

Beyond Machinery: Understanding Technology through Local Knowledge in Natural Textile Dyeing

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ABSTRACT

Natural textile dyeing represents one of the earliest forms of human technological practice developed through continuous interaction with natural resources and local environments. Despite growing interest in sustainability and traditional knowledge, technology is frequently associated with machinery, industrial production, and laboratory-based innovation, resulting in limited recognition of the technological knowledge embedded within traditional dyeing practices. This paper aims to examine how technology is understood and practiced through local knowledge system in natural textile dyeing. Drawing upon previous findings, document analysis, and relevant literature on local knowledge and natural dyeing practices, this conceptual paper discusses broader understandings of technology in traditional textile production. This discussion highlights that technology in natural dyeing is not confined to machinery but is embedded in a sequence of interconnected practices, including material selection, fabric preparation, colour extraction, mordanting, dyeing, finishing, and evaluation, all of which are informed by accumulated knowledge and environmental understanding. The paper argues that technology should be understood as a system of practice in which knowledge, techniques, materials, and environmental interactions collectively shape the production and transmission of natural dyeing knowledge within a cultural context. It concludes that traditional natural dyeing constitutes a legitimate technological system, demonstrating that technology can be expressed through local knowledge and cultural practice as much as through mechanical innovation, thereby contributing to discussions on cultural sustainability, heritage preservation, and sustainable textile development.

Keywords: Local knowledge, traditional technology, natural textile dyeing, cultural heritage, sustainable textile practices

INTRODUCTION

Long before industrial production and mechanised processes, communities cultivated their sophisticated local knowledge to produce cultural objects and used them for practical significance. Precedent, societies utilised minerals, plants, insects, and soils as sources of colour for cave paintings, crafts, and everyday artefacts, while colour itself functioned as a marker of belief, identity, and cultural expression (Adjaye, 2024; Belfer, 1992; Hasan, 2003). Earth-derived pigments obtained from natural resources such as stones, soils, plants, fungi, and insects were processed according to the geographical conditions and local expertise (Kumar & Tripathi, 2011; Makhunton et al., 2014; Sanli et al., 2011). The development of these practices required prolonged experimentation, creativity, and accumulated local wisdom, reflecting complex processes of success, failure, and adaptation over generations (Bebit & Ibrahim, 2013). Consequently, natural dyeing should not merely be regarded as a precursor to modern textile production but as an early technological system grounded in knowledge, skills, techniques, and environmental relationships that continue to influence contemporary and industrial textile practices.

As scientific and industrial modernity continues to shape contemporary societies, technology is increasingly distinguished between traditional and modern forms, with the latter often perceived as more advanced and serving as the dominant marker of innovation, economic development, and scientific progress. The definitions associated with technology are the application of scientific knowledge in industrial, agricultural, traditional and modern technologies as complementary expressions, medical, and commercial contexts, meanwhile,

contemporary manufacturing systems further reinforce the perception that technology is fundamentally dependent upon specialized equipment, mechanization, and laboratory-based innovation (Anita Tyagi, 2011). However, such interpretations represent only one dimension of technological development. Alternative perspectives have long argued that technology encompasses broader processes of production that integrate knowledge, skills, techniques, and intentional action to achieve particular goals (Ahmad & Mujani, 2012; Kechot et al., 2012; Koetjaraningrat, 2002). A recent study similarly argues that technology should be understood as a plural system of knowledge and practice rather than collections of tools or machineries (Koch et al., 2024; Silvia Fernández Sabido & Sabido, 2025). From this standpoint, technology exists prior to the creation of artefacts themselves, emerging through engagement with the conditions necessary for human survival and cultural continuity.

Despite the historical importance, traditional and local knowledge systems have gradually received less attention as industrial production and synthetic technologies continue to expand. The increasing use of synthetic dyes has changed textile production practices and, at the same time, reduced the transmission of traditional knowledge that was once shared and refined across generations of local communities (Bebit & Ibrahim, 2013). Traditional technologies are often appreciated for their aesthetics and symbolic values, yet the knowledge, techniques, and environmental understanding behind these practices remain less documented and less studied (Koetjaraningrat, 2002). Much of this knowledge is still passed on orally through everyday activities and social interactions, making it vulnerable to being lost as communities respond to changing lifestyles and market demands (M. Z. A. Aziz, 1994; Canagarajah, 2002; N. M. Nawawi, 2016; Olsen, 2003). Consequently, recognising natural textile dyeing as a technological practice requires greater attention to the knowledge, experiences, and cultural relationships that sustain these traditions in society.

Although sustainability and traditional knowledge have received attention in recent years, discussions about technology still tend to focus on machines, factories, and scientific inventions, leaving many traditional practices overlooked. This paper explores how natural textile dyeing reflects a different way of understanding technology through local knowledge, practical experience, and close relationships with the surrounding environment. The process involves a series of activities, from selecting raw materials, and preparing fabrics to extracting colours, mordanting, dyeing, finishing, and assessing the final result, all of which rely on skills that have been developed and shared over time. These practices invite us to the question: is technology only defined by modern tools and industrial systems, or can it also be understood through the knowledge and actions that communities have cultivated across generations? Therefore, by considering natural textile dyeing from this perspective, this paper contributes to ongoing discussion on cultural sustainability, heritage preservation, and more inclusive approaches to textile development.

LITERATURE REVIEW

Understanding Technology Beyond Machinery

Technology has been understood in different ways across historical periods and cultural traditions, reflecting changing human needs, values, and relationships with the material world. According to the Kamus Dewan Bahasa dan Pustaka (DBP), technology refers to activities or studies that apply scientific knowledge for practical purposes in industry, agriculture, medicine, business, and other fields, indicating that the concept is fundamentally grounded in knowledge and practice. The contemporary discussion often associates technology with manufacturing processes supported by tools and machinery (Anita Tyagi, 2011). Scholars also have argued that its essence lies in human actions, practical skills, and culturally embedded practices that transform the material world through *techné*, understood as knowledge, art, and craft (Eric Schatzberg, 2025; Ramić, 2024). Therefore, technology should be viewed not merely as mechanical innovation or technological artefacts but as a dynamic process through which human knowledge, creativity, and environmental understanding are translated into meaningful forms of production and cultural expression.

Rather than being confined to machines or physical artefacts, technology encompasses the knowledge, skills, techniques, and practical processes that communities develop to support everyday life and adapt to their surroundings. Koetjaraningrat (2002) explains that technology extends beyond tools and equipment to include the ways people organize production and fulfil their needs. Meanwhile, Ahmad and Mujani (2012) emphasizes that purposeful planning and action are important aspects of technological activities. Recent studies also suggest

that technology should be viewed as a combination of people, practices, knowledge, and tools within particular social and cultural settings rather than as a product alone (Koch et al., 2024). Besides, Silvia Fernández Sabido and Sabido (2025) argues that both traditional and modern technologies are shaped by their environment and intended purposes, and they simultaneously can preserve cultural identity when communities actively participate in their development and use. Therefore, understanding technology beyond the machinery requires recognising traditional and modern technologies as complementary expressions of human creativity, shared knowledge, and cultural adaptation rather than as opposing forms of development.

Integrating Traditional and Modern Technologies: A Hybrid Perspective

Technology has often been discussed by distinguishing traditional technologies from modern technologies, with the latter frequently regarded as more advanced, efficient, and scientifically legitimate. Traditional technologies are commonly associated with inherited knowledge, manual skills, and the use of local resources, whereas modern technologies are linked to scientific advancement, mechanisation, and industrial production. Although this distinction has been useful for describing historical patterns of technological development, it may oversimplify the way technology is understood and practiced today. Previous studies increasingly recognize that traditional and modern technologies are not mutually exclusive but frequently coexist and complement one another within the same technological systems. By not replacing traditional knowledge, contemporary technologies often support and extend existing practices through scientific knowledge, improved materials, digital documentation, and sustainable production methods. Based on this perspective, technology can be understood as a dynamic continuum in which knowledge is continuously reproduced, adapted, and refined in response to changing cultural, environmental, and socio-economic conditions.

Table 1 shows how traditional and contemporary technological practices are integrated within natural textile dyeing. Rather than representing two separate or competing systems, the table demonstrates that the interaction of inherited local knowledge with scientific and technological innovations characterises contemporary natural textile dyeing. Traditional technological practices such as selection of dye plants, seasonal harvesting, colour extraction by boiling, soaking, or fermentation, mordanting, and knowledge transmission continue to form the foundation of the dyeing process (Widagdo, 2017). Meanwhile, contemporary technologies enhance these practices through scientific approaches such as using spray drying (Krisnawati et al., 2022), Soxhlet (Geelani et al., 2013), gamma irradiator (Adeel et al., 2020), and ultrasound (Tengku Shaheera Tuan Zainal Abidin. et al., 2016). This integration enables practitioners to improve efficiency, consistency, and environmental responsibility while preserving the cultural values and experiential knowledge embedded within local technological traditions. Consequently, technological development in natural textile dyeing should be understood not as the replacement of traditional practices by modern technologies, but as the continuous adaptation and integration of both approaches to address contemporary needs.

Table 1 Integration Perspective of Traditional and Contemporary Technologies in Natural Textile Dyeing

Traditional Technological Practices	Contemporary Technological Practice	Integration Perspective in Natural Textile Dyeing	References
Knowledge of local dye plants	Scientific identification of dye compounds	Scientific analysis complements practitioners' experiential knowledge in selecting suitable dye plants.	Karabulut and Atav, (2020); Potsangbam et al., (2008)
Seasonal harvesting based on local experience	Environmental monitoring and resource management	Traditional ecological knowledge is strengthened through contemporary environmental management for sustainable harvesting.	Koetjaraningrat (2002)
Colour extraction through inherited techniques	Controlled extraction using laboratory equipment	Scientific control improves consistency while maintaining traditional extraction principles.	Diksha et al. (2022); Taif et al., (2017); Zarkogianni et al. (2010)

Traditional mordanting practices	Colour fastness and quality testing	Laboratory testing enhances product quality while preserving traditional dyeing techniques.	Choudhury (2018)
Oral transmission and apprenticeship	Digital documentation and knowledge sharing	Traditional knowledge is documented and shared using contemporary communication technologies.	Erawati et al., (2012); Pringgenies et al. (2013)
Community-based textile production	Sustainable production and market innovation	Local knowledge supports sustainable textile production while responding to contemporary economic needs.	Bardhan & Bhattacharya, (2022); Liviawati et al. (2021); Roengthanapiboon et al. (2024)

Therefore, technology is better understood not as a choice between traditions and modernity, but as a continuous process of knowledge creation, adaptation, and innovation. Within natural textile dyeing, local knowledge remains the foundation upon which technological practices are preserved, refined, and transformed, providing the basis for understanding local knowledge as an enduring form of technological heritage.

Local Knowledge as a Foundation of Technological Heritage

If technology extends beyond machines and physical artefacts, an important question arises: where does technological knowledge originate and how is it sustained across generations? Local knowledge originates from efforts to solve everyday problems by transforming surrounding environments into meaningful and beneficial resources (Horn & Gurel, 1968). Siti Zainon Ismail (1990) explains that people interact directly with their environments, suggesting that materials, landscapes, and natural conditions continuously shape community experiences and ways of living. Rohidi (2011) similarly describes local knowledge as a form of learning developed through long-term experiences and intergenerational interactions that sustain social, cultural, economic, and ecological balance. Meanwhile, Nygren (1999) notes that knowledge is often viewed as less advanced than modern practices. Therefore, this paper defines local knowledge as a dynamic system of intergenerational skills that is continuously shaped through interaction between people, knowledge, and the environment. Rather than representing inherited traditions alone, local knowledge is a dynamic system of practice that enables communities to adapt local resources, develop practical solutions, and sustain technological heritage across generations.

Table 2 Extracted characteristics of local knowledge from past studies

Characteristics	Description	References
Intergenerational transmission	Knowledge passed down through generations and community practices.	Hastuti et al., (2013); Kadir & Hamid, (2013)
Experienced-based learning	Knowledge developed from everyday experience and problem - solving.	H. Aziz et al., (2016); Rohidi (2011)
Human-environment interaction	Understanding formed through direct engagement with local surroundings.	Ernawi (2009); Siti Zainon Ismail (1990)
Community values and cooperation	Shared meaning, rituals, and collective practices.	Prijotomo (2009); Ridwan (2007)
Sustainability and harmony	Maintaining ecological and social balance.	Ernawi (2009); Shaari & Wahab (2010)

The relationship between local knowledge and technology is particularly evident in traditional textile practices, where skills and techniques are passed down through generations through observation, participation, and community training. Malaysian textile traditions such as weaving, batik, and natural dyeing embody forms of technological heritage that rely on accumulated knowledge to select materials, develop processes, and adapt environmental resources for specific cultural purposes (Ghani & Zakaria, 2013). Shaari and Wahab (2010) further argue that these practices represent expressions of community life that support human well-being while maintaining harmony with the natural environment, demonstrating that technological development can occur

without ecological destruction. Unlike large-scale industrial production, local textile technologies often employ simpler tools and locally available materials, reflecting practical knowledge and resourcefulness rather than dependence on sophisticated machinery (Twigger Holroyd et al., 2017). Consequently, natural textile dyeing may be understood as a form of technological heritage in which knowledge, cultural values, and environmental relationships collectively sustain both traditional practices and contemporary discussions on sustainable textile development.

Natural Textile Dyeing as Cultural and Technological Heritage

Natural textile dyeing is a production process that transforms natural resources into functional and culturally meaningful textiles through a sequence of interconnected activities. It is widely acknowledged as one of humanity's earliest technological practices, emerging long before the development of synthetic colourants and industrialised textile production (Belfer, 1992; Schetky, 1969; Yang et al., 2020). It reflects the deep interconnection between people and their natural environment, where colour-producing materials from plants, insects, minerals, and animals have been transformed into textiles through accumulated knowledge and experience across generations (Abel, 2017; Achmad Sopandi Haji Hasan, 2003). As both a cultural expression and a body of practical knowledge, natural textile dyeing constitutes a form of cultural and technological heritage in which identity, belief systems, aesthetics, and environmental understanding are embedded within a production process (Ghani & Zakaria, 2013; Norwani Md. Nawawi, 2016).

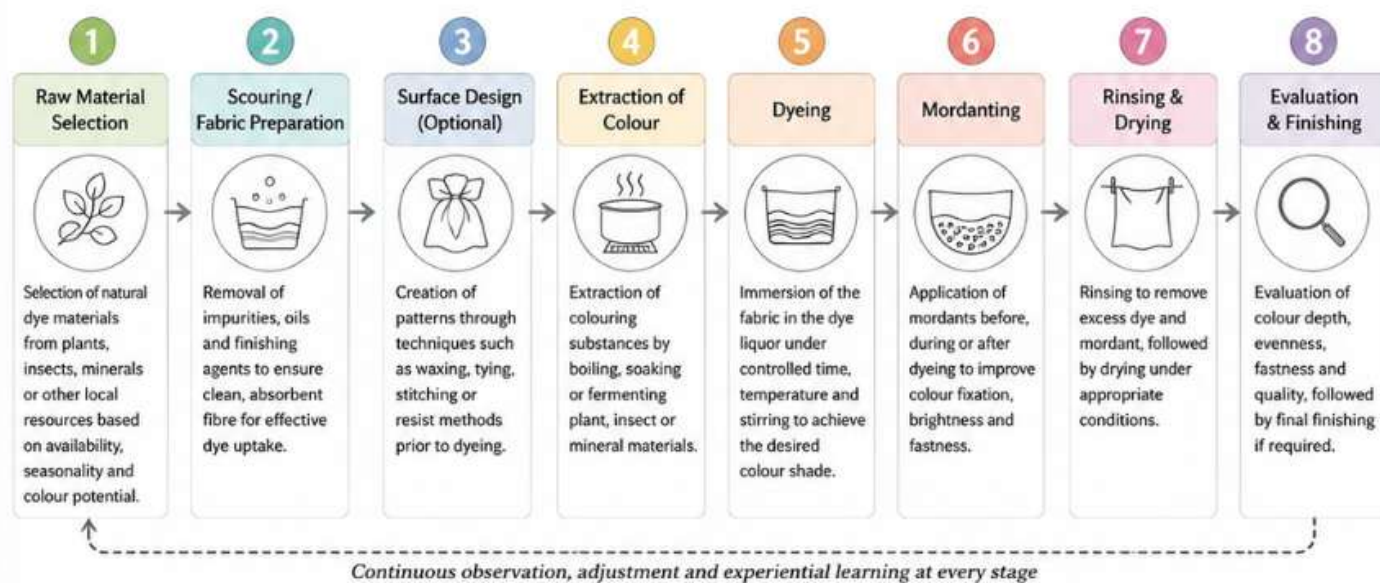


Figure 1 The sequence of natural dyeing process

The natural dyeing process involves a series of interconnected stages that require both technical skills and experiential judgement. Referring to Figure 1, it begins with the selection and preparation of natural dye materials, followed by fabric scouring, surface design where necessary, extraction of colouring substances, dyeing, mordanting, rinsing, drying, and evaluation of colour performance (Kanchana et al., 2013; Khattak et al., 2015; Swami et al., 2012; Widagdo, 2017). During these stages, practitioners continuously observe colour development, adjust extraction time and temperature, select appropriate mordants and respond to variations in raw materials and environmental conditions (Choudhury, 2018; Gupta, 2019; Salehan et al., 2009; Samanta & Konar, 2011; Yang et al., 2020). Therefore, natural textile dyeing should be understood as an integrated technological system in which every stage embodies practical knowledge, decision-making, experimentation and adaptation, demonstrating that technological heritage resides not only in the finished textile artefact but also in the accumulated knowledge, skills, and techniques embedded throughout the entire production process.

Natural textile dyeing is increasingly recognised as both cultural and technological heritage because it embodies the accumulated knowledge, skills, techniques, and environmental understanding developed by the practitioners. While cultural heritage is commonly associated with the preservation of traditions, identity, and artistic expressions, scholars argue that traditional textile practices also preserve technological knowledge through the

organisation of materials production process, and practical expertise (Ghani & Zakaria, 2013; Twigger Holroyd et al., 2017). Natural textile dyeing not only represents the process inherited from the past, but also reflects a dynamic technological system in which practitioners continuously observe and pick natural resources, experiment with dye materials, refine production techniques, and adapt their practices according to local environmental conditions and cultural needs (Bebit & Ibrahim, 2013; Makhunton et al., 2014; Sanli et al., 2011). This perspective is consistent with broader interpretations of technology that define technological development as the integration of knowledge, practice, skills, and purposeful action rather than the application of machines or industrial equipment (Ahmad & Mujani, 2012; Eric Schatzberg, 2025; Koch et al., 2024; Koetjaraningrat, 2002). Consequently, natural textile dyeing should be understood as cultural and technological heritage, where technology is preserved through the continuity of knowledge and practice rather than through artefacts alone. Collectively, these studies suggest that natural textile dyeing is more than a craft tradition. It represents a technological system grounded in knowledge, skills, environmental adaptation, and cultural practices.

DISCUSSION

Natural textile dyeing expanded the understanding of technology that extends beyond machines, industrial equipment, and scientific inventions. Drawing upon the literatures, this discussion brings the technology is fundamentally a system of practice that can shape the human action. In addition, the use of Theory of Practice as the principal theoretical lens, the following discussion explains how natural textile dyeing represents a technological practice through the dynamic relationship between local knowledge, repeated practice, and cultural adaptation.

Technology as Practice: Interpreting Natural Textile Dyeing through Theory of Practice

Theory of Practice provides a useful theoretical perspective for understanding technology as a form of human practice rather than merely machines. Originating from the work of Pierre Bourdieu, the theory explains that practices emerge through the interaction of habitus, practice, field, and capital, shaping how individuals and communities acquire, apply, and reproduce knowledge within particular cultural contexts (Asimaki, 2014; Power, 1999). Habitus refers to the knowledge, experiences, and dispositions accumulated through repeated learning, while practice represents the actions that people repeatedly perform in their daily lives. These practices occur within a particular field, such as the social, cultural, social, cultural, and environmental context, where different forms of capital – including cultural, social, symbolic, and economic capital – influence how individuals perform and adapt their activities. Rather than viewing practices as a fixed routine, Theory of Practice explains that practice continuously evolves through interaction between individuals and their surroundings.

Natural textile dyeing exemplifies the principle of Theory of Practices because its technological development is embedded in the continuous interaction between knowledge, experience, environment, and practical action. Within this perspective, technology is not viewed as an outcome of machinery alone but as a dynamic process in which knowledge systems influence technological systems through repeated practice and adaptation to changing circumstances. Hermayulis. et al. (2014) argue that the knowledge and technology developed in traditional textile production constitute a form of traditional craftsmanship, reflecting continuous innovation in techniques, methods, and production processes. Likewise, the natural textile dyeing process requires practitioners to work on the trial and error, demonstrating that technological knowledge is continually reproduced through practice rather than remaining static. This interpretation supports the argument that natural textile dyeing represents a technological practice in which local knowledge, practical skills, and environmental adaptation are inseparable elements of technological development (Asimaki & Koustourakis, 2014; Hermayulis. et al., 2014; Power, 1999). Therefore, natural textile dyeing demonstrates that technology is a living practice, continuously shaped by knowledge, experience, and environmental interaction.

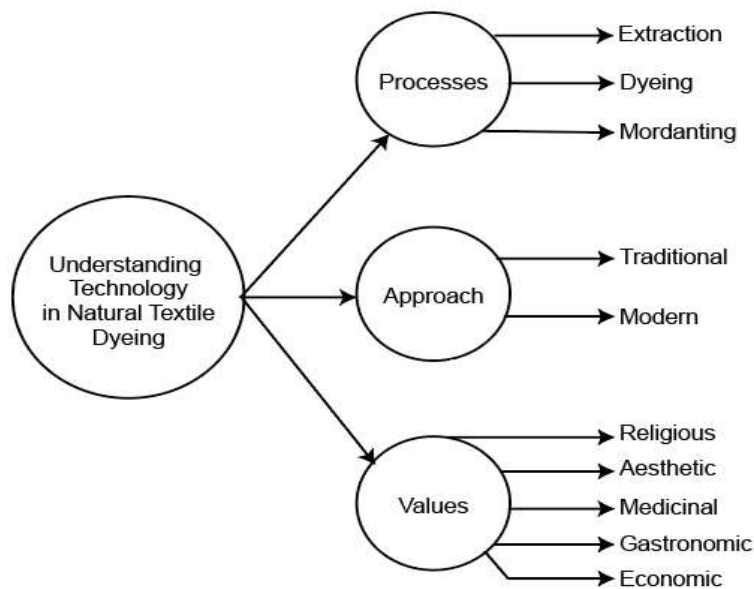


Figure 2 Understanding technology in natural textile dyeing

Figure 2 summarises how technology in natural textile dyeing may be understood beyond its conventional association with machinery. The figure illustrates that practitioners conceptualise technology through three interconnected dimensions: process, approach, and values. To demonstrate the practical application of the proposed framework, Figure 2 can be understood throughout the production of Malaysian textiles such as Batik and weaving. Both of these textiles provide suitable examples because both traditions combine inherited local knowledge with contemporary technological practices while preserving the cultural significance. The dimensions of process, approach, and values interact with the production process and collectively shape the technological practice. As shown in Table 3, the framework of understanding technology can also be applied to examine how technological knowledge is expressed through production activities, the integration of traditional and modern approaches, and the cultural, social, and economic values embedded in natural textile dyeing.

Table 3 The Three-Dimensional of Understanding Technology in Malaysian Natural Batik and Limar Textile

Dimension	Definition	Malaysian Natural Batik	Limar Textile (Natural Dye Weaving)	References
Description		Batik is a type of textile produced through the process of applying wax and dyeing fabric.	Traditional Malay weaving is the finest product of the Malay handloom. Limar refers to one of the techniques where the warp thread was tied and dyed to create the unimaginable ingenuity patterns.	Ismail (2018)
Process (What is done?)	Refer to the sequence of the technological activities and practical operations. It highlights how technology is enacted through systematic practice and continuous adaptation to available materials and environmental conditions.	Selection of natural dye plants → colour extraction → wax application → mordanting → repeated dyeing → wax removal → finishing and quality evaluation.	Selection of silk yarn, cotton yarn, and dye plants → colour extraction → mordanting → yarn dyeing → drying → pattern arrangement by tying the warp → weave → finishing and quality evaluation.	Ismail (2018), Shaari and Abd Rahman (2014), Hussin et al. (2020)

Approach (How is it done?)	Refer to the manner applied throughout the process, including traditional, modern, or integrated approaches.	Traditional knowledge of dye preparation and wax resist techniques is complemented by laboratory colour fastness testing, improved extraction and dyeing equipment, temperature control, and sustainable production practices.	Traditional weaving knowledge and natural dyeing techniques are complemented by quality control, digital documentation, improved yarn preparation, and conservation practices to maintain heritage textiles.	Ayele et al. (2020), Ghani (2009)
Values (Why is it done?)	Refer to the cultural, social, environmental, and economic meanings that guide technological practice and knowledge transmission.	: Preserve Malay cultural identity. : Produce distinctive aesthetic qualities. : Support artisan livelihoods and eco-tourism. : Promotes environmentally sustainable textile production.	: Preserve royal and Malay textile heritage. : Maintain traditional craftsmanship. : Strengthens community identity. : Support cultural tourism and local weaving economies while safeguarding traditional knowledge.	Haron and Yusof (2014), (Cohen (2001), N. Nawawi et al. (2015)

These three dimensions can be further interpreted through Bourdieu's Theory of Practice, which explains that practices emerge from the interaction between habitus, field, and capital. In natural textile dyeing, technological practice is not simply the execution of technical procedures but the outcome of accumulated knowledge, repeated experience, and continuous interaction with the surrounding social and environmental context. The practical knowledge required to select suitable dye materials, determine appropriate extraction and mordanting methods, and adapt techniques according to environmental conditions is gradually embodied through repeated participation and learning. At the same time, these practices are influenced by the field in which practitioners operate, including cultural traditions, community expectations, available resources, and economic considerations. Consequently, technology in natural textile dyeing should be understood as a dynamic practice in which knowledge systems and technological systems continuously interact, allowing technological knowledge to evolve through experience, adaptation, and everyday practice rather than through machinery alone.

Beyond explaining technological practice, the three dimensions of process, approach, and value also provide a lens for examining contemporary issues that influence the continuity and sustainability of natural textile dyeing. The values dimension from the understanding technology provides a perspective for understanding the contemporary commercialization of natural textile dyeing. As natural dyes gain increasing recognition within sustainable fashion, cultural heritage, and creative industries, local technologies knowledge is becoming both a cultural asset and an economic resource (Koch et al., 2024; Twigger Holroyd et al., 2017).

This development creates new opportunities for artisan communities and contemporary practitioners to strengthen local livelihoods while preserving traditional knowledge through value-added textile products. At the same time, increasing commercial interest raises important considerations regarding the protection of local knowledge, equitable benefits sharing, intellectual property, and the ethical use of community-based technological practices (UNESCO, 2015). From this perspective, commercialization should therefore extend beyond the economic value to acknowledge the cultural, social, and environmental values embedded within natural textile dyeing. Supporting the active participation of the process's activities in the development and

commercialization of natural textile dyeing contributes not only to sustainable livelihoods, but also to the continued transmission and safeguarding of technological knowledge as an integral part of cultural heritage.

Technology, Coloniality and Local Knowledge

The contemporary understanding of technology as machinery, industrial production, and scientific innovation did not emerge naturally but developed through specific historical processes. During the Industrial Revolution, rapid advances in mechanisation and factory-based production transformed manufacturing and economic systems, leading technology to become increasingly associated with machines, engineering, and industrial efficiency (Sharma & Singh, 2020). As industrialization expanded globally, this interpretation of technology became widely accepted within education, policy, and public discourse, often positioning technological progress as closely linked to scientific advancement and mechanized production. The historical development has narrowed the broader meaning of technology by emphasizing applied science and industrial artefacts, while giving less attention to technology as human knowledge, practical skills, and cultural practice (Adetoun Adedotun Amubode, 2009; Eric Schatzberg, 2018). Therefore, technology came to be understood primarily through its material outputs rather than through the knowledge and practices that enable people to create, adapt, and sustain them.

As industrial and scientific conceptions of technology became increasingly dominant, many forms of local technological knowledge received less recognition within academic, industrial, and policy contexts. Technologies developed through generations of practical experience, environmental observation, and cultural transmission were often viewed as traditional crafts or cultural practices rather than as legitimate technological systems. This shift contributed to the marginalization of indigenous and local knowledge, despite its also play important role in resource management, material innovation and sustainable production (UNESCO, 2015). In natural textile dyeing, for example, practitioners possess sophisticated knowledge of dye plant selection and harvesting, mordanting, colour extraction, and colour modification that has been developed through long-term interaction with local environments. However, because these practices rely primarily on experiential knowledge instead of industrial machinery, they have often been overlooked within conventional understandings of technology.

Acknowledging the historical marginalisation of local technological knowledge provides an opportunity to reconsider how technology is understood in contemporary scholarship. This argument encourages scholars to understand that technological development is shaped not only by scientific and industrial advancement, but also by the accumulated trial-and-error experiences, practices, and innovation of the local practitioners. Within natural textile dyeing, this perspective highlights how the actions of observation, experimentation, and adaptation have contributed to the continuous development of technological knowledge. Therefore, this perspective provides the theoretical basis for interpreting technology through the Theory of Practice, where technological knowledge is continuously produced, reproduced, and transformed through the interaction between people, knowledge, culture, materials, and the environment.

Conceptual Framework: Technology as Practice in Natural Textile Dyeing

Based on the preceding discussion, this paper proposes a conceptual framework in Figure 3 to explain technology as practice in natural textile dyeing. The framework integrates Theory of Practices with local knowledge and the natural textile dyeing process to illustrate how technological knowledge is generated through continuous interaction between people, practice, and environment.

Figure 3 illustrates technology as a dynamic system of practice in natural textile dyeing. The framework synthesises Theory of Practice with studies on technology, local knowledge, and natural textile dyeing to demonstrate how technological knowledge is continuously produced through the interaction between local knowledge, habitus, field, and capital, and repeated practice. Local knowledge forms the foundation from which practitioners acquire knowledge of natural resources, cultural values, and practical skills, while habitus represents the embodied dispositions developed through long-term experience and participation. These dispositions are enacted within particular social, cultural, environmental, and economic contexts (field and capital), shaping how practitioners can perform the sequence of natural textile dyeing activities, including raw material selection, fabric treatments, colour extraction, dyeing, mordanting, rinsing, drying, and evaluation.

Throughout these stages, continuous observation, experimentation, reflection, and adaptation generate technological knowledge in the form of practical skills, decision-making abilities, innovation, and technical refinement. Rather than viewing technology as machinery or industrial equipment, the framework demonstrates that technology emerges through practices, where knowledge, experience, environmental interaction, and cultural values collectively sustain technological development while contributing to cultural and technological heritage as well as sustainable textile development.

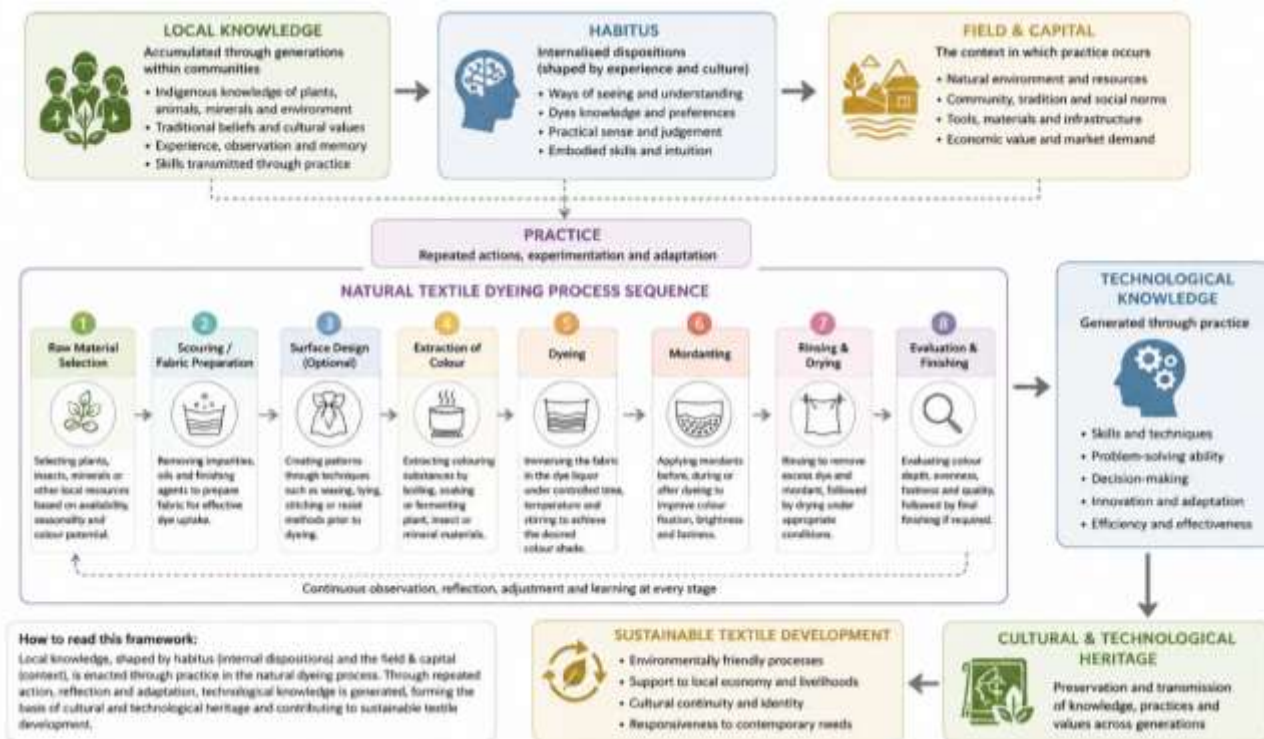


Figure 3 Conceptual framework: Technology as practice in natural textile dyeing

The proposed conceptual framework offers a practical foundation for future empirical research. Researchers may employ the three dimensions of process, approach, and values to guide the observation, interviews, participations, and document analysis when examining the natural textile dyeing practices. This framework may assist in identifying how technological knowledge is enacted, transmitted, and adapted across different cultural and environmental contexts.

The processes throughout the natural textile dyeing are influenced by changing environmental conditions and the availability of natural dye resources. Variations in seasonal cycles, biodiversity, and access to plant materials require practitioners to continuously adapt their technological practices while maintaining the underlying principles of local knowledge. This adaptation demonstrates that traditional technologies are not static systems but dynamic practices that evolve in response to environmental and societal changes. Understanding these adaptive processes further supports the view of technology as an interaction between knowledge, people and the environment.

LIMITATIONS AND FUTURE RESEARCH

This paper contributes to a broader understanding of technology through local knowledge in natural dyeing, and several limitations should be acknowledged. First, this paper is conceptual in nature and develops its arguments through the synthesis of interdisciplinary literature instead of the presentation of empirical findings. This proposed conceptual framework is intended as a theoretical model that reconceptualizes technology as a practice embedded within knowledge, skills, environmental interaction, and cultural values. Meanwhile, the framework also provides a coherent perspective for understanding technology beyond machinery, its broader applicability would benefit from further empirical examination across diverse natural dyeing traditions and cultural contexts.

Future studies may apply and further refine the proposed conceptual framework through qualitative investigations involving interviews, participant observation, and comparative case studies with practitioners who are doing natural textile dyeing. The studies would provide opportunities to examine how technological knowledge is embodied in everyday practice, transmitted across generations, and continuously adapted to changing environmental, social, and economic conditions. Drawing upon Theory of Practice, these empirical investigations may also deepen understanding of how habitus, field, and capital shape technological practices within different communities (Asimaki & Koustourakis, 2014; Power, 1999). Comparative research may involve other traditional technologies, such as weaving, pottery, woodcraft, or indigenous food processing, and can evaluate more on the transferability and broader applicability of the proposed framework.

In addition, future research should examine how contemporary practitioners negotiate the relationship between local knowledge and modern technological innovations within rapidly changing socio-economic and environmental contexts. Several issues should get attention, such as sustainability, commercialization, intellectual property, cultural heritage preservation, and the adaptation of traditional dyeing practices to changing resource availability and environmental conditions. Exploring these dimensions would contribute to a more comprehensive understanding of technology as a dynamic system of practice that continuously evolves through the interaction of knowledge, people, culture, and the environment while supporting the long-term sustainability of traditional technological heritage (Koch et al., 2024; Twigger Holroyd et al., 2017).

CONCLUSION

As a conclusion, this paper argues that natural textile dyeing should be understood as a technological practice and not merely a traditional craft or a production process supported by simple tools. By synthesising literature on technology, local knowledge, natural textile dyeing, and Bourdieu's Theory of Practice, this paper demonstrates that technology emerges through the continuous interaction between knowledge, experience, environmental adaptation, and repeated practice. The proposed conceptual framework further illustrates that technological knowledge is generated not only through the sequence of natural textile dyeing activities, but also through the integration of local knowledge, habitus, field, and capital, which collectively shape technological practice. This broader interpretation challenges the dominant perception of technology as machinery and industrial innovation, recognising that traditional knowledge systems also embody legitimate forms of technological development. Consequently, understanding technology through natural textile dyeing offers a more inclusive perspective that acknowledges the contribution of local knowledge to cultural continuity, technological heritage, and sustainable textile development.

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