

Digital twinning in conceptualising metaversity academic library information hubs

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The potential of digital technology like digital twins within the context of artificial intelligence can be used for facilitating information retrieval, sharing of contents, and creating collaborative environments to encourage engagement. This article explores the utilisation of digital twinning to bring about digital transformation in South African universities and academic libraries, as this technology is still underutilised. By considering digital twinning technologies, universities can enhance teaching practices and research capabilities and contribute to societal development. Digital twins, namely virtual replicas and models of physical systems or processes, provide universities with the means to simulate, evaluate and optimise infrastructures, resources, and operations. Artificial intelligence-powered recommendation systems can tailor or modify informative content searches, academic publications, and other information resources, based on specific research interests and knowledge preferences. An interpretivism paradigm, bricolage and foresight methods are applied to provide a comprehensive understanding of the future of functions and services to be offered by academic libraries. Findings propose that by utilising digital twins, academic libraries can enhance their societal impact, sustainability, and service delivery. Digital twin technology offers academic libraries the opportunity to enable real-time monitoring, process analysis and simulation, to provide insights into information resource utilisation, patron preferences and space optimisation.

Keywords: Digital twinning, artificial intelligence, academic libraries, bricolage, foresight methods

1 Introduction

With the advent of technological advancements, higher education institutions across the globe have expanded their educational offerings via digital learning (Ju Hyun 2021: 134). Offering teaching, learning and research opportunities via a virtual environment, or what Far and Rad (2022) call the *metaverse*, has had a noticeably positive impact on expanding educational opportunities. Duan et al. (2021) highlight the use of the metaverse to enhance educational practices, particularly in terms of affordability, equality, diversity, accessibility and humanising the virtual space. The term “metaverse” describes a virtual environment that is produced when the digital and physical domains collide, enabling immersive and dynamic encounters (Prakash et al. 2023: 9). Kshetri (2022) broadens the scope of the metaverse’s importance by adding that it can be used to improve student success, combine virtual and real-world interactions to enhance digital and personalised learning experiences and enable the testing of complex experiments.

One of the key support functions fostering the enhanced use of virtual education relates to library and information services (Xiao 2022). Physical academic libraries are being extended by the expansion of digital data brought about by large databases, the expansion of the web, big data analytics and augmented realities. Therefore, academic libraries must modernise existing support services and resource offerings. Libraries must explore novel ways of improving offerings to stay abreast of innovative technologies and to participate in this virtual revolution (Iakovides et al. 2022: 37). For example, through the application of digital twinning, academic libraries can be used to create virtual versions of the physical library spaces to increase accessibility, and serve as a persistent space in which the university community can gather to interact, converse and share information (Iakovides et al. 2022: 37).

Digital twinning is a virtual representation of a physical object or activity that acts as its real-time digital equivalent. The digital twin is a collective representation of internal and external data obtained and shared in a virtual space to cater for the needs of users (Kumar et al. 2020: 3). Hence, digital twinning in the academic library context can be used to provide a shared collaboration space in terms of networking, big data management, content analysis and accessibility (Picone et al. 2021: 6).

As more data are being saved in a digital cloud-based format, the application of digital twinning could be broadened. Sophisticated algorithms can be used to integrate, produce and manage information derived from the sense data (Longo

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et al. 2019). This heralds a new era of information sharing that will make a huge amount of previously inaccessible data available, which will make the simulation more comprehensive and dynamic, and create incredible potential value by breaking down information silos, verifying information and including digital twins (Lv & Xie 2021: 16). In this era of augmented realities, smart sensors, and the Internet of Things (IoT), digital twinning is becoming increasingly important. Digital twinning offers a successful approach to sharing existing information and achieving real-time communication between the virtual and physical worlds (Chen & Lee 2021: 92).

2 Contextualising the research

Using digital twins for the purpose of information sharing is not a familiar concept in the South African context. Towards supporting the National Development Plan 2030, Sustainable Development Goals 2030 and the African Union's Agenda 2063, consideration of the use of digital twins to expand information access and use in the Global South, has become a key focus area. Digital learning through digital twins in the metaverse aims to break down barriers to social interaction by allowing for global participation on an equal footing, unrestricted by geographical boundaries (Mystakidis 2022: 494). The aim of digital learning via digital twins in metaversities is to assist students to comprehend, study and relate to new concepts (Dahan et al. 2022: 4). Digital twins have the advantage of simplifying preparations for lecturers, are more cost effective than real-life experiments and can accommodate a large number of students that can interact in one session (Zacher 2021: 42). Digital twinning in the metaverse thus supports the expansion of interactive learning opportunities, information sharing and social communication (Iakovides et al. 2022: 38).

In the broad sense of the metaversity, with more specific reference to metaverse academic libraries, a digital twin information hub offers a virtual platform that provides augmented services to supplement, enhance and offer multi-level user interaction as part of the current academic library experience (Oladokun et al. 2023: 2). More importantly, this digital twin information hub, previously known as an academic library, can use innovations such as multi-level user interaction, smart sensors to monitor systems and processes, cloud computing to offer faster and more accessible information sharing and smart human-machine interfaces. The focus of digital twinning in the metaverse academic library is on embracing various prospects in which information can easily be shared among all stakeholders (Longo et al. 2019). However, for this to materialise, coexistence between virtual and physical spaces and an intellectual community that embraces the metaverse space, are required (Tlili et al. 2022: 3). Proponents Duan et al. (2021: 153) surmise that such a coexistence may increase quality education and enhanced access to learning opportunities for a larger number of students.

The above view of Duan et al. (2021) is supported by Sawahel (2022), who states that intellectual expertise and opportunities for collaboration via digital twins in the metaverse will put South African universities in a better position to offer extended educational opportunities for students, thus supporting equality and quality of life. The value of digital twins in providing advanced educational opportunities are explained by Nyapela (2020), who indicates that innovations such as digital twins, together with the ever-increasing data and digital footprint, offer excellent prospects for growth and development. However, more research is required to predict future scenarios and propose the use of digital twin technology within the metaverse context, to encourage and enhance information sharing.

Xiao (2022: 36) proposes that such research should be considered at a macro, meso and micro level. The macro view of the digital twin metaverse ecosystem is linked to the virtual society and the metaverse university, also known as a metaversity with the aim of promoting information access. In the meso or central view, all functions, and facilities in the physical space of the academic library should be reconsidered for their role and place in the digital twin information hub, which will be a virtual twin representation of all library functions, to provide users with a dynamic and tailored information-sharing virtual platform. In the micro view, this digital twin information hub should generate various types of twins, for instance, transforming users into twins to support links to interdisciplinary research groups. The envisioned digital twin information hub resembles a virtual chat room where users can interact, meet, work together, discuss and share information (Park et al. 2021). These interactions will be user orientated, field aligned and integrated with digital technology, enabling users to be geographically apart while remaining virtually connected.

3 Brief literature review

Exploring the topic from a wide perspective is essential in the research process to discover ways, prospects and novel ideas towards the use of digital twinning in academic libraries (Hines et al. 2019: 7). There is a worldwide projection of an exponential growth in digital twin technology with a proposed 68% expansion by 2030. Eleftheriou and Anagnostopoulos (2022: 15) argue that this unprecedented rate is due to recent technological breakthroughs and significant private sector investments. Lv and Xie (2021: 17) believe that the rapid growth of big data, the IoT and smart automation technologies has increased the frequency of use of digital twins as a novel type of technology in many sectors; for example, health, manufacturing, construction, retail, energy, aerospace, and engineering, among others. Similarly, Yu and He (2022: 6) point

out that the digital and intelligent application designs of digital twins demonstrate their potential for use across numerous of the prior mentioned industries, especially with data integration and automation of processes. However, compared to these industries, digital twin technology is still underused and under-researched at higher education institutions to promote information exchange (Addanki & Corrin 2023). Chen and Lee (2021) acknowledge that interest in metaversities has expanded globally. Towards the expansion of metaversities, the uses of digital twins to enhance information sharing in virtual higher education settings require extensive research. The reason for the increased interest in digital twinning as metaverse technologies, relates to its growth potential for higher education, since it offers an exceptional opportunity to completely transform the way in which students, researchers and academics engage with and acquire information (Wang et al. 2023: 453).

Against the backdrop of the prospective expansion in the use of digital twins for enhancing information access in the metaverse, it is evident that the physical object, the virtual object and the interaction between the two collectively constitute the main components of the digital twin notion (Alnowaiser & Ahmed 2023: 1075). The core of the digital twin information hub would be the communication or interaction between these physical and virtual objects, aligned with the predefined requirements of a virtual space: a way to share information, a way to engage in real-time interaction, a way to share data and a shared feeling of presence, space and time (Almarzouqi et al. 2022: 43422). Linked to the actual object, its digital representation, and the link between the two, interoperability, information modelling, data sharing, management, synchronisations, transmission and datafication are the primary interface components that define digital twinning. According to Nativi et al. (2021: 5) for this digital twin information hub to function accurately, cutting-edge components need to be considered. Far and Rad (2022: 3) and Duan et al. (2021: 155) highlight the following fundamental components in utilising digital twinning to support information sharing.

- Infrastructure: In this component, the fundamental and physical requirements, such as technology, network and processing power are established.
- Interaction: The ecosystem and infrastructure are connected via this interface component, where digital twins, the creation of content and completely immersed user interactions are crucial aspects of this interaction component, which links the real and virtual spaces in the metaverse.
- Ecosystem: The digital twin ecosystem functions as a living, dynamic virtual world that can support nearly all individuals in the world in a sustainable manner. This alternative virtual ecosystem or metaverse component combines artificial intelligence, monetary value and content generated by users.

The above components provide the context to ensure the synchronisation process between the physical and virtual space, and to secure and ensure access to information (Hassan et al. 2023: 406). Automated information management tools, amalgamated with data-driven artificial intelligence technologies are revolutionising the way users obtain and engage with knowledge (Oladokun et al. 2023: 19). Coupling such experiences with a digital twinning context provides opportunities for major advancements in how users utilise and engage with academic library environments (Eriksson et al. 2022: 470). Amzat and Adewojo (2023: 18) opine that integrating artificial intelligence into libraries that are infused with metaverse technology has the potential to significantly improve user experiences with the ability to create customised learning pathways. Enakrire and Oladokun (2023: 5) claim that cutting-edge artificial intelligence enhancements could prospectively give library operations a greater level of recognition, to the point where future library services could be customised, so that it aligns to the needs and expectations of individual users, thereby increasing the value of expanding the role of academic libraries in teaching, research, knowledge creation and knowledge sharing.

4 Theoretical considerations towards the development of a digital twin framework for academic libraries

The initial literature review identified three main ideas pertinent to the topic of this study: digital twins, metaversities and information sharing. These topics serves as an intangible foundation to evaluate theories relevant to this research. These topics were explored to have a better understanding of the capabilities of digital twins in a metaversity in promoting sharing of information in a collective manner. Briefly, four existing theories were considered towards the creation of a proposed conceptual framework related to using digital twinning in the metaverse of academic libraries. These theories are the diffusion of innovation (DOI) theory (2018), unified theory of acceptance and use of technology (2020), digital twin theory (2021) and the digitalisation framework (2022).

The first theory related to the DOI theory observes a range of innovations by incorporating four variables that affect how rapidly a new invention spreads, including timeframe, communications networks, inventiveness and democratic structure (Taherdoost 2018: 963). Accordingly, the lifecycle of any innovation follows a specific path, which starts with discovery, development, distribution and acceptance or application. Oyuga et al. (2023) elaborate that the innovation would

be continuously enhanced based on user feedback and new, improved solutions would diffuse more rapidly. The incorporation of the DOI enables the generation of a diversified picture of technology usage, based on user adoption stages, depending on the various groups of prospective adopters or risk takers, the middle-of-the-road group, those seeking evidence and the late comers or traditional conservers.

The unified theory of acceptance and use of technology (UTAUT) was considered as a second possible theory. Based on UTAUT, behavioural intent can be predicted by influence, performance, communication and favourable environment expectations (Alowayr 2022: 2). The four basic determinants when using UTAUT are expected usefulness, simplicity of use, biased standards and facilitating circumstance. In addition, the UTAUT considers gender, expertise, age and informed consent of usage as inputs (Hewavitharana et al. 2021: 7). In other words, UTAUT examines the acceptability to and use of technology from a wider spectrum of social and societal forces by the user (Passey 2020: 6).

Thirdly, the digital twin technology theory or digital twin model (DTM), as per Chen and Huang (2021: 2), was considered to explore and anticipate the unknown world, identify better ways to ignite human innovation, pursue optimal growth and improve current theory and understanding of beings by developing visual representations. Grieves (2005) introduced the first digital twin impression at the University of Michigan, which was described as the “Mirrored Spaces Model”. The concept of a digital twin proposes three segments: the real segment, the virtual segment and the data flow between these segments (Agrawal et al. 2023: 3). Hence, the data- and information-sharing process serves as the connection structure that unites the real space with one or more virtual spaces. Any collection of processes or resources can be included in the actual segment, from simple networks to efficient methods; and from user groups to networked educational platforms (Brucherseifer et al. 2021). The virtual segment contains the group interaction, operational components, and data components. It is in the virtual segment where the twinning component lies. This twinning component is needed to maintain the virtual duplicate in synchronisation with the real world.

Towards the realisation of the virtual environment, digitalisation is needed. As the final theory, the digitalisation framework (DF), as explained by Agrawal, Fischer and Singh (2022: 19-20), was considered. This theory combines two viewpoints on technology adoption. Firstly, institutional requirements, such as the desire of an institution’s leadership to obtain a specific value or an edge over rivals. The needs and causes for inadequacy would be identified and digital twins would be developed to address them. Secondly, there must be a technology push, where technology acts as a catalyst for implementing innovative solutions. The digitalisation framework is important, as it provides an overview of questions to be asked in the utilisation of digital twin technology. Agrawal et al. (2022) highlight that researchers from universities should be better able to assess the proposed digital twin applications and models, by using the framework as a basis to consider the economic benefits that digital twins offer, the technological skills needed to construct it and the managerial adjustments needed to sustain the value produced by digital twins. Diagrammatically, the key components of the above theories that were considered in the proposal of a conceptual framework as the outcome of the article, is presented in figure 1.

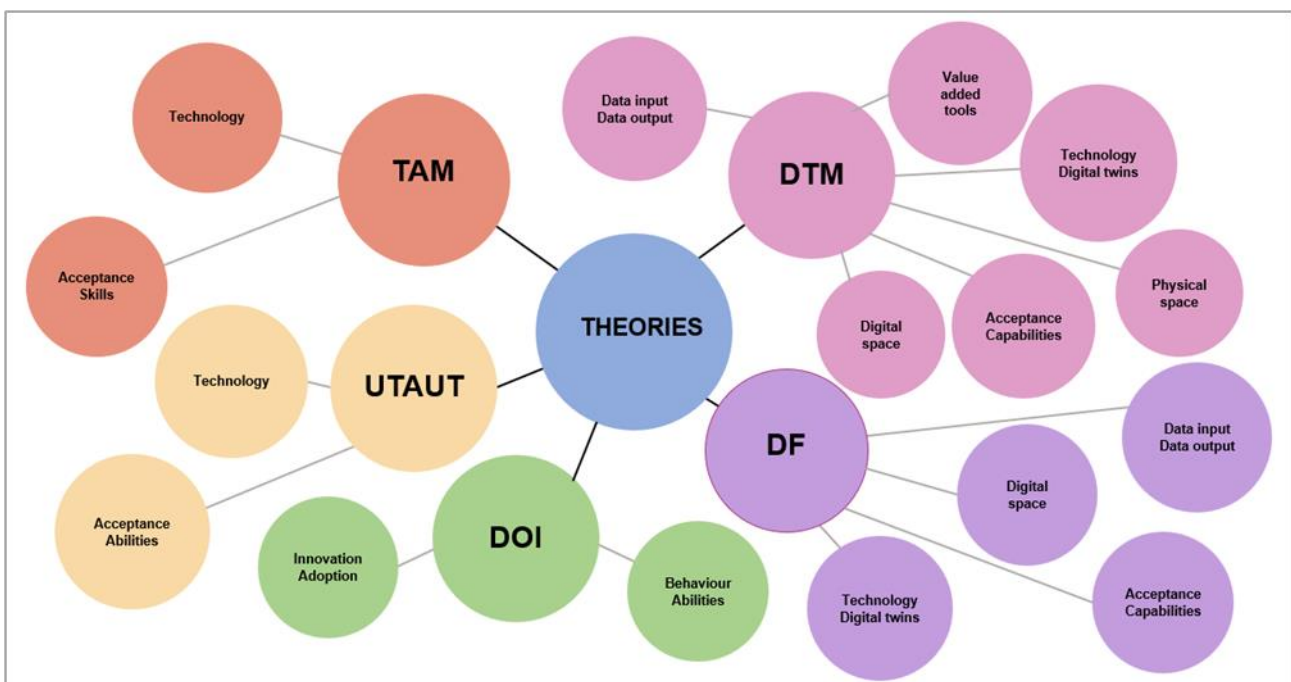


Figure 1: Components of theories relevant to the research

Linked to figure 1, it is clear that all theories revolve around technology. However, the DTM and DF both address digital twin technology, which is more relevant to this study. User acceptance and skills, which are crucial factors in the introduction of novel concepts or new technology, were identified as similarities between all these models. The DTM and DF both contain information exchange, and more specifically input and output of data between the physical and virtual environments, which are fundamental components in proposing a conceptual framework. Considering the key and relevant components of the four theories, in line with the main ideas pertinent to the topics of digital twins, metaversities and information sharing, the discussion section of the article provides a proposed framework for the use of digital twinning in academic libraries.

5 Problem statement

Humanity is being forced to tackle tremendous challenges to save the planet and create a more equitable and sustainable society. Sustainable development requires responsible use of resources and sharing of information, thus providing an advantage for all communities (Chen & Lee 2021). Digital twins can support the achievement of sustainable development goals, because they allow for the streamlining of processes that lead to cost savings, reduced manpower and environmentally friendly engagements (Carvalho & da Silva 2021: 2). The problem is that the application of digital twins in the academic library environment in South Africa is limited. Carroll (2019) explains that although African libraries are bridging the digital divide, many challenges still exist for academic libraries to offer the full spectrum of metaverse services. Linked to the expansion of metaverse technologies, Nyapela (2020) suggests that the success of innovations such as digital twins depends on them providing a dynamic and powerful impetus to minimise digital divides.

Referring to the sustainable development goal of quality education, where the decrease of digital divisions is imperative to promote educational opportunities, it is crucial to study ways in which digital twins as building blocks of the metaverse can be constructed to promote accessible, affordable, and inclusive education for all (Tlili et al. 2022: 28). Therefore, collecting, evaluating, and exchanging important information, best practices and policy recommendations across civil society, the commercial sector and research associations, are vital in supporting educational opportunities. Such opportunities focus on improved standards of living and quality of life (Nativi et al. 2021: 2). In supporting growth and development, optimal digital artificial intelligence-enhanced information sharing and optimisation have a significant cross-cutting function to ensure that academic libraries are able to provide students from various social and educational backgrounds with access to information (Palomares et al. 2021).

In this, South Africa is still in its infancy and lacks prospects related to digital twinning with the aim of making available, transferring, and encouraging information sharing. Such aims will fulfil the goal of higher education to ensure equal access to quality education for all (Chen & Lee 2021). Linked to this problem, the focus of this research is to propose a conceptual framework that can be used as a starting point in the discussion of applying digital twinning in the South African metaversity ecosystem.

6 Research methodology

Aligned to key components of the various theories and the literature review, the purpose of the research, in response to the research problem, was to propose a blueprint of the conceptual structure to introduce digital twinning in a metaversity academic library context. The objective was to gain insights from existing literature that could be used towards conceptualising the digital twin metaversity library. Towards exploring the purpose and objective, an interpretivist paradigm was followed, where the bricolage and futuristic designs were combined towards the conceptualisation of a proposed blueprint.

Following an interpretivist worldview, the role of the researchers was to make an intentional effort to elucidate the contexts and true nature of a phenomenon within a specific contextual setting (Babbie 2017). This conceptual non-human research collects and explores non-empirical qualitative data, using an interpretivist perspective. As a result, the interpretivist paradigm, following a qualitative approach and bricolage design, were extensively used throughout this research with the intention of exploring and understanding the meaning of digital twin innovations within a metaversity context. In particular, the bricolage design made it necessary for the bricoleurs to perform a number of different undertakings and to employ innovative techniques (Sobolewska 2017: 3) towards proposing a conceptual framework, relevant to the application of digital twinning in the South African metaversity, with specific reference to the academic library. This study therefore borrowed and used strategic foresight methods to assess the practicality and prospects of digital twin technology for the purpose of information exchange in metaversities, as a way of proposing solutions that depart from the idea of logical thinking or reasoning.

Strategic foresight is a systematic approach in acquiring knowledge about potential futures, creating predictions, and directing and enabling decisions in the present (Iden et al. 2017: 17). According to Magruk (2021: 2), such a holistic, forward-thinking investigation of innovative technology progresses in the form of foresight application, intended to prevent undesired

tendencies and outcomes. One of the key benefits of using the foresight methodology is its wide range of research techniques, which may be applied in a variety of situations and configurations (Magruk 2021: 2). Inayatullah and Black (2020) highlight that the future could be shaped in the desired direction by using foresight techniques and tactical analysis. Five phases are used to apply strategic foresight. Grumbach (2023: 4) and Conway (2021) explain that these include scoping futures by exploring literature to conceptualise a potential future, scanning trends and drivers to ensure that the foresight will remain relevant, developing possible futures through patterns and trends, and analysing outcomes to bridge the gap between the present and the scenario that is imagined for the future. The final phase includes strategising and planning, based on the views of existing authors to propose a blueprint of the envisioned digital twin information-sharing hub, which should be strategically planned, designed, and described.

Collected data created through a conscious act of searching for it and discovering it (Andrew & Karetai 2022: 98) were used to suggest the digital twinning framework. Data were collected from the digital twin open research publishing platform for researchers, academics and professionals involved in digital twin technologies, as well as Google Scholar, Scopus, Web of Science, and others. Google Scholar was selected since it integrates worldwide scientific repositories and provides metadata for academic research from multiple disciplines. According to Martins, Cunha and Serra (2018: 3), using already-existing data for research is becoming increasingly prevalent when the future is uncertain. Using existing data to evaluate the perceptions of researchers, research institutions and countries to comprehend the trends of developments in particular research fields, is necessary to propose a conceptual framework for the digital twinning in the metaversity academic library (Lee, Ahn & Kim 2021: 1).

7 Discussion of a futuristic digital twinning information hub in metaversity academic libraries

The proposed conceptual framework has incorporated the five stages of the strategic foresight methods to explore the conceptualisation of a digital twin information hub that may be applicable to the South African higher education context. Linked to the phases of the digitalisation framework (figure 1) and aligned to the various levels of consideration as described in the digital twin technology theory, the conceptual framework as proposed in figure 2, provides a diagrammatical representation of components to consider in conceptualising the digital twin information hub. The components of the conceptual framework have been developed around the most important concepts that have been identified and linked to the metaversity notion of digital twin information sharing, digital learning, and the digital twin ecosystem, all within a higher education context.

On a macro scale, the emphasis is on defining the metaversity. The metaverse has been a hot topic of discussion for academics and researchers, as it exists to give students a platform for problem-solving in the learning context, where questions and dialogues are always combined (Tlili et al. 2022: 15). It is anticipated that education in the metaverse will be devoid of time and space restrictions and will offer equal opportunities to students who struggle because of their physical circumstances and environments (Park & Kim 2022: 13). Adopting the metaversity concept to take the lead in the metaverse is unquestionably necessary for academics to remain relevant. It should be highlighted that such adoption should be done with caution by looking at the potential advantages, disadvantages, and requirements, particularly given the digital divide that exists not only in South Africa, but also across Africa (Hassanzadeh 2023: 11). Despite this digital divide, the extent of the need for access to higher education has increased incrementally. Therefore, it is important to explore future probabilities and scenarios for a digital twin information hub, for information sharing among the metaversity research community.

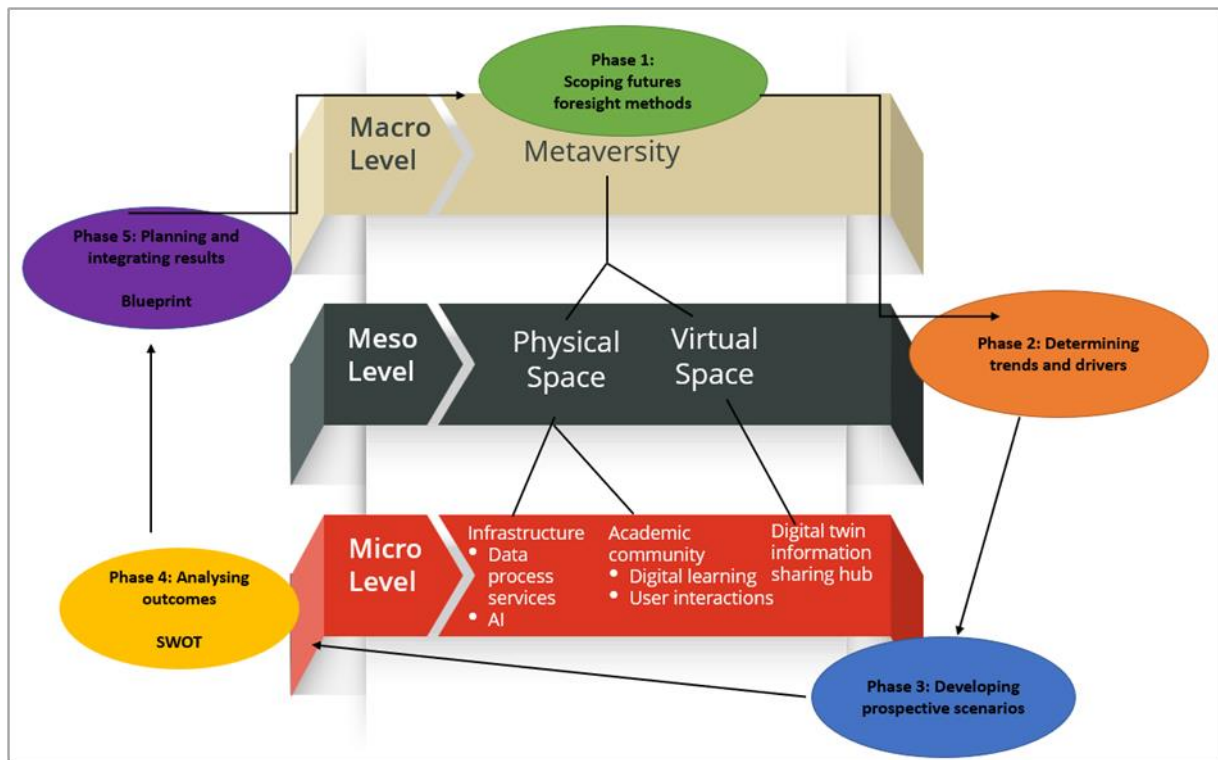


Figure 2: Digital twin metaversity conceptual framework

Towards the exploration of various possibilities and the use of digital twin information hubs, a considerable amount of work must be done in gathering, evaluating and disseminating important information globally to conceptualise a framework that is tailor-made for the South African and African environment (Nativi et al. 2021: 2). At a meso level the focus is on conceptualising the physical and virtual space, inclusive of the trends and drivers that will inform the infusion of these spaces into a digital twin environment. While most universities have made efforts to propagate their using of technological innovations, many have not yet developed environments that make it possible to share information with their counterparts locally and abroad (Syed et al. 2021: 1021). This is where digital twins can play a valuable role. By using a digital twin that has the ability to contextualise analytic results, information can be shared with more ease (Bestjak & Lindqvist 2020). Yu and He (2022: 1) agree and reiterate that data sharing is a deciding factor in digital twin adoption to create meaningful synthesis of data from several sources. Conceptualising a digital twin information hub, therefore, requires that academic libraries in metaversities collaborate towards finding a space where physical information and virtual connections can be promoted.

At a micro level, the focus is on creating an infrastructure, preparing an academic community, and creating a digital twinning space to share information. Future universities will be reliant on digital learning environments to ensure a wider range of access to learning opportunities. Thus researchers, academics and support staff such as academic librarians must understand how the metaverse functions and what specific technologies are part of it (Dahan et al. 2022: 5). For example, using the digital twin concept with virtual reality technology may be a revolutionary addition to any curriculum, since it makes learning more enjoyable, secure and interactive (Iakovides et al. 2022: 3). Metaversities have an immense amount of potential since virtual worlds give students access to activities that are not available or accessible in the real world (Follows 2022: 11). This also relates to the future role of academic libraries, where the use of digital twins can support digital learning.

In the broad context of the metaversity, an academic library is a virtual space that provides online services to enhance, improve or supplement the library experience through modification, engagement, personalisation and content diversity (Iakovides et al. 2022: 6). The limitations of a closed and unified portfolio of support services would be eliminated by a more accessible ecosystem of technology advancements (Liu 2021: 83). Mourtzis (2023) claims that the current conception of the metaverse is thought of as a novel digital space; a shared interactive and immersive augmented reality or environment that integrates important technologies like artificial intelligence, virtual reality, blockchain and cloud computing in digital ecosystems (Bojic 2022: 14). In determining the scope and extent of infrastructure required towards the establishment of a digital twin information hub, an analysis of academic libraries' current strengths, weaknesses, opportunities, and threats is required. Such information is imperative to assist with the planning of infrastructure, application of artificial intelligence applications and infusion of existing services, to create a virtual environment similar to the current physical environment. If developed in such a way that it can support teaching, learning and research, the digital age resurrection of the library sector

is in sight (Liu 2021). Hassanzadeh (2023: 13) explains that in this new digital twin library environment, the virtual world will determine the way educational practices are supported and will have an impact on the ultimate survival of academic libraries in metaversities. For this reason, the development of a blueprint for digital twins, with a focus on information-sharing prospects in the South African metaversity ecosystem is an important starting point towards further discussions to make the application of digital twinning in academic libraries a reality.

9 Conclusion and recommendations

A variety of conceptually viable theories were explored, each of which offered a partial, but not complete, description or application relevant to the intended research. The digital twin meta-concept framework provides a fundamental basis to highlight focal points of the research. The conceptual framework concentrated on these main ideas and the phases from the foresight methods used to identify and critically analyse variables to consider in a digital twin environment. The conceptual framework systematically incorporates and highlights essential aspects of innovation-driven research, giving a broader understanding of the phenomenon of interest. Presenting concepts in a graphical style, a technique called “concept mapping” inspires and permits a more explicit conceptualisation of key focus areas that require attention when considering the infusion of digital twinning into the metaverse academic library. On the basis of these observations, the following recommendations are made. Firstly, further research is imperative to dissect the application of the proposed conceptual framework to determine the varied technological, community and information-sharing methods required, to ensure the application of digital twinning in an academic library context. Secondly, to rethink the roles of current libraries to remain sustainable, and, lastly, to upskill and reskill librarians for the new metaverse and digital twin era. The value of this research is that it provides a starting point for further discussion and conceptualisation of the practical application of digital twinning relevant to academic libraries in metaversities.

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