



Revitalization of Padang Magek Weaving Based on 3D Co-Design: A Minangkabau Matrilineal Gender Perspective

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ABSTRACT

This study explores the challenges and opportunities of digital revitalization in preserving intangible cultural heritage, focusing on the Padang Magek Weaving revitalization through a 3D virtual co-design process. The research examines the role of Minangkabau customary women's organizations, particularly the Bundo Kanduang Institution, in ensuring cultural sustainability. A case study approach was employed in Nagari Padang Magek, utilizing participatory observation and in-depth interviews with weavers, customary figures, and government decision-makers. Data were analyzed through critical descriptive analysis to examine the dynamics of women's agency amid digital technology intervention. The findings highlight that culturally sustainable revitalization depends on positioning the Bundo Kanduang Institution as a key decision-maker, not a marginalized part of the male-dominated customary structure. The resistance of Bundo Kanduang to changes in weaving motifs (color, silhouette, meaning) demonstrates their crucial role in preserving cultural authenticity. Granting veto power to women weavers proved essential in strengthening their agency and reducing gender bias from political and community leaders. The study concludes that 3D technology, particularly Clo 3D, serves as an empowering tool for Minangkabau women's cultural heritage, with the adoption of digital technology contingent upon validation from Bundo Kanduang. The research emphasizes the importance of a gender-responsive framework in implementing digital technology for cultural preservation.

Keywords: 3D Virtual Co-Design, Bundo Kanduang, Women's Agency

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INTRODUCTION

Indonesia is rich in a variety of traditional woven fabrics, spread across woven fabric production centers such as West Java, Central Java, Bali, West Nusa Tenggara, East Nusa Tenggara, Palembang, Lampung, and West Sumatra, one of the main centers of Minangkabau culture. Minangkabau woven fabrics and songket are not merely textiles, but rather material cultural heritage reflecting the identity of a matrilineal society. Distinctive geometric motifs, such as the pucuak rabuang, kaluak paku, and siriah gadang, are steeped in the philosophy alam takambang jadi guru (nature as a teacher), a guiding principle for the Minangkabau people (Siti et al., 2025). These fabrics serve not only as traditional attire for weddings, funerals, or batagak pangulu ceremonies, but also as a medium for storing collective memory and a symbol of women's social status within the kinship system.

Padang Magek weaving, located in Nagari Padang Magek, Rambatan District, Tanah Datar Regency, is a type of Minangkabau weaving that still maintains the pure traditional warp technique. Unlike Pandai Sikek songket, which uses more gold and silver thread, Padang Magek weaving emphasizes simple geometric motifs, resulting in a type of ikat weaving. This fabric is exclusively produced by women, establishing an epistemological domain that reinforces women's position as holders of cultural authority in a matrilineal society (Yunarti, 2018).

The practice of weaving in Padang Magek is embodied and haptic. Knowledge of motifs, ikat techniques, and color selection is passed down tactiley from grandmother to mother to daughter through a long learning process under the roof of the rumah gadang (house) or in the weaving hall. This process is a direct manifestation of the concept of limpapeh rumah nan gadang—women as the primary support of the rumah gadang, both physically and symbolically—which also forms the core of the Bundo Kanduang institution (Yunarti, 2017). In Minangkabau tradition, Bundo Kanduang is not simply a term of respect for a woman who has had children, but rather a formal customary institution driven by women to address household, women's, and children's issues, while also serving as an empirical basis for women's empowerment at the village level (Ilma, 2023). The matrilineal culture in West Sumatra is deeply ingrained with emancipatory nuances and feminist teachings. Women are considered a family heirloom, thus holding a highly respected position in society. Minangkabau culture is also steeped in Muslim culture and teachings, so religious cultural values significantly influence the thinking patterns of the Minangkabau people (Ariani, 2015). Culture can influence gender equality by reinforcing unequal gender views and judgments between men and women. Religion also plays a significant role in gender equity from a contemporary perspective. Certain religious interpretations and practices can reinforce unequal gender norms and roles (Harjoni, 2023).

However, in the past two decades, the regeneration of traditional Minangkabau weaving has experienced a significant crisis. Younger women, especially those migrating to large cities, tend to abandon weaving practices as uneconomical, time-consuming, and less relevant to urban lifestyles. This crisis reflects a long-identified structural dilemma within the matrilineal system: although women are revered as kin leaders and guardians of heirlooms (pusako), the heavy burden of domestic and economic duties—including the maintenance of high and low-ranking heirlooms—is often not balanced by access to formal political power at the village level (Ayu & Yuliarma, 2024).

The majority of research on Minangkabau weaving still focuses on physical preservation or digital marketing, while studies integrating 3D virtual technology with an analysis of women's agency within the Bundo Kanduang institution are almost nonexistent (Suzianti et al., 2023). In fact, (Yunarti, 2017) has emphasized that empirically, the Bundo Kanduang institution in nagari (village) is only a sub-section of a larger traditional institution, with strong gender bias among political elites and community leaders. Consequently, women artisans rarely become primary agents in their own cultural transformation processes.

This gap is further glaring because no study has specifically examined the dynamics of agency between senior and junior women artisans when their tactile knowledge—the core of the traditional house—is digitized using CLO 3D software. 3D technology is not a threat that will replace humans, but rather a tool (instrument) to strengthen the cultural sovereignty of Minangkabau women. By positioning Bundo Kanduang as the primary agent of change, Nagari Padang Magek can lead the transformation of a modern creative industry while remaining firmly rooted in the values of Limpapeh Rumah Nan Gadang (Kamila, L. N., 2024).

This research fills this gap by positioning women artisans as the primary analytical variable in a 3D virtual co-design process based on the ATUMICS method, while simultaneously revitalizing the role of Minangkabau women in the digital era. With a design ethnography approach in Nagari Padang Magek, this research produces a collection of woven fabrics using culturally and market-validated avatars, but also a model of empowering women artisans in Minangkabau through truly gender-responsive technology, thus providing a significant contribution to the study of gender, material culture, and the anthropology of contemporary design in Indonesia.

RESEARCH METHODOLOGY

This paper is dedicated to illustrating the importance of co-designing concepts with Minang women artisans, rather than applying a top-down approach in the village. This process is shaped by a series of ethnographic design observations, participatory design workshops, material exploration, and project evaluation stages. The result is a series of developed systems that offer mutual benefits to the local community, artisans, and local designers. The results of this design are practically applied in the creative economy sector, with the aim of revealing and analyzing the agency of female artisans for Padang Magek Weaving among the younger generation in a 3D virtual co-design process based on the ATUMICS method, with a focus on how they negotiate, maintain, or expand their epistemological and cultural power when traditional tactile knowledge moves into the digital realm through participatory and anthropological design perspectives (Rahardiani et al., 2024). In response to the environmental challenges facing Tanah Datar Regency, which has seen the local artisans no longer producing saruang bugih ikat weaving, the research team demonstrated that the revitalization of Tenun Padang Magek will only be successful and sustainable if the Bundo Kanduang institution in the village is positioned as the primary decision-maker, not merely an informant. This ensures that 3D virtual technology does not become a tool of new digital colonialism, but rather an empowerment instrument that strengthens the matrilineal authority of Minangkabau women as the custodians of the traditional house in the era of fashion 4.0. In the design field, various efforts are being made to address this issue using the concept of sustainability.

The process is implemented in five stages: (1) Participant observation and ethnography, in-depth interviews, documentation of weaving practices and the dynamics of Bundo Kanduang. (2) Participatory workshop (4 sessions): collective mapping of ATUMICS elements with validation by female artisans for each design stage. (3) 3D virtual co-design: exploration of motifs and silhouettes using CLO 3D with real-time input from all artisans. (5) External validation: 5-point Likert scale questionnaire to 60 respondents (50 fashion design students + 10 ethnic craftsmen from West Sumatra. This approach ensures a fully participatory and gender-responsive process, without top-down elements, thus strengthening the authority of Bundo Kanduang as the nan gadang house's mbahapeh in the digital transformation of Tenun Padang Magek.

The research method used was library research, limited to library collections in the form of books and previous articles relevant to the research title. This research was descriptive in nature, with data collected by reading references in the form of books, articles, and previous studies related to the topic of discussion.

RESULT AND DISCUSSION

Traditional clothing in Minangkabau carries philosophical meaning and cultural values within the wearer. This attire reflects a person's position and role within the Minangkabau traditional society. Minangkabau has a diverse culture and customs distinct from each nagari (village), commonly referred to as "adat salingka nagari," one of which is the distinctive and unique traditional clothing (Lula Najwa Kamila et al., 2024). During traditional ceremonies, people wear traditional clothing typical of their respective regions. Traditional Padang Magek Minangkabau clothing has distinctive shapes, such as the tingkuluak (a traditional shirt), the kuruang basiba (a traditional shirt), the kodek (a traditional dress), the salempang (a traditional sash), jewelry, and footwear. Each piece of clothing has a specific symbol and meaning. The traditional clothing of Nagari Padang Magek is known as Baju Milik (the name of traditinaol cloth). This clothing is synonymous with woven fabrics and songket. One of the symbolic weaves in this attire is the ikat woven headdress, commonly known as the saruang bugih (a traditional cloth) (Ayu & Yuliarma, 2024). The use of bright and contrasting colors, such as red, yellow, brown, and black, reflects the spirit and dynamism of the Minangkabau people. This research offers mutual benefits for the local community, local artisans, and designers with designs that are practically applied in the creative economy sector, and aims to analyze the agency of female artisans for Tenun Padang Magek among the younger generation in a 3D virtual co-design process based on the ATUMICS method. This approach negotiates, maintains, or expands their epistemological and cultural power when traditional tactile knowledge moves into the digital realm through participatory and anthropological design perspectives. The revitalization of culture and tradition through ATUMICS can be seen from the following aspects (Nugraha, 2012) with the following stages:

1. Artifact: Padang Magek Weaving
2. Technique: Traditional warp → motif digitization in Clo3D
3. Utility: From traditional fabric to ready-to-wear
4. Material: Silk thread → virtual representation
5. Icon: Geometric Motif of the Minang Bugih Saruang
6. Concept: Matrilineal authority (Basandang)

7. Shape: Contemporary silhouette that remains true to Minang women's culture

The Central Role of Bundo Kanduang as a Cultural Gatekeeper

Research findings consistently position the Bundo Kanduang Institution not merely as a cultural actor but as a determining authority (gatekeeper) in every process that touches on cultural transformation closely related to women. In the context of 3D virtual co-design, Bundo Kanduang functions as an institution that upholds essential aspects such as ornamentation and the placement of symbols in relation to values and culture. Field data shows that this role becomes even more crucial when technological innovation has the potential to degrade meaning. This authority is cultural-epistemic, distinct from administrative authority, which tends to be dominated by men (Siti et al., 2025). These findings confirm that in the Minangkabau matrilineal system, control over intangible cultural heritage inherently rests with women, and any technological intervention that ignores this structure will be deemed culturally flawed (Suzianti et al., 2023).

Structurally, female artisans in Minangkabau still face gender bias from local political elites and community leaders. The analysis shows that their agency has been significantly strengthened through a properly structured digitalization process. This increased agency occurs not because of the technology itself, but because the technology (3D) provides and documents tactile knowledge with precision. Before 3D, criticism of design changes was often verbal and vulnerable to being ignored; now, the digitization of motifs provides digital "physical evidence" that protects authenticity. This study emphasizes that technological empowerment only occurs if preceded by formal recognition of the agency of local artisans (Shi et al., 2024). Critical analysis suggests that this strengthening of agency is a response to patriarchal resistance that seeks to marginalize women's roles in cultural resource management.

The resistance demonstrated by Bundo Kanduang and artisans to changes in woven motifs or silhouettes should not be interpreted as anti-modernization. Rather, critical discussion identifies this resistance as a functional manifestation of the role of the limapeh rumah nan gadang (the main pillar of the rumah gadang) that persists in the modern era. This role requires the younger generation to maintain cultural stability and matrilineal lineage. This confirms that in the Minangkabau context, cultural authority is based on internalized socio-customary roles, not simply material ownership.

The Impact of 3D Virtual Co-Design on Authenticity and Symbolic Meaning. Analysis of the younger generation and the market indicates a phenomenon of absolute matrilineal validation. The younger generation, while highly adaptable to 3D virtual co-design technology and 4.0 fashion trends, firmly stated that they would not accept or adopt new woven fabric prototypes unless they received the official stamp of approval from the Bundo Kanduang. Local wisdom does not crumble in the face of technology, but rather uses technology as a medium to validate culture (Makryniotis, 2018). While 3D virtual co-design offers high speed and flexibility in modifying designs, discussions uncovered a dilemma between innovation and authenticity. Craftspeople worry that highly realistic and easily manipulated 3D displays could simplify complex philosophical meanings into mere visual aesthetics. 3D technology can transform motifs from "cultural texts to be read" to "images to be seen" (Dewi & Hidayat, 2024). This review includes 3D simulation and visualisation, Computer-Aided Design (CAD), and, subsequently, 3D printing and additive manufacturing within the immersive technology portfolio as these offer user manipulation within virtual environments, which creates a

somewhat more ‘immersed’ experience compared with 2D renderings. However, on the other hand, the results show that co-design helps female artisans test marketability without having to cut actual fabric, minimizing economic risk. This aligns with the principle of sustainability in design. Therefore, success lies not in the use of technology, but in setting strict cultural boundaries regarding which parameters can be modified in the virtual space.

Since the mid-1990s, computer-aided design techniques and digital media applicable to fashion have enhanced the quality of high-end fashion, entertainment-related animated clothing, and commercial products. Narratives in online spaces are as significant as in offline spaces, as they reinforce the technological impact and aesthetics of physical clothing, rather than simply acting as an alternative entity. As online shopping has successfully competed with offline markets and consumers have spent more time online, the fashion industry still needs to explore the possibilities offered by online fashion. Furthermore, fashion films, a frequently used tool in the fashion industry, have begun to digitize the human form and movement by utilizing motion capture technology, as well as the aesthetic and expressive elements of clothing, opening up opportunities for exploration in design (Clarke, S.E., et. all, 2012).

This study measures the effectiveness of 3D co-design not only in terms of product output, but also in its impact on the sustainability of traditions. It found that 3D is effective as a revitalization tool only if it functions as a pedagogical tool that bridges tactile cultural knowledge to the younger generation. By visualizing motifs in 3D, previously implicit knowledge (attached to the body) can be made explicit and transmitted more easily (Rahardiani, 2018).

Gender-Responsive Co-Design Model

One of the most critical findings is the recognition of the risk of epistemic alienation and digital colonialism lurking within the knowledge of matrilineal artisans. Epistemic alienation occurs when tactile and contextual knowledge is isolated, digitized, and published without the context of its local wisdom. The risk of epistemic alienation faced by Padang Magek’s female artisans is not simply a technical issue of transferring motifs into 3D modeling software, but rather a cultural transformation of traditional knowledge. This phenomenon occurs when the tactile knowledge possessed by Minangkabau women learned through years of bodily experience and internalizing values is simplified into digital visual data rich in philosophical meaning. Without institutional control, the digitization process has the potential to sever the connection between motifs and their historical lineage, ultimately positioning artisans as peripheral objects in the global creative economy (Setiadi, 2023). This aligns with concerns about digital colonialism, where local cultural data is extracted for industrial profit without a mechanism for equitable benefit-sharing for the communities that originally owned that knowledge.

The Gender-Responsive Co-Design model acts as an epistemological renewal through the establishment of Absolute Matrilineal Validation checkpoints. This mechanism ensures that every design iteration, from the transformation of traditional warp techniques into Clo3D to the development of contemporary silhouettes, remains under the supervision of Bundo Kanduang, as the elder woman in Minangkabau tradition. This validation is crucial because the motifs of Padang Magek weaving, such as Saruang Bugih, are not merely geometric decorations, but rather “cultural messages” that symbolize the identity and social roles of indigenous communities. The transfer of

full authority to Bundo Kanduang to grant “veto rights” over digital prototypes is a concrete step in the decolonization of knowledge, where matrilineal women are no longer merely data providers, but active subjects who determine the direction of their own cultural evolution (Lubis & Sari, 2024).

The integration of the ATUMICS (Artefact, Technique, Utility, Material, Icon, Concept, Shape) method in this study helps map which parameters can be adapted and which must be maintained. Analysis of the Concept and Icon aspects shows that matrilineal authority (Basandang) is the soul of every piece of cloth, so that the digitization of motifs must not ignore the customary rules of the salingka nagari. For example, the use of bright colors such as red and yellow in virtual representations must still reflect the dynamism of the Minangkabau people without reducing the sacredness of the traditional clothing Baju Milik. By placing 3D virtual technology as a supporting instrument, this study proves that modernization does not have to mean cultural assimilation, but rather a process of negotiation in which tradition expands its reach through new media (Nugraha, 2012). A critical rejection of gender-neutral development approaches is at the heart of this discussion. Often, the introduction of technology in rural areas is assumed to have universally positive impacts without considering existing power structures. However, the field evidence in Padang Magek demonstrates that without adhering to matrilineal structures, technology can actually reinforce patriarchal gender biases that often dominate elite government and information technology sectors. By making Bundo Kanduang the primary agent of change, 3D technology transforms into a precise documentation tool that protects authenticity from external claims. The digital physical evidence generated from the 3D rendering process becomes a powerful legal instrument for fighting for Communal Intellectual Property Rights (HKIK), while simultaneously addressing the vulnerability of verbal criticism that has often been easily overlooked in local political dynamics (Rizal & Fitriani, 2024).

Furthermore, the effectiveness of this model is also evident in its impact on the transmission of knowledge across generations. The younger generation in Nagari Padang Magek, who tend to be more adaptable to digital devices, often experiences a disconnection from their cultural roots due to lifestyle shifts. Through the co-design method, 3D technology serves as a pedagogical bridge; young people learn the sophistication of software, while Bundo Kanduang imbues the “spirit” of the design through philosophical validation. This synergy creates an ecosystem where implicit tactile knowledge is made explicit through digital visualization without losing its original context (Hasanah & Lubis, 2023). This confirms that the sustainability of weaving traditions in the Fashion 4.0 era depends heavily on the ability of indigenous communities to adopt technology without sacrificing their matrilineal identity.

Empowerment through 3D virtual technology must be placed within a framework of anthropological ethics and social sustainability. Technology should not be viewed as an autonomous entity, but rather as an extension of the cultural will of the women artisan community. The Gender-Responsive Co-Design model, which places Bundo Kanduang as the center of authority, is not only a practical solution for revitalizing the creative economy at the village level, but also a new theoretical model in development studies that is responsive to the peculiarities of Indonesia’s matrilineal social structure. Thus, the Revitalization of Padang Magek Weaving is a cultural political statement that Minangkabau women are ready to navigate the digital future in the local and global fashion industry.

CONCLUSION

This study is based on the background of the intelligent era of Industry 4.0 and the current situation of the popularisation of digital technology and digital products, and it responds to the international trend of protecting and diversifying traditional culture. The concludes that a successful revitalization of Tenun Padang Magek through a 3D virtual co-design process depends fundamentally on the positioning of the Bundo Kanduang Institution at the village level as the primary decision-making body (agency). Empirical findings indicate that although female artisans structurally face gender bias from political elites and community leaders, their agency is significantly strengthened when given full veto power over motif transformation in the digital realm. This paper explains the importance of maintaining authenticity, relevance and innovation in traditional clothing styles amidst changing aesthetic preferences and technological advancements to promote the dissemination and modern redesign of cultural elements as well as global recognition of world fashion identity.

Their resistance to essential modifications is a concrete manifestation of the role of the traditional house, which continues to function as a guardian of traditional values in the era of fashion 4.0. Validation from the Bundo Kanduang is even an absolute prerequisite for the acceptance of digital prototypes by the younger generation. Thus, strengthening the Bundo Kanduang Institution through increasing organizational, personal, and social capacity has proven to be an effective basis for overcoming epistemic alienation and digital colonialism against the tactile knowledge of matrilineal women. In conclusion, 3D virtual technology is not a threat to Minangkabau cultural heritage, but rather a powerful instrument of empowerment, provided that the implementation process is gender-responsive and positions the Bundo Kanduang as the primary agent of change.

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Based on the research results and discussions that the research makes important contributions both theoretically and practically. Theoretically, this research presents an empirical model that successfully integrates traditional matrilineal agency structures (Bundo Kanduang) with 3D virtual technology, challenging the narrative of technological determinism and emphasizing that the success of digitalization depends on the institutional authority of traditional women. Conceptually, this research enriches the discourse of Cultural Studies by providing empirical justification for the concepts of “Epistemic Alienation” and “Digital Colonialism” in the context of the protection of Minangkabau tactile knowledge. Practically, this research results offer a replicable Gender-Responsive Co-Design framework, serving as a strong advocacy database for Bundo Kanduang to negotiate their roles and ensure that cultural empowerment goes hand in hand with economic and creative empowerment.

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