also represents a space of acceptance, illustrating that kindness should be accepted and passed on by every being, not just humans but also nature and animals.

3) Low Body Position: One character in the picture is seen kneeling or in a lower position when receiving something. This depicts humility and respect for others, one of the key values in relationships between beings. This humility reinforces the message that in giving and receiving, no one is higher or lower, all are equal in the eyes of God. The act of kneeling or being in a lower position also symbolizes the willingness to serve and the recognition of the worth of the other, further reinforcing the narrative of kindness and compassion.

4) Traditional Clothing and Ornaments: The traditional clothing and ornaments worn by the characters in the picture refer to the cultural heritage and spirituality embodied in every aspect of their lives. This reinforces the message that the noble values of kindness and compassion are ingrained in the social and cultural life of the people from generation to generation. The traditional clothing and ornaments, with their rich history and cultural significance, serve as a visual reminder of the enduring nature of these values, further reinforcing the narrative of kindness and compassion.

4.1.3. Ceramic Model Making and Molding Process

Following the design phase, the production process shifts to physical model creation, which determines the artistic fidelity and technical execution of the relief reproductions. As scholars in ceramic heritage reproduction emphasize (Cooper, 2010), this stage requires close collaboration between designers and master sculptors to ensure historically accurate, three-dimensional interpretations of cultural artifacts such as the Borobudur reliefs. The team selected local high-quality clay as the primary modeling medium due to its optimal plasticity and detail-capture capabilities, particularly for reproducing the temple's intricate narrative panels. Artisans meticulously translated the two-dimensional designs into tactile forms while maintaining iconographic precision, proportional fidelity, narrative coherence and visual balance.

This comprehensive approach allowed for thoroughly evaluating the composition's educational and aesthetic qualities before puzzle segmentation. The intact modeling phase served as essential quality control, ensuring the reproductions met both artistic and pedagogical objectives before further production stages.

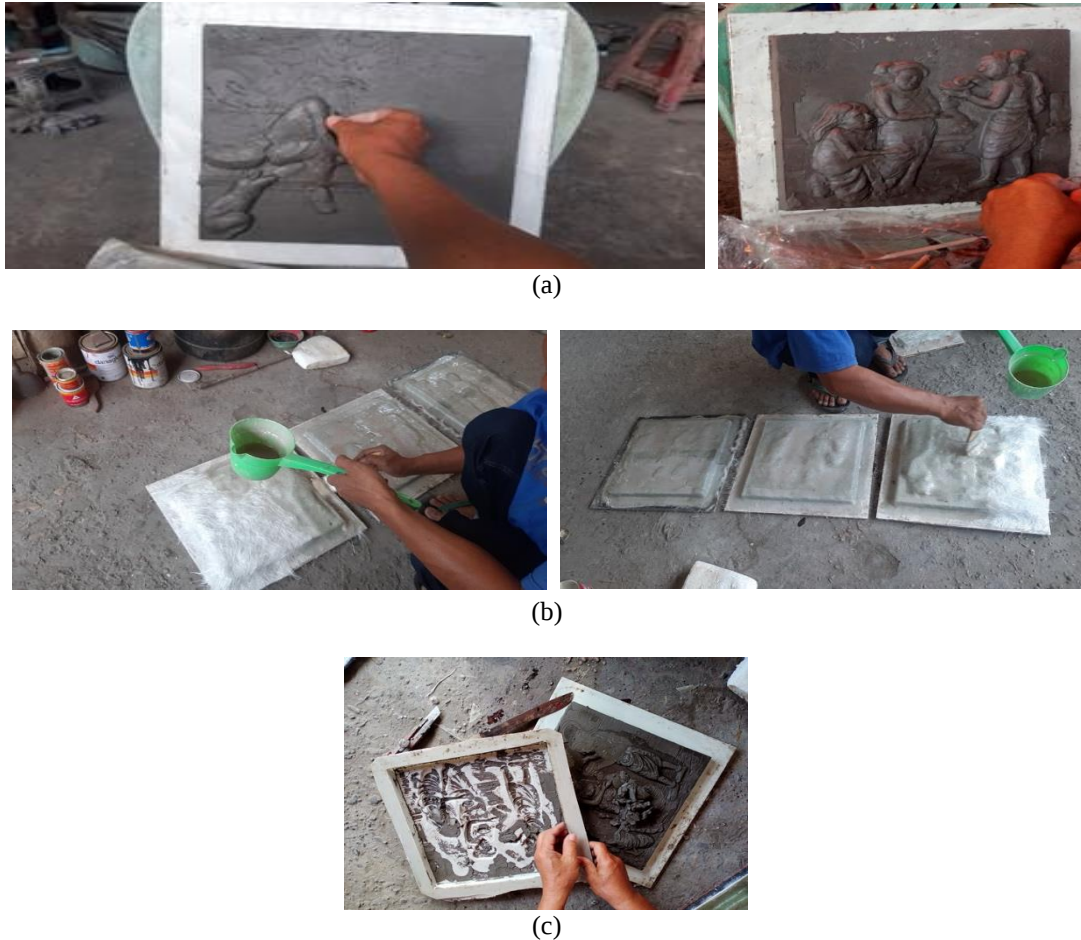


Figure 5. a) Making the model according to the master design,
 b) the process of molding the model with resin-fiberglass material and
 c) the process of removing the mold from the model that has been done
Source: Researcher (2024)

The next step is to make the mold once the clay model is complete and all details are checked. In this case, the molding material used is resin fiberglass, which was chosen for its strength and resilience in capturing the fine details of the clay model. Resin fiberglass also provides advantages in terms of the durability and flexibility of the mold, allowing for accurate reproduction of the ceramic form at a later stage.

Once the molding process is complete, the model is retained in one piece without breaking into puzzle-like parts. This molded model serves as a template for ceramic production, which will be broken down into puzzle pieces later. At this stage, our primary focus is to ensure the accuracy and quality of the model before proceeding to the next steps. The finished mold is cleaned and re-tested to ensure the achieved shape matches the drawing design. The corners of the mold that are still closed are cleaned and made open, facilitating the subsequent molding process with clay.

4.1.4. Ceramic Puzzle Molding and Firing Process

The ceramic molding and firing process is crucial in manufacturing quality ceramic products. This process requires precise steps to avoid failures such as cracking or bursting during firing. The primary raw materials used to make these ceramics are Borobudur soil, Sukabumi stoneware and kaolin. These three materials were chosen because they support

the durability and strength of ceramics after the firing process. Before use, these materials must go through a kneading process: kneading the clay until it is homogeneous. This process aims to remove air bubbles trapped in the clay, as air bubbles can cause cracks or even explosions during the firing process.



Figure 6. Kneading process
Source: Researcher (2024)

After the clay material is ready, the next step is the molding process. The mold that will be used is first smeared with kerosene, which aims to prevent clay from sticking to the surface of the mold. Clay material that has been kneaded is then processed by slabbing, a technique of forming sheets of clay. The sheet is then inserted into the mold until complete and pressed carefully to ensure no gaps or voids.



Figure 7. Process of Filling Soil in Molds
Source: Researcher (2024)

Once the clay is in the mold, the mold is allowed to dry for about an hour. This drying is essential to make the clay harder so that it is easier to remove from the mold without deforming. After that, the molded clay is removed from the mold and smoothed to ensure that no details are missed.

In the next stage, the half-finished mold is cut into nine pieces. Each piece is trimmed in detail and given a unique code for easy identification of each relief. The cut and coded ceramics are dried at room temperature for three to four days. This drying

process aims to reduce the water content in the clay so that it is better prepared for firing and to prevent deformation due to too rapid water evaporation.



Figure 8. Tidying up details of molding and cutting results
Source: Researcher (2024)



Figure 9. Results of molded ceramics for designs 1, 2 and 3 in the drying process
Source: Researcher (2024)

After the ceramics have gone through the drying process, the next step is firing the biscuits. This firing occurs in a gas furnace at around 1000°C for approximately four hours. As in glaze firing, the biscuit firing process aims to change the clay structure from plastic to solid without making it vitrified (glassy). The ceramic product still has a high enough porosity to absorb glaze at the finishing stage.



Figure 10. Ceramic firing process
Source: Researcher (2024)

4.1.5. Finished Products Ceramic Puzzles and Packaging

After the high-temperature bisque firing at 1000 degrees Celsius, the next stage is the coloring process. Two experiments were conducted with coloring: the first used glaze and the second used special ceramic paint. The glaze was applied with a brush and fired again at 1200 degrees Celsius. However, the artistic result was not very appealing. This was because the glaze surface did not adhere well; there was significant crawling due to the buildup of layered glaze. As a result, this artistic approach was considered less suitable for a school-age audience. Additionally, the clay shrinkage was very noticeable - up to 30% - causing the puzzle pieces to become too small. The researcher's second method was ceramic paint to achieve better color artistry. This method proved easier and produced more engaging aesthetics for children, as seen in the color combinations and the play of colors that created a better sense of volume.

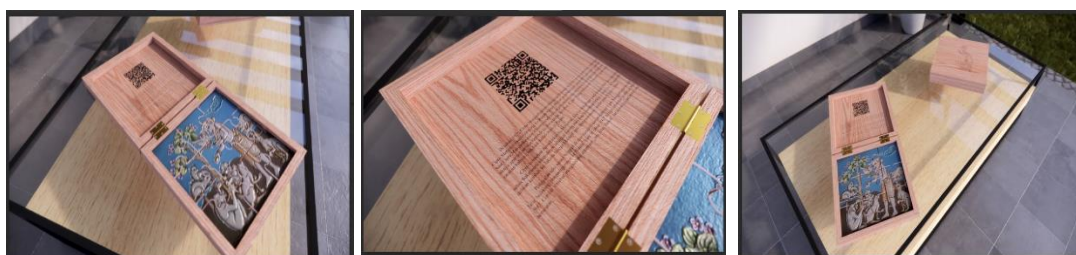


Figure 11. Educational ceramic puzzle in wooden packaging with barcode and narration

Source: Researcher (2024)

In the last stage, the final product is an educational ceramic puzzle that raises the theme of noble values from the reliefs of Borobudur Temple, packaged in a way that emphasizes aesthetic elements and functionality. This product is packaged in a wooden box with an elegant appearance and a natural and exclusive impression. The choice of wood material provides physical protection for the ceramic puzzle inside. It enriches the image of the product as a work of art closely related to the philosophy of nature and spirituality. The wood material also gives a strong and durable impression, making this packaging visually beautiful, practical and functional for long-term storage.

The wooden box offers durable storage and includes a scannable barcode, adding an interactive layer to the puzzle experience. When scanned with an Android device, the barcode provides digital content explaining the moral teachings and Buddhist values depicted in the Borobudur Temple reliefs. This integration bridges physical puzzle assembly with digital learning, enhancing the educational impact.

Inside the box, the ceramic puzzle pieces recreate Borobudur's reliefs, preserving their artistic beauty while conveying timeless virtues like compassion and wisdom. Combining wood and ceramic materials elevates the product's aesthetic and cultural value, transforming it from a simple puzzle into an interactive educational tool celebrating art, history and spirituality.

4.2. Planned Evaluation and Simulation Scenario

Although the ceramic puzzle prototypes have been successfully developed, direct user testing has not yet been formally conducted. A structured evaluation plan has been designed to ensure the educational effectiveness and cultural impact of the puzzle. This

planned testing will help measure how well the puzzle communicates the moral and philosophical values embedded in Borobudur's reliefs.

4.2.1. Initial Demonstration and Informal Trial

A small-scale trial was conducted with school students to demonstrate the basic functionality of the puzzle and observe user interaction in an informal setting. While no systematic data collection or evaluation was performed, the trial confirmed that the ceramic puzzles were playable and the QR-code scanning feature was functional and engaging.



Figure 12. Students listen to the audio explanation after scanning the QR code with a tablet or smartphone to understand the moral values in the puzzle artwork based on Borobudur's reliefs

Source: Researcher (2024)

The puzzles were arranged neatly in a wooden box with clearly carved reliefs. After assembly, students scanned the barcode embedded in the box, which led to YouTube links with audio explanations describing the philosophical meaning behind the scenes. Two puzzle artworks were featured in this demonstration:

- 1) "Sharing Food Generously". Link: <https://youtube.com/shorts/946KAvtfCyU>

This ceramic educational puzzle, inspired by a Jataka relief from Borobudur, teaches the value of generosity through sharing food with all beings, especially beloved animals. The act of giving is presented as an expression of kindness that returns to the giver in the form of blessings.

- 2) "Avoiding Excess". Link: <https://youtube.com/shorts/F3lNkGwSHZY>

This artwork encourages self-control and moderation, reflecting Buddhist values that discourage greed or overindulgence.

4.2.2. Simulation Use Scenario

The puzzle is intended to be used in a classroom or museum-based learning environment. In this scenario, students or visitors will:

- 1) Receive a puzzle set representing selected Borobudur reliefs, each piece engraved with symbolic imagery.
- 2) Assemble the ceramic puzzle guided by visual cues and tactile exploration.
- 3) Scan embedded QR codes that link to digital content (narration, animation or expert commentary) explaining the story and values behind each relief panel.

4) Participate in a guided reflection session where learners discuss their interpretation of the moral teachings, supported by prompts provided in the companion guide.

4.2.3. *Evaluation Plan*

To assess the educational outcomes, the following qualitative evaluation methods are planned:

1) Observation Protocols: Facilitators will document how participants interact with the puzzle - focusing on engagement indicators such as curiosity, collaboration and problem-solving behavior.

2) Semi-Structured Interviews and Focus Groups: After the activity, participants (students and educators) will be interviewed about their understanding of the Buddhist values (e.g., generosity, compassion, wisdom) represented in the puzzles. Their ability to recall and reflect on these themes will serve as an indicator of learning depth.

3) Preliminary Content Test (optional): For student groups, a simple before-and-after assessment could be administered using open-ended prompts like “What do you know about karma?” or “Why is generosity important in Buddhist teachings?”.

4) Thematic Analysis: All qualitative data (observational notes, interviews and student reflections) will be analyzed using thematic coding (Braun & Clarke, 2006) to identify patterns in understanding, misinterpretation and engagement.

4.2.4. *Research Goals of the Simulation*

This planned evaluation aims to:

1) Assess how effectively the puzzle communicates complex philosophical concepts.

2) Evaluate user interaction with both the ceramic material and digital components.

3) Determine improvements for future design iterations based on user feedback.

4) Explore how hybrid physical-digital tools can support cultural heritage education.

4.3. *Production and Accessibility Considerations*

The development of the ceramic puzzle utilized affordable, locally sourced clay as its primary material. This choice was not only aligned with the traditional craft-based approach of the project but also allowed for cost efficiency. Based on the formulation developed by exploring local materials from the Borobudur area, the soil in the surrounding region has the potential for further development. However, it requires the addition of several raw materials to improve its quality so that it can withstand high-temperature firing. The local community can easily apply this method, as it only requires a clay mixing container. Moreover, this improvement remains very affordable, with the clay costing less than IDR 7,000 per kilogram.

To ensure scalability and repeatability, the production process used low-tech molding techniques (slab casting with resin-fiberglass molds) to ensure reproducibility in resource-limited settings, enabling the pieces to be mass-produced with consistent quality. Partnerships with local pottery cooperatives (e.g., Kelompok Pengrajin Gerabah Borobudur) secure bulk pricing and sustain traditional craftsmanship.

By combining local materials with mold-based reproduction, the project demonstrates the potential for large-scale dissemination without compromising the

integrity of the original design. The relatively low cost of raw materials and the efficiency of the molding technique make this educational tool feasible for broader distribution, including school programs, museum shops and cultural outreach initiatives.

Partnerships with educational institutions or cultural heritage organizations may further reduce production and distribution costs in future development stages. Additionally, hybrid models - such as simplified printed puzzles or augmented reality applications - can be developed as digital complements to the ceramic version, extending the tool's reach to broader and more diverse audiences.

5. Conclusion

The creation of this ceramic puzzle design is an attempt to combine elements of history, spirituality and education in the form of interactive media. This research departs from the need to convey the noble messages contained in the reliefs of Borobudur Temple to the broader community, especially the younger generation, through more creative and modern means. With the restriction of direct access to the temple for preservation reasons, people now need an alternative means to enjoy the beauty still and explore the noble values of the existing reliefs. By using ceramic puzzles as a medium, the moral and spiritual values contained in the teachings of Gautama Buddha can not only be understood visually. However, they can also be felt physically through play and learning experiences.

The process of working on this project involves several important stages, namely observation and literature review of Borobudur Temple reliefs, sketching and design adapted from the meanings contained in the reliefs, making ceramic molds with resin-fiberglass molding techniques, making ceramics and finishing the final product packaged in a wooden box. Each of these stages is meticulously designed to ensure that every aspect of the product, both in terms of visuals and moral messages, can be effectively conveyed to users. The additional innovation of an interactive barcode that presents a digital narrative is a modern step in strengthening the educational dimension of this product, ensuring that users gain a comprehensive understanding of the historical and spiritual significance of the Borobudur Temple.

Overall, this research has succeeded in creating an interactive and artistic educational product, combining traditional art with modern technology. This ceramic puzzle offers a fun gaming experience and becomes an effective tool to teach the values of virtue, compassion and wisdom taught by Gautama Buddha. Through this medium, the spiritual teachings of the Borobudur reliefs can be received by various groups, enriching historical and moral knowledge in a more innovative and exciting form. In the end, users can help preserve the cultural heritage of Borobudur Temple by learning about the noble values of Gautama Buddha without having to set foot in the temple.

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