DIGITAL PRESERVATION OF RUMAH TUKANG KAHAR FOR CULTURAL HERITAGE TOURISM

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Abstract

The paper focuses on exploring the virtual collaboration process in the digital preservation project of Rumah Tukang Kahar, a traditional Malay house in Negeri Sembilan, Malaysia, as a form of cultural heritage tourism. The purpose of the project is to develop an augmented reality interface through mobile app, website, and pamphlets with AR markers, to virtually and physically boost Malaysia heritage tourism economy. This paper describes a year-long virtual collaboration process between multidisciplinary and transnational researchers with various expertise between Malaysia and Indonesia under the Indonesia-Malaysia Research Consortium (I'MRC) initiatives. The paper reflects on the design and product development process and challenges within the virtual collaboration between two universities. The researchers' involvement in the virtual collaboration process suggests that effective asynchronous and synchronous communication using online textual and visual communication tools and platforms leads to more effective, productive, and meaningful outcomes in research, collaboration, and product development.

Keywords: digital preservation, virtual collaboration, Rumah Tukang Kahar, cultural heritage tourism

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Introduction

This study explores the virtual collaboration process within the joint cultural heritage research between Universiti Teknologi Malaysia (UTM) in Malaysia and Universitas Negeri Malang (UM) of Indonesia under the Indonesia-Malaysia Research Consortium (I'MRC). The research focuses on two different heritage artefacts that are significant to the local heritage of the two countries. The researchers from Indonesia are looking at the heritage of *Topeng Malangan* (Sidyawati et al., 2022), while the researchers from Malaysia are focusing on Rumah Tukang Kahar (RTK) which is the main subject of the research in this paper. The traditional house of RTK is part of the recent restoration of architectural heritages in Malaysia. Although the focus of the content or subject of the research project varies among researchers, the methodological process and discussions are done collaboratively due to the shared resources and output of the virtual tools and platforms.

The collaborative research took place during the global COVID-19 pandemic, which presents many constraints and challenges but also provides an opportunity for virtual collaboration between researchers with different expertise from two different countries. The research collaboration was enabled through the use of virtual collaborative tools and a design process based on asynchronous or synchronous methods and text-based or visual discussions. The research is a multidisciplinary project that has demonstrated the importance of working with researchers from different fields in producing results, learning, working together, and negotiating between teams to achieve the desired outcomes. This is commonly referred to as a community of practice (CoP), where members come together to pursue a common goal, to learn from others by sharing experiences and knowledge and developing their personal and professional skills (Lave & Wenger, 1991).

The intended outcome of the virtual collaboration was the digital preservation of cultural heritage through the reconstruction of a three-dimensional digital model of Rumah Tukang Kahar. The actual and digitally generated 3D images of the artefacts will be displayed in tourism promotional materials such as printed pamphlets and websites. Mixed reality technology is introduced in the implementation of augmented reality (AR) and embedded markers in the tourism pamphlets to activate the AR interface on the mobile app. Information, images, and 3D representations of Rumah Tukang Kahar were displayed on all products through the AR interface to promote and preserve our cultural heritage in the built environment.

The cultural heritage in Malaysia

Malaysia is one of the world's most popular tourist destinations (Mosbah & Khuja, 2014) as the country is blessed with a diverse and rich cultural heritage. Malaysia's cultural heritage represents the various ethnic groups with different local knowledge disciplines manifested in ancient monuments or buildings, historical sites, artefacts, colourful festivals, rituals,

and exotic cuisines or dresses (Ismail et al., 2014). Malaysia has therefore become a major tourist attraction for travellers seeking a unique cultural experience.

The built environment, which includes "buildings, townscapes, archaeological remains," is part of the cultural heritage that is significant to the local culture (Ismail et al., 2014, p. 3). It needs to be preserved as it contributes to place attachment (Low & Altman, 1992; Wang, 2023), sense of place, and local identity (International Council on Monuments and Sites [ICOMOS], 2011; Ismail et al., 2014). Heritage buildings or architectural heritage are usually kept in museums (Bennett, 2004), historic sites, institutions, and places dedicated to the preservation of their tangible and intangible evidence in relation to local communities and the environment.

The architectural heritage is exhibited and visited by tourists, especially heritage tourists (Adie & Hall, 2017; McKercher, 2002; Nguyen & Cheung, 2014) as part of the heritage tourism (Park, 2013). Heritage tourism is considered one of the leading market segments of tourism in the future (World Tourism Organization [UNWTO], 1997), which is actively promoted by locals to contribute to the economic empowerment of their community (Bhuiyan et al., 2013; Trisnawati & Idaman, 2019). The following section discusses Rumah Tukang Kahar as a form of architectural heritage in Malaysia.

The heritage of Rumah Tukang Kahar

Rumah Tukang Kahar (translated as the House of Tukang Kahar) is a traditional house built by the master craftsman, Tukang Kahar in 1880. Tukang Kahar is a well-known master craftsman who inherited his woodworking skills from his father. He is also a respected person who has good connections with the courtiers of the time. Tukang Kahar and his fellow carpenter, Tukang Taib were responsible for the design and construction of the Istana Seri Menanti, the old royal palace in Negeri Sembilan, Malaysia (Radzi et al., 1994; Sulaiman, 2017). The palace itself is one of the largest traditional Malay buildings in the Malay Archipelago. It is the tallest traditional wooden palace in the world built without nails and an architectural gem. It was built in 1902 to replace an older palace that had been burnt down in an earlier war against the British colonial rulers. Today, it is a well-preserved structure that welcomes visitors as a dignified royal museum.

Rumah Tukang Kahar was relocated from a village after it became uninhabited and then moved to its current location on the palace grounds and conserved by the Negeri Sembilan Museum Authority in 2014. The house embodies the Malay craftsmanship; wisdom, technology, and artistry of Malay architecture with its nail-free construction, bright ambience, and meaningful carvings (Mohamad Rasdi et al., 2005; Y.-R. Chen et al., 2008). The carving is based on the ancient Malay guidebook *Tajul Muluk*, which often refers to mythical and spiritual references (Lah et al., 2015; Radzi et al, 1994; Sulaiman, 2017).

Malay architectural heritage such as Rumah Tukang Kahar demonstrates a unique cultural identity and model of vernacular architecture (Hosseini et al., 2014) and reflects the dynamic and transient nature of Malay architecture compared to the notions of the Western built environment. The principles of Western cultural heritage are based on the authenticity of materials, suggesting that the emphasis is on the values of the objects. The Malay house, on the other hand, represents the value of its immateriality and intangibility due to the metaphorical relationship of the artefact or object as 'living' (Chapagain, 2013).

Figure 1. Rumah Tukang Kahar (side view), an architectural heritage that was built and inhabited by the master craftsman known as Tukang Kahar (Image by KALAM)

The heritage is understood in terms of its culture, function, and use (Vellinga et al., 2007). This also suggests that historical artefacts are the result of repeated and ongoing interactions in the lived world of the people and communities surrounding these artefacts (Byrne, 2008). Nevertheless, a significant heritage such as Rumah Tukang Kahar needs to be conserved in order to preserve and promote its cultural and historical significance (Historic England, 2016; International Council on Monuments and Sites [ICOMOS], 2013).

Despite its significant value, cultural heritage such as Rumah Tukang Kahar is declining due to threats from contemporary developments (de la Torre, 2013). Moreover, the nature of this architectural heritage which is inherently ephemeral due to the use of wooden materials (Lim, 1987; Waterson, 2010) and lack of documentation or 'blueprints' (Ariffin, 2001; Mohd Rashid, 2018) contributes to its extinction. Therefore, the urgency to preserve the heritage with the significant cultural value of a built environment is paramount and requires further action and investigation. One possibility is the digital preservation of cultural heritage.

Digital preservation of the architectural heritage

Digital preservation in architectural heritage is an emerging method for heritage discovery, analysis, and representation (Alfonso & Michela, 2016; Khalid, 2022). Apart from recording the physical condition and appearance of the heritage objects, the digital preservation documentation process creates new knowledge that serves as a "critical investigation with the potential of bringing about new insights into the interpretation of the object: its authenticity, provenance, historical use, and transformation" (Bentkowska-Kafel & MacDonald, 2017, p. xiii). The digital preservation documentation process has been introduced to replace 2D drawings of architectural heritage monuments with three-dimensional representations that are more accurate and precise (Shih et al., 2007) and enable cost-effective measures (Khalid, 2022; Li et al., 2023; Shih et al., 2007) both in the documentation process and in conservation.

In the age of digitisation and globalisation, digital preservation of architectural heritage offers new user experiences (Khalid, 2022; Thwaites et al., 2019) such as in interactive storytelling (Psomadaki et al., 2019) and provides democratic access to heritage objects, while creating "over time a balanced and equitable representation" of local heritage for remote audiences or virtual visitors on a global scale (Colin, 2003, p. 14). Digital preservation is an act of raising awareness (Li et al., 2023; Thwaites et al., 2019), which could present itself as a conceptual object that gives meaning to people (Colin, 2003).

The digital preservation of Rumah Tukang Kahar as an architectural heritage reflects the spirit of physical heritage conservation practises (Kurin, 2004) and provides an opportunity to promote heritage in virtual tourism (Verma et al., 2022). The mobile app was developed to enable foreign and domestic tourists around the world to learn about cultural heritage artefacts from the comfort of their homes before travelling to a destination in Malaysia and Indonesia. This is part of virtual tourism where the 'virtual tourist' has early access to information, including images and objects, with the added benefit of being able to explore and manipulate heritage objects via AR.

The attempt to preserve RTK digitally not only contributes to heritage conservation but also adds value to existing cultural tourism. Using AR to promote cultural heritage could increase interest in virtual tourism and boost the local economy while preserving cultural heritage for the future. As tourists are constantly looking for any opportunity to visit culturally unique and authentic destinations, virtual tourism could become a niche in the historical and cultural heritage sector (Basiya & Rozak, 2012; Verma et al., 2022).

Constructing the augmented reality of Rumah Tukang Kahar

The research produces a prototype of a common mobile app using augmented reality (AR), a website, and a physical pamphlet with AR markers of Rumah Tukang Kahar. Blender, a 3D computer graphics programme, was used to create the digital model of Rumah Tukang Kahar, which was later exported to the Vuforia

engine and the Unity app used by the app developer to develop the AR interface.

To try the augmented reality prototype, users need to install the app on their mobile phones, which is currently limited to Android devices. The app works in conjunction with the printed pamphlet, which contains information about Rumah Tukang Kahar's cultural heritage. Hovering over specific images with AR markers in the printed pamphlet brings the virtual heritage objects to life as each marker represents a different aspect of the heritage representation. The markers exist as a multi-layered approach to representing built heritage (Mwale et al., 2022). One marker illustrates the complete shape of the house, the other a detail of the wooden staircase with its carvings, and another marker shows the construction process of the house from the foundation to the roof structure. Users can change the scale and orientation of the objects on AR with finger gestures on their mobile device screen to interact with them.

Figure 2. The Rumah Tukang Kahar's application interface demonstration of augmented reality via the pamphlet design (Image by authors)

Although the mobile app presents the physical or tangible image of Rumah Tukang Kahar in digital 3D format, it also shows the intangible aspect of the house, which is part of the intangible culture of the people (Maudlin, 2009). The heritage of Malay architecture, reveals both the tangible and intangible expressions of cultural heritage as interwoven in its appearance (Iacono & Brown, 2016). Both tangible and intangible heritage rely on each other's existence for meaning, identity, and authenticity (Mohd Rashid, 2018). Recent studies have explored how museum exhibitions address different levels of "narratives, visitor interests, and unpacking layers of objects' meanings" (Mwale et al., 2022, p. 91). Therefore, in the mobile app produced, RTK is visualised in the form of digital storytelling (Psomadaki et al., 2019) through animations and sounds in the building sequence of the house to illustrate the house-building practises and activities associated with the assembly of the architectural heritage.

Figure 3. Rumah Tukang Kahar and Topeng Malangan *traditional heritage promotion website (Image by authors)*

Detailed tourist information and heritage images are also presented on the website and in the pamphlet for further information. All results and progress have been shared among researchers to ensure consistent use of the platforms and information while promoting the traditional house and masks as a common heritage of the *Nusantara*[1]. In this way, tourists can learn about the tourism heritage of two different countries that embody a similar spirit from a single point of reference. The prototype mobile app and pamphlet can be accessed and downloaded by anyone through the website. With simple instructions, the mobile app is easy to use and could be replicated and further developed to include other heritage objects or sites in *Nusantara*, which will be useful in promoting heritage tourism in both countries. As the COVID-19 pandemic is gradually phasing out, the use of augmented reality could add further value and promote local tourism heritage and the local economy through virtual engagement.

Virtual collaboration process between researchers

This joint research used the methodological framework negotiated and agreed by both parties from Malaysia and Indonesia. However, as the research took place in different countries and during the COVID-19 pandemic, physical interaction between researchers from both countries and between the research team members within the same university was limited. Therefore, the research opted for virtual collaboration in communication, site visits and design production through various virtual tools and platforms. The methods conducted for the research were adopted and revised from the developmental model summarised by Aka (2019), which was derived from Borg and Gall (1983) and Lee and Owens (2004)

[1] *Nusantara* is an old Javanese term referring to the 'archipelago' or a group of Malay islands influenced by the culture and language of the Malays. These include Indonesia, Malaysia, Singapore, Southern Thailand, the Philippines, Brunei, Timor Leste, and Taiwan.

discussion on research methodologies. This model is divided into four main phases, (1) research and planning; (2) design development; (3) digital product development; and (4) reporting and dissemination (Figure 4).

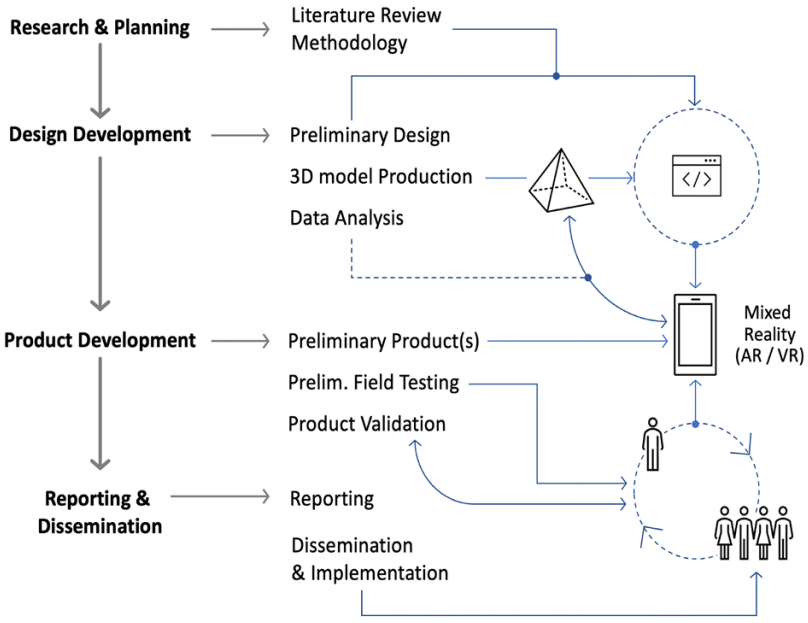

Figure 4. The methodology and process used by the researches adapted from Aka (2019) (Image by authors)

In this research, virtual collaboration becomes one of the most important means for communicating and conducting research activities. The research outcome was the development of a physical and digital format of cultural heritage: an augmented reality (AR) mobile app, an informative tourism website, and a physical pamphlet with AR markers, forming the comprehensive heritage tourism package of Rumah Tukang Kahar in Malaysia. Figure 5 demonstrates how stakeholders from Malaysia and Indonesia conducted virtual collaboration through virtual tools to develop an augmented-reality tourism package.

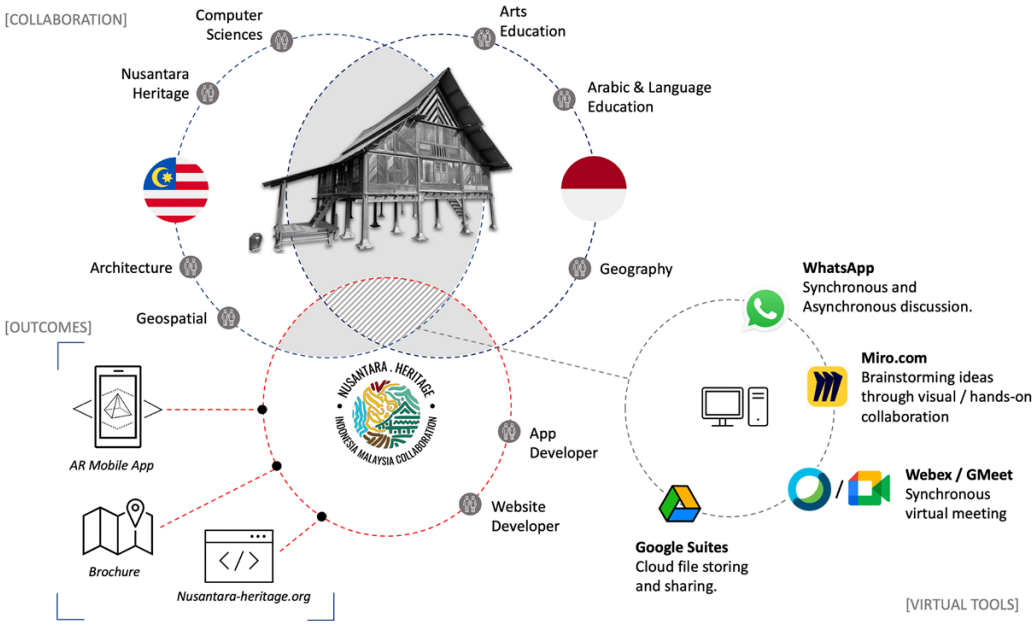

Figure 5. The overview of virtual collaboration involving researchers with different backgrounds and expertise to jointly produce the output of the AR of Rumah Tukang Kahar (Image by authors)

Virtual collaboration is the process of team members working together from different geographical locations and time zones, using information and communication technology to accomplish their tasks (Garro-Abarca et al., 2021). To achieve this within a specific timeframe, the collaboration used both asynchronous and synchronous distributed collaboration (Tate et al., 2014). The former describes a virtual collaboration that took place in the context of a continuous 'asynchronous communication' or a process that did not take place at the same time at the researchers' own pace. The latter on the other hand, speaks of periodic 'synchronous communication' where online discussions took place in real time via online video conferencing. Both types of collaboration were effective when all researchers were not available in the same place due to the constraints of the COVID-19 pandemic.

The global COVID-19 pandemic has challenged the physical workplace and further increased the demand for virtual collaboration, especially among scholars worldwide. Thus, the prevailing norm of working from the comfort of one's home and remotely has become common and inevitable (Garro-Abarca et al., 2021). Virtual collaboration mirrors traditional collaboration in its characteristics and procedural aspects, such as behaviours and trust (Tschannen-Moran, 2001), learning and developing knowledge together (Barfield, 2016), and achieving productive and enjoyable outcomes (Datnow, 2011). However, participants in virtual collaboration rely solely on technological means for communication, without physical interactions (Garro-Abarca et al., 2021).

Chen and Lin (2004) point out that virtual collaboration is essential for the success of organisations as they benefit from the applications of virtual teams, virtual meetings, and virtual learning. In contrast, virtual collaboration through video conferencing is said to limit idea generation and lead to a narrower cognitive focus confined to a small screen (Brucks & Levav, 2022). The following section discusses the workflows of developing a physical and digital format of Rumah Tukang Kahar as a form of cultural heritage.

Multidisciplinary and transnational workflows in producing digital architectural contents

In the course of the research, different expertise is needed in fulfilling the technical or non-technical tasks. Technical tasks relate to mobile app delivery or web development, including testing and debugging, while non-technical tasks relate to content creation, graphic or user interface design and project management. The members of the research team have different backgrounds, disciplines, and expertise, which is in line with the idea of a multidisciplinary approach (Mcgregor, 2004).

Although working with a multidisciplinary team in the context of virtual collaboration is not transdisciplinary at this stage (Lawrence, 2010), it means that there is synergy and knowledge transfer disciplines to solve a particular problem. However, individual researchers usually remain within their

respective disciplines and apply their concepts and methods, even if they do not necessarily share a common goal (Lawrence, 2010; Mcgregor, 2004). Virtual collaboration took place internally within research teams, between universities and with other parties, including local practitioners and digital developers from Indonesia (Table 1).

Table 1. List of collaborators from Malaysia and Indonesia with their expertise

Country	Affiliation	Expertise
Malaysia	University researchers	Computer sciences
		Nusantara heritage
		Architecture
		Geospatial
	Practitioner	Nusantara heritage
Indonesia	University researchers	Arts education
		Arabic & language education
		Geography
	App developer	Software & application design
	Website developer	Website & visual design

In addition, the use of other Google Suites such as Google Slides and Google Drive enables simultaneous virtual collaboration and sharing of digital resources. Google Slides was used to present the common tasks and explain the responsibilities of each researcher systematically and sequentially. It also enables the development of curated content for the digital products, such as the AR interface to present the 3D digital house form, the detailed house components, and the narrative of the house building process. The focus using Google Slides is the ability to organise content in the form of presentation slides, which allows for a more efficient process of receiving, editing, and subdividing each other's research contributions to achieve a manageable output. Meanwhile, Google Drive was used to manage and store digital content, including digital versions of Rumah Tukang Kahar 'constructed' and 'preserved' in 3D modelling software format to be utilised by software developers from Indonesia. The practise of using Google Slides and Google Drive simulates the aspect of knowledge practises in organisations where technologies serve as a form of communication, content sharing, and common reference point, such as knowledge repositories (or knowledge sharing systems) where research participants respond, engage, and manipulate project information and outcomes (Jarrahi & Sawyer, 2013).

Researching ideas, especially for product development of the intended outcomes—the AR mobile app, the website, and the printed pamphlet of Rumah Tukang Kahar requires a different aspect of engagement. While the content of the research outputs was developed in Google Suites, the product development requiring visual engagement took place in Miro, a highly collaborative online tool for virtual collaboration (*Design Research*, 2017; Mohd Rashid et al., 2020). Miro replaces physical

whiteboards and physical discussions with a tangible and accessible platform where researchers can comment and sketch their ideas (Figure 6), similar to the concept of Sticky Notes brainstorming methods (Burgess et al., 2021; Jensen et al., 2018).

Miro is used in asynchronous and synchronous virtual communication modes where researchers "compile, record, display and communicate their thoughts visually using images as well as sketches" (Mohd Rashid et al., 2020, p. 275). Virtual collaboration benefits from the virtual environment or space for researchers to participate as it "can enhance the same time/different-place interaction (..) providing synchronous virtual meeting support within a space that acts as a persistent repository of informational objects representing resources used and generated by the [virtual] collaboration, and moreover in such a way as to complement the rich potential of web technologies as a means for asynchronous collaboration" (Tate et al., 2014, p. 2).

The advantage of using a virtual whiteboard is its visual properties, as images and drawings are better understood than instructional text during design development. Since the visual appearance of the products is one of the main focuses in this research, as in user experience (UX) design and graphic creations, virtual discussion over the visual representation of the products is more appropriate and productive. Although the organisational appearance and layout of research data in Miro was random and disorganised, it clearly shows the development and iteration of ideas that went into the research project. The images, sketches, and comments become a form of "visual inquiry and illustration" (Saginatari & Perkasa, 2021, p. 25). It resembles the creation of 'catalogue drawings' which is beneficial to researchers as it facilitates design thinking and frames the process as an investigative procedure to explore specific information (Karimah & Atmodiwirjo, 2021). The images

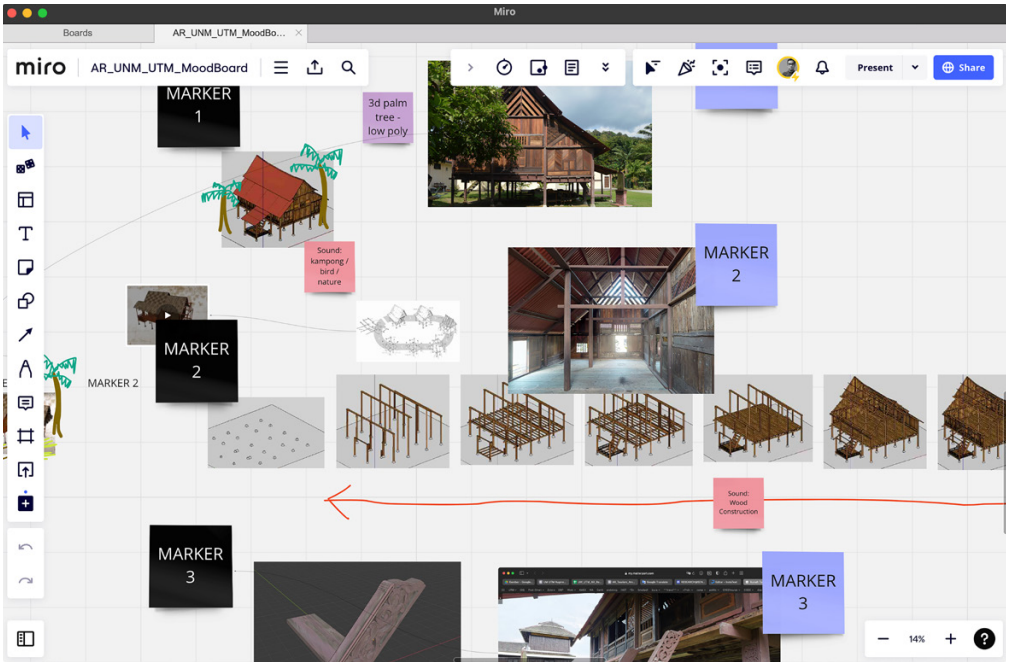

Figure 6. Using the Miro enables virtual collaboration between the researchers, the mobile app developer, and the website developer to achieve the intended decisions and outcomes (Image by authors)

and drawings on the Miro platform offer insights into different representations of the research process, including its research goals, as action, and as a projection of possibilities, but most importantly is knowledge gathered by researchers as a record (Bordeleau & Bresler, 2010). Ultimately, it creatively builds collaborative knowledge (Saginatari & Perkasa, 2021).

The use of virtual communication has effectively enhanced the aspect of collaboration through sharing online resources and asynchronous and synchronous discussions. Since the research outputs such as the AR mobile app, pamphlet and website can be accessed online, downloaded and printed locally, the testing and evaluation of these products could be done by the local researchers at each university. Subsequently, the discussions and feedback can be conducted through Webex and Google Meet, which could also enhance collaboration through real-time discussions and decision-making among the research members and developers. WhatsApp was also used extensively to share information and facilitate real-time discussions, providing a convenient and inclusive approach to sharing ideas (Chen & Neo, 2019). This method resembled oral interactions fostering spontaneity and dynamism compared to traditional emails (Crystal, 2010; Jesenská, 2015).

Table 2. The asynchronous and synchronous methods and virtual tools adopted for communication and workflows

Virtual Collaboration Methods	Webex & Google Meet (video conferencing)	Google Drive (storage)	Email (communication)	WhatsApp (communication)	Miro
Asynchronous		X	X	X	X
Synchronous	X			X	X

Challenges in virtual collaboration

As Rumah Tukang Kahar is located in Negeri Sembilan, Malaysia, both the research team from Malaysia and Indonesia were unable to visit the site during the COVID-19 pandemic due to travel restrictions. Laser scanning or LiDAR technologies for heritage conservation (Khalid, 2022; Li et al., 2023; Shih et al., 2007) were useful but not necessary at this time, but alternative resources such as existing virtual tours and online imagery provide initial data. Therefore, the research relies on the data of previous online and digital documentation of previous projects and the collection of measured drawings at KALAM[2] for the digital development and reconstruction of the three-dimensional version of Rumah Tukang Kahar.

Initially, the preliminary communication method or reference was developed in Google Sheets, where virtual teams could provide feedback and responses in a systematic manner, but it failed to achieve engagement throughout the research

[2] KALAM refers to the Centre for the Study of Built Environment in the Malay World, a Centre of Excellence (CoE) located in UTM JB. It was set up in June 1996 on the foundation of numerous intricate measured drawing works of historical buildings since 1975, out of concern for the rapid disintegration and elimination of Malaysia's architectural heritage.

period. Studies have shown that the challenges of virtual collaboration affect performance (Brucks & Levav, 2022; Garro-Abarca et al., 2021), but in this project, the researchers quickly adopted other means of communication to keep the project moving forward continuously and to everyone's benefit. From a text-based appearance of Google Sheets, the discussions moved towards a multiple communication approach that is a more engaging and visually appealing aspect of virtual collaboration; video conferencing, and the use of Google Slides and Miro. As virtuality increases due to the high reliance on virtual communication tools and the increase in virtual work, interpersonal coordination may potentially decline as relationships between virtual collaborators are mediated in part by the level of 'trust' (Peñarroja et al., 2013). However, the use of synchronous video conferencing tools, e.g., during regular progress meetings, becomes a medium for immediate interaction and negotiation with each other, enhancing virtual collaboration and strengthening trust between researchers from both universities. The highlight of the virtual collaboration was a joint symposium where the virtual collaborators physically met at Universitas Negeri Malang in Indonesia to exhibit and introduce their joint work to a live audience.

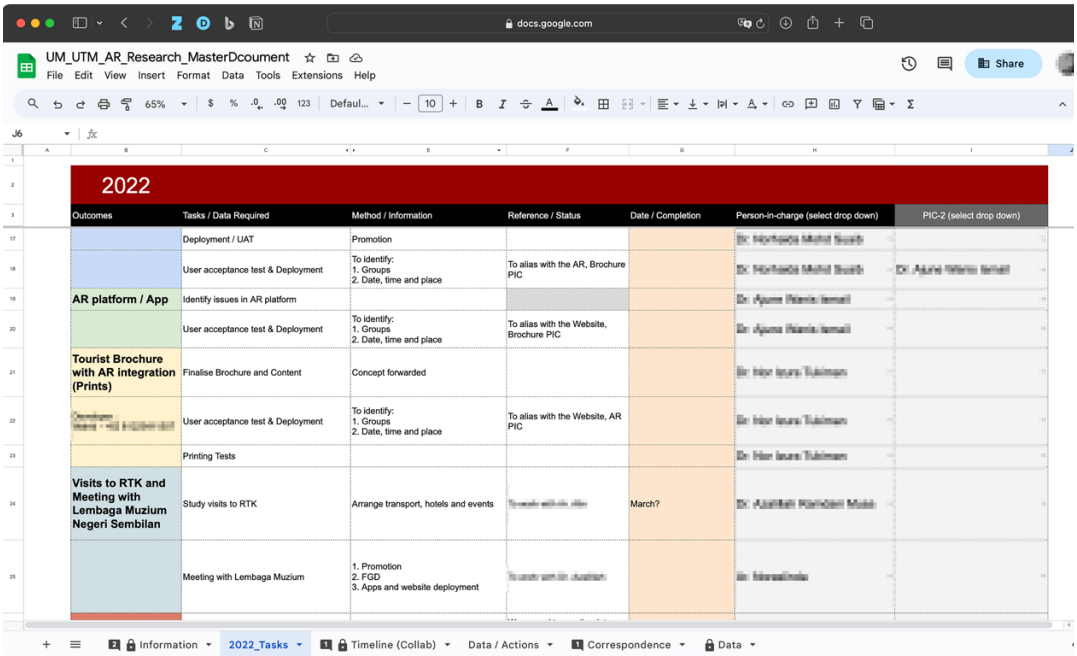

Figure 7. The Google Sheet web application was initially used as a reference point for engaging and distributing tasks among virtual collaborators but was underutilised (Image by authors)

Continuing virtual collaboration and reflection

This paper discusses the virtual collaboration process happening in the creation of the augmented reality interface of Rumah Tukang Kahar as part of cultural heritage tourism. The project produced mobile app, website, and AR-marked printed pamphlets of Rumah Tukang Kahar throughout the pandemic COVID-19. This paper articulates new ways of working together, sharing new ideas and the demand for continuous learning and improvement in the use of virtual tools and the creation of architectural digital content. Researchers work in a

multidisciplinary and transnational environment where digital and physical research output has taught researchers the value of collaboration and, above all, the idea of skilful facilitation and negotiation with others outside their own field. Moreover, the virtual working conditions open up various possibilities for collaboration beyond individual countries into a collective endeavour under the banner of the Nusantara region.

The Rumah Tukang Kahar has been digitally conserved and can now be publicly visited and downloaded via the mobile app for virtual tourists. The result should not be seen as a challenge to the role of museums, but rather as a complement, as heritage objects are now accessible, immersive and engaging (Verma et al., 2022), and suitable for today's generations.

Working in collaborative 'virtual teams' (Garro-Abarca et al., 2021) benefits architectural heritage by offering alternative representations of cultural objects in a new light, e.g., through the use of augmented reality (AR). The creation of AR Rumah Tukang Kahar requires multidisciplinary expertise from different fields, to document the three-dimensional form of Rumah Tukang Kahar, produce the AR model, produce the narrative about the Rumah Tukang Kahar, and generate the cultural tourism product package for a wider audience. It requires further collaboration with others from the technology sector and the cultural heritage tourism industry. Architectural heritage benefits from this multidisciplinary engagement as potential technologies could be adopted and implemented to ensure the preservation and sustainability of the cultural heritage (Li et al., 2023) of Malaysia's traditional architecture, which is notoriously short-lived.

In a virtual creative working environment, ideas are often lost and some opinions may not be heard. The different modes of communication from a text-based such as WhatsApp to a visual-based platform like the Miro app, allow for a different mode of collaboration appropriate to the situation. For example, compiling ideas for representation can be done in Miro, while discussion on design decisions that need to be taken can be done through WhatsApp. The researchers have adopted a virtual workflow that is familiar and accessible and encourages researchers to contribute and give feedback. The use of multiple digital tools enables virtual collaboration and communication, adding value to normal face-to-face collaboration.

Ultimately, the research project contributes to preserving cultural heritage assets such as the Rumah Tukang Kahar, promoting its value for cultural tourism and making it known worldwide through virtual means. As the project progresses, the research team reflects on the experiences and insights gained during the process of producing the Rumah Tukang Kahar cultural heritage package. The multidisciplinary approach of virtual collaboration responds to what is called a community of practice (CoP), where meaningful collaboration takes place to achieve the expected outcomes, creating both collective and personal output. Nevertheless, in the post-pandemic period, a hybrid approach that combines online and offline engagements

may provide a better platform for future collaboration. Future research may explore such approaches in different multidisciplinary projects that integrate digital and physical architectural representation, providing new collaborative methodologies for cultural architectural heritage.

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