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- If a DOI is not available a URL to the original document or the publication containing the document should be provided.

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Editorial: Impact of Innovative IT Solutions

Katherine M. Malan – sacj.editor@gmail.com
Department of Decision Sciences, University of South Africa

All of the research articles published in this issue synergistically focus on the potential impact of innovative IT solutions on society and business. The topics include the use of big data analytics in rural hospitals, digital sharing platforms to support SMEs, detective analytics to mitigate financial crime, virtual reality to support psychotherapy, the impact of digital technology on teaching in schools, and the transformative potential of generative AI. The six research papers included in this issue are:

- Identifying factors affecting the adoption of big data analytics in South African rural-based hospitals to improve service delivery by Rambau, Munyoka and Mashau.
- Contextualising Design: Aligning digital sharing economy platforms with local SMEs' sharing practices in resource-constrained countries by Abebe and Twinomurinzi.
- The use of detective analytics for mitigating financial crimes: A South African perspective by Mlambo and Iyamu.
- An investigation into the feasibility of using virtual environments as an induction method in SHIP® therapy by Malan, Bosman and Bothma.
- A multilevel analysis of digital technology to support teachers to improve their professional practice by Dlamini and Fleisch.
- Generative AI: Concerns, usage, challenges, opportunities and sentiments by Twinomurinzi and Gumbo. This is the second paper of a special issue of extended papers from the SAICSIT 2023 conference.

Authors of these papers are affiliated with seven different higher education institutions in South Africa, showing that SACJ remains an important publication outlet for South African researchers.

Submission statistics

For information, we present the following updated statistics around submissions, acceptance rates and the processing time of articles.

Malan, K.M. (2025). Editorial: Impact of Innovative IT Solutions [Editorial]. *South African Computer Journal* 37(1), vii–viii. https://doi.org/10.18489/sacj.v37i1.22860
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Year	2022	2023	2024
Submissions	111	95	96
Desk rejection	54	62	56
Desk rejection rate	49%	65%	58%
Final acceptance	17	12	
Acceptance rate	15%	13%	

The figures above translate into an overall rejection rate of approximately 86%. This may seem high, but it can be attributed to the large number of submissions from all over the world due to the indexing of SACJ on Scopus. To quantify the reach of SACJ, between 1 January and 30 June 2025 we received 56 submissions from 22 different countries (11 from South Africa, 15 from other African countries, and 30 from outside Africa).

Similar to SACJ, South African Journal of Science reported a rejection rate of 82% in 2024. In terms of submission processing time, the median time to a first decision (desk reject / send to review) since 2023 was 2 days and the median time to final decision for submissions sent to review was 5 months.

Thank you to all authors for submitting your manuscripts to SACJ and for entrusting us with your research. Thank you also to the editorial team for all your work behind the scenes and to the many reviewers who support our journal.

SACJ 37(1) June 2025
Research Article

Identifying factors affecting the adoption of big data analytics in South African rural-based hospitals to improve service delivery

Thifhindulwi Maxwell Rambau, Willard Munyoka, Nkhangweni Lawrence Mashau
University of Venda, Thohoyandou, 0950, South Africa

ABSTRACT
The healthcare sector is progressively recognising the potential of big data analytics to revolutionise patient care, operational efficiency and decision-making processes. However, rural-based hospitals face challenges in embracing big data analytical tools to improve their service delivery to their patients. The adoption of big data analytics will assist rural-based hospitals in predicting and making informed decisions to manage the limited resources that they have and allocate them appropriately. However, there is a lack of literature that explores and identifies the factors that affect the adoption of big data analytics in rural-based hospitals to improve service delivery. This research employs a quantitative research methodology using surveys to identify the factors that affect the adoption of big data analytics in rural-based hospitals. This study found that rural-based hospitals prefer a hybrid method to collect data and it impedes the adoption of big data analytics in rural-based hospitals. Therefore, there is a need to implement modern infrastructure to integrate various data collection methods to promote the adoption of big data analytics in rural-based hospitals.

Keywords big data analytics, rural-based hospitals, healthcare, decision-making, service delivery

Categories • **Information systems ∼ big data, data analytics**

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1 INTRODUCTION

Globally, rural-based hospitals play a critical role in the local communities by providing emergency medical services to the citizens (Miller et al., 2020). These hospitals use a traditional method to collect data and provide services to the citizens (Khalifa & Househ, 2021; Malelelo-Ndou et al., 2019; Nevhutalu, 2016). However, urban hospitals use diverse platforms to collect data from the patients, which results in the government storing tons and tons of data (Kaur

Rambau, T.M., Munyoka, W, and Nkhangweni, L.M. (2025). Identifying factors affecting the adoption of big data analytics in South African rural-based hospitals to improve service delivery. *South African Computer Journal* 37(1), 1–13. https://doi.org/10.18489/sacj.v37i1.17830
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et al., 2021; Kelvin & Morrisson, 2023; Rehman et al., 2021). In the disposal of this data, rural-based hospitals are still grappling with managing their resources and allocating them accordingly in order to provide efficient service delivery (Batko & Ślęzak, 2022; McCarthy et al., 2021).

Nevhutalu (2016) reported that patients in many rural-based hospitals express frustration with the services received. These complaints often stem from the lengthy process of retrieving their files and waiting to be seen by a medical practitioner (McCarthy et al., 2021; Miller et al., 2020; Nevhutalu, 2016). Furthermore, patients with chronic diseases are subjected to long queues during their compromised health state (McCarthy et al., 2021; Nevhutalu, 2016; Zolbanin et al., 2022). However, other scholars have suggested big data analytics (BDA) to curb these challenges (Gomes et al., 2022; Imran et al., 2021; Ramesh & Santhi, 2020). Recently, BDA has become a popular mechanism for the survival and growth of many institutions worldwide (Brossard et al., 2022; Khanra et al., 2020; Miller et al., 2020).

Likewise, healthcare institutions are also progressively recognising the potential of BDA to transform patient care, operational efficiency and decision-making processes (Batko & Ślęzak, 2022; Ghaleb et al., 2021; Ramesh & Santhi, 2020). In recent years, these institutions have witnessed a paradigm shift with the advent of BDA, presenting unprecedented opportunities to manage and use resources efficiently daily (Gomes et al., 2022; Kelvin & Morrisson, 2023; Yu et al., 2021). However, these potential benefits of BDA are well documented from an urban hospitals' perspective (Shafqat et al., 2020; Shahbaz et al., 2019; Zolbanin et al., 2022).

On the contrary, there is a lack of evidence of the opportunities presented by BDA in rural-based hospitals. This challenge is attributed to the lack of widespread adoption of BDA in rural-based hospitals. In the context of this study, adoption refers to embracing and using BDA tools and technologies to inform rural-based hospitals' decision-making to improve service delivery. Adoption, in this sense, means the incorporation of BDA tools into hospitals' day-to-day operations to respond quickly in addressing patients' needs.

Other studies explored the challenges of data quality and implementation of computer-based knowledge management systems in public healthcare systems in urban areas (Botha et al., 2014; Maramba et al., 2020). Some of the studies that were conducted in rural public hospitals investigated the use of a virtual ICT framework to support the doctors (Nevhutalu, 2016). However, various scholars have postulated that it is significant for rural-based hospitals to adopt BDA to improve service delivery to their patients (Brossard et al., 2022; Miller et al., 2020; Nevhutalu, 2016). Therefore, this study seeks to address the gap in the existing literature by delving into the factors that affect the adoption of BDA in rural-based hospitals, with a primary focus on improving service delivery. Furthermore, the ultimate goal is to promote the successful adoption of BDA in rural-based hospitals, thereby enhancing service delivery, improving patient care, and addressing healthcare disparities in underserved communities (Batko & Ślęzak, 2022; Ghaleb et al., 2021).

This study is divided into six sections: Section 2 presents a literature review on big data analytics in healthcare institutions. Section 3 presents the research approach to choosing rural-based hospitals and their personnel who responded to the questionnaire. Section 4 presents

the results of the study and Section 5 discusses the results pertinent to the identification of the factors that affect the adoption of the BDA in rural-based hospitals. Section 6 concludes and provides recommendations to the rural-based officials who are contemplating adopting BDA (Khanra et al., 2020).

2 BIG DATA ANALYTICS IN THE HEALTHCARE INSTITUTIONS

Various scholars see big data as a precursor to big data analytics (Benzidia et al., 2021; Kelvin & Morrisson, 2023). Big data refers to enormously large and complex datasets that surpass the processing capabilities of traditional data analytical technologies and require sophisticated analytical methods and technologies for storing, processing and analysing (Hiremath et al., 2023; Kelvin & Morrisson, 2023; Seefong et al., 2023). Big data is characterised by four V's: velocity, volume, veracity and variety (Hiremath et al., 2023; Leow et al., 2023).

However, in the healthcare institutions big data is described as a high volume of health data collected from various sources, including physician notes, electronic health records (EHR), medical imaging, lab reports, X-Ray reports, case history, diet regime, genomic sequencing, payer records, pharmaceutical research, wearables, medical devices and many other sources that are not mentioned (Kaur et al., 2021; Ramesh & Santhi, 2020).

To analyse big data, there is a need of BDA techniques to uncover hidden information to assist organisations with decision marking (Leow et al., 2023; Yu et al., 2021). BDA refers to the process of examining and uncovering meaningful patterns, trends, and insights within vast and complex datasets, commonly known as big data (Ghaleb et al., 2021; Leow et al., 2023). In healthcare institutions, BDA involves the systematic analysis of vast and diverse datasets to extract valuable insights, identify patterns, and support informed decision-making for improving patient care, operational efficiency, and overall healthcare quality (Khanra et al., 2020; Zolbanin et al., 2022).

BDA in healthcare institutions includes the use of different techniques, such as statistical analysis, machine learning, data mining, and predictive modeling (Gomes et al., 2022; Shafqat et al., 2020). Most healthcare institutions leverage these analytics capabilities to gain more patient insights, optimise hospital processes, improve operational efficiency, and drive innovation (Batko & Ślęzak, 2022; Hiremath et al., 2023; Kaur et al., 2021). Overall, BDA plays a crucial role in helping organisations make informed decisions, identify opportunities and address challenges in today's data-intensive and rapidly evolving business landscape (Botha et al., 2014; Gomes et al., 2022).

Furthermore, integrating BDA in healthcare institutions with big data applications has the potential to enhance shared knowledge, monitor the outcomes of prevention focused approaches and enhance the efficiency of patient management (Gomes et al., 2022; Khalifa & Househ, 2021; Rehman et al., 2021). This context, often ignored by managers, engineers and policymakers, may present an opportunity that warrants exploration within the healthcare sector (Khalifa & Househ, 2021; Shafqat et al., 2020).

3 RESEARCH METHODOLOGY

This research employed a quantitative research methodology to investigate the factors that affect the adoption of big data analytics in rural-based hospitals to generalise the findings from a sample to the given population and draw conclusions that will apply beyond the sampled hospitals (Cresswell & Clark, 2011; Kothari, 2004; Saunders et al., 2019). The study focused on four rural-based hospitals in the Vhembe district in the Limpopo province, South Africa, utilising a convenience sampling method for selecting the hospitals. In this case, convenience sampling was used to select rural hospitals based on their availability and accessibility (Klein & Myers, 1999; Myers, 2013). Furthermore, this method was used for its simplicity and practicality, especially because of the tight given timeframe, budget and other constraints that made it difficult to implement more rigorous sampling techniques (Borgstede & Scholz, 2021; Crotty, 1998).

The target population included workers from the selected rural-based hospitals' Information and Communication Technology (ICT) departments, administrators, doctors and nurses. The sample comprised both computer-users and non-computer-users in the ICT departments who worked as data collectors. Computer users comprised of administrators and IT personnel. In addition, non-computer users are comprised of doctors and nurses. A total of 200 participants were sampled using simple random sampling techniques. Simple random sampling is considered one of the most straightforward and unbiased techniques for selecting a representative sample from a larger population (Myers, 2013). Furthermore, this method afforded all the participants from the population an equal opportunity to be selected (Kothari, 2004; Saunders et al., 2019). Fifty questionnaires were distributed to each selected hospital.

To collect data, this study utilised a structured questionnaire designed to gather information on factors influencing the adoption of BDA in rural-based hospitals. The questionnaire exclusively featured closed-ended questions, allowing for standardised responses and quantitative data analysis (Myers, 2013; Saunders et al., 2019). The questionnaire covered key aspects related to the adoption of BDA and questions were designed to assess participants' perspectives on the barriers that affect the incorporation of big data analytics into their daily work.

Prior to data collection, ethical approval was obtained from the University of Venda (UNIVEN), Faculty of Management, Commerce and Law ethics review committee. Participants were provided with informed consent forms explaining the purpose of the study, ensuring confidentiality and emphasising their voluntary participation. The anonymity and privacy of participants were strictly maintained throughout the research process.

4 RESULTS

From the distributed questionnaires, 174 were returned. Out of 174 questionnaires, 17 were not completed in full and were discarded from the analysis. Out of the collected questionnaires, 150 questionnaires were analysed using appropriate statistical methods, such as descriptive

statistics and inferential statistics. The aim of data analysis was to identify patterns, correlations and trends in the responses, providing insights into the factors that affect the adoption of big data analytics in rural-based hospitals. Results extracted from participants are presented in the following subsections:

4.1 Participants' demographic information

Participants' demographic information is depicted in Figure 1. The gender distribution in Figure 1 shows a slightly higher representation of females (59,3%) compared to males (40,7%). This gender balance is important for ensuring diverse perspectives in the study, particularly considering the potential impact of gender on attitudes and perceptions.

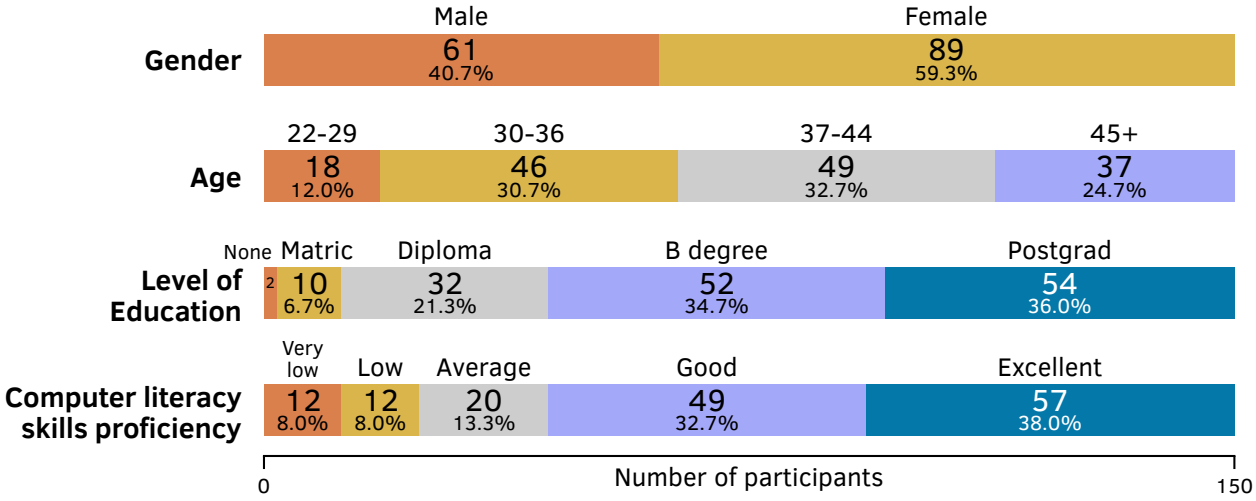

Figure 1: Demographic information

The age distribution shows that few participants (12,00%) were between the age of 22–29 and 24% of the respondents were between the age of 45 and above. While a diverse range of participants, with a significant portion falling within the 30–36 age groups (30,70%) and 37–44 age group (32,70%). This diversity is beneficial for capturing a broad range of experiences and viewpoints, as different age groups may have varying levels of familiarity and comfort with technology, including BDA tools.

Similarly, the educational backgrounds of participants are diverse, with a substantial proportion of participants holding university degrees. A total of 21,30% of the participants hold a diploma, while 34,70% hold a bachelor's degree. The highest proportion (36,00%) of the participants hold postgraduate qualifications. This indicates that the rural-based hospitals have a well-balanced sample of educated staff, which may positively impact their ability to comprehend and engage with complex topics such as BDA.

Furthermore, the results in Figure 1 show that the majority of participants (70,70%) reported having either good or excellent computer literacy skills proficiency. This high level of

computer literacy is a positive aspect, suggesting that a significant portion of the sample may be well-equipped to engage with and adopt new technologies, such as BDA tools.

4.2 Status of big data

A significant majority of respondents (67,30%) indicated that they collect data using both data collection methods (see Figure 2). While 32,70% of the respondents indicated that they use traditional data collection method. However, there was no participant who used a digital platform as a single means of collecting data from the source systems. The results show that rural-based hospitals are using a hybrid data collection method.

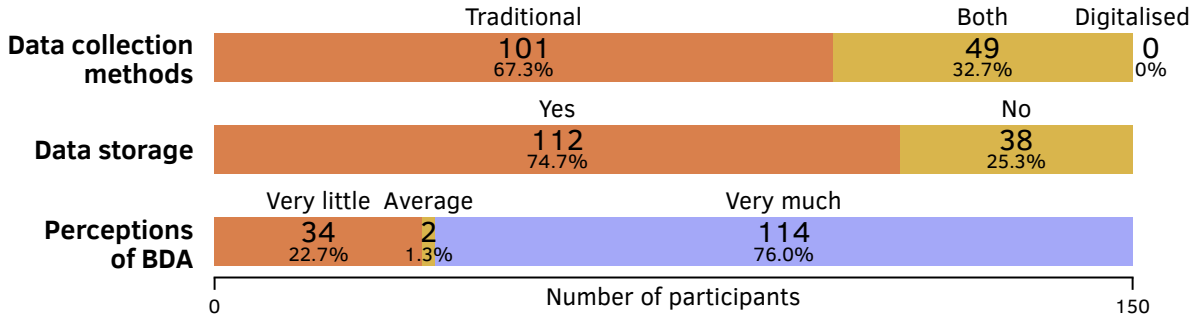

Figure 2: Status of big data

The researchers also explored data storage in rural-based hospitals. Figure 2 shows that the majority of respondents (75.00%) indicated that the data is stored in a centralised storage. While 25,00% of the respondents indicated that the data is not centralised. Furthermore, the researcher examined if the participants were aware of BDA tools. All the participants indicated that they were aware of the BDA tools.

Figure 2 presents the results of the respondents' perceptions of the extent to which rural-based hospitals use BDA. The majority of respondents (76.00%) indicated that rural-based hospitals use BDA to an average extent. This suggests that, according to the respondents' perceptions, these hospitals are actively incorporating BDA into their operations, albeit not at an extremely high level. A notable portion of respondents (23.00%) expressed the perception that the usage of BDA in rural-based hospitals is very little. While 1,00% of the respondents expressed that the usage of BDA is very much.

4.3 Perception of big data analytics

The results in Figure 3 show that, a vast majority of 92,00% of the respondents strongly agree that, in general, they find the integration of big data analytics useful in the rural-based hospitals and 6,70% of the respondents support this statement. This high level of agreement indicates a strong belief in the value and utility of incorporating BDA into hospital practices.

While 1,30% of the respondents are not sure of this statement. The results also show that there are no participants who dispute this statement.

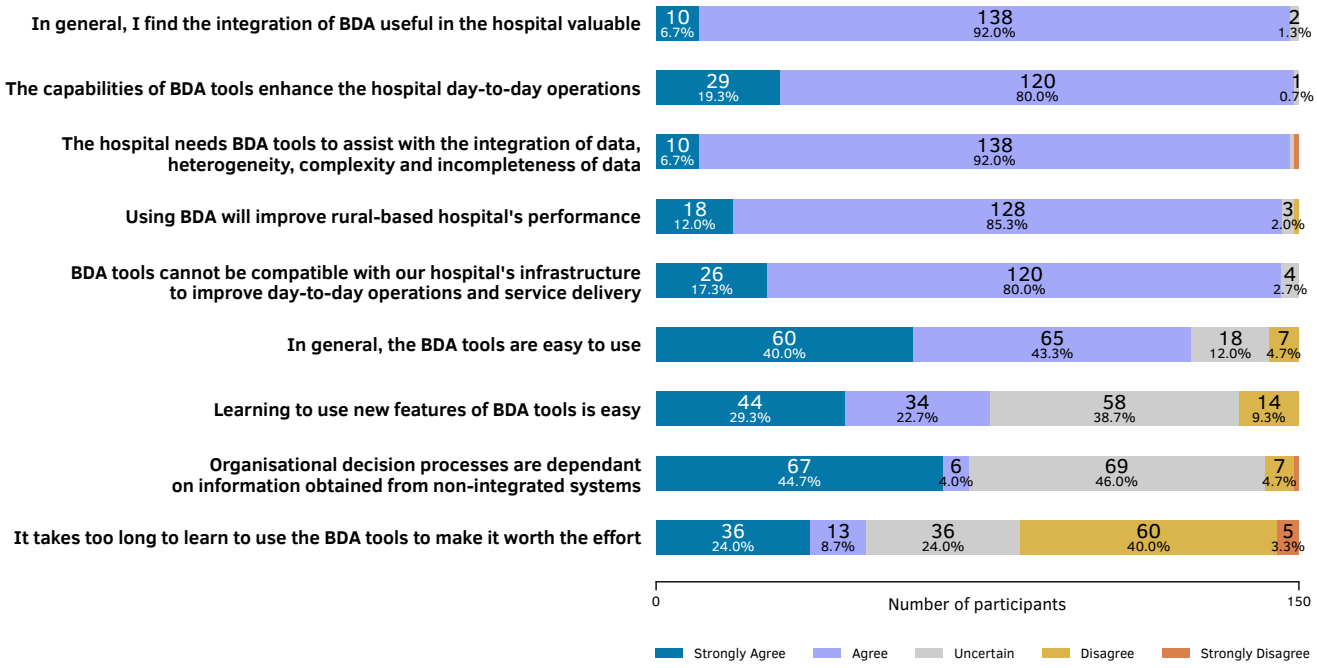

Figure 3: Perceptions of big data analytics

This study also explored the capability of BDA tools to enhance rural-based hospitals' day-to-day operations. The results reveal that 19,3% of the participants agree and 80,00% of the participants strongly agree that the capabilities of BDA tools enhance day-to-day operations and can be compatible with the hospital's operations and service delivery. This underscores a positive perception of the potential impact of these tools on hospital functions.

Furthermore, the participants responded to a question about the need for BDA in rural-based hospitals. An overwhelming majority of 6,70% of the respondents agree and 92,00% strongly agree that rural-based hospitals require BDA tools to address the integration of data, heterogeneity, complexity, and incompleteness of data. This suggests a consensus among participants regarding the critical role of BDA tools in managing diverse and complex healthcare data. Few participants (0,70%) were not sure about this and 0,60% strongly disagreed that rural-based hospitals require BDA tools to address the integration of data, heterogeneity, complexity, and incompleteness of data.

The majority of the respondents (85,30%) strongly agree that using big data analytics will improve rural-based hospitals' performance. While 12,00% of the respondents concur with the majority. This positive perception aligns with the potential benefits associated with the integration of analytics in healthcare operations. Only 2,00% of the participants indicated that they are unsure about using data analytics to improve healthcare performance. Fewer

respondents (0,70%) disagree that using big data analytics will improve rural-based hospitals' performance.

Furthermore, the researchers probed infrastructure compatibility with BDA tools in rural-based hospitals. The results show a consensus that there is a lack of infrastructure that accommodates BDA tools in rural-based hospitals. A total of 98,00% of the participants agree (17,30%) and strongly agree (80,00%) that BDA tools are not compatible with the existing infrastructure in rural-based hospitals. However, 2,70% of the respondents were not sure about this statement.

In Figure 3 the results show a consensus that it is easy to use BDA tools. A total of 83,30% of the participants agree, out of 83,30%, 40,00% agree and 43,30% strongly agree that, in general, BDA tools are easy to use. On the other hand, 12,00% of the participants are uncertain about this statement. In addition, 4,70% of the participants highlighted that BDA tools are difficult to use.

As depicted in Figure 3, the results show that 29,30% of the respondents agree and 22,70% strongly agree that learning to use new features of BDA tools is easy. However, 38,70% of the respondents were uncertain about this statement. A total of 9,30% disagree that learning new features of BDA tools is easy. The responses on learning new features of BDA tools show a more varied pattern, indicating that opinions on ease of learning differ among participants.

The results in Figure 3 show that 44,60% of the respondents agree and 4,00% of the respondents strongly agree. Therefore, a substantial portion 48,60% of the respondents believe that organisational decision processes depend on information obtained from non-integrated systems. On the contrary, 46,00% of the respondents were uncertain about the organisational decision process, which depends on the information extracted from the data collected from non-integrated systems. This indicates a significant concern or acknowledgment among participants about the influence of non-integrated systems on decision-making. A total of 5,40% of the respondents disagree with this statement.

Lastly, a notable 32,70% percentage feel that learning how to use BDA tools takes too long, which may impact the perceived value of investing time and effort in utilising these tools. While on the other hand, 24,00% of the respondents are not sure how long it takes to learn BDA tools. A total of 43,30% disagree with the statement.

In Figure 3 the results show a consensus that it is easy to use BDA tools. A total of 80,30% of the participants agree (40,00%) and strongly agree (43,30) that, in general, BDA tools are easy to use. On the other hand, 12,00% of the participants are uncertain about this statement. In addition, 4,70% of the participants highlighted that BDA tools are difficult to use.

The majority of the respondents (85,30%) strongly agree that using big data analytics will improve rural-based hospitals' performance. While 12,00% of the respondents concur with the majority. This positive perception aligns with the potential benefits associated with the integration of analytics in healthcare operations. Only 2,00% of the participants indicated that they are unsure about using data analytics to improve healthcare performance. Fewer respondents (0,70%) disagree that using big data analytics will improve rural-based hospitals' performance.

Lastly, a vast majority of 92,00% of the respondents strongly agree that, in general, they find the integration of big data analytics useful in the rural-based hospitals and 6,70% of the respondents support this statement. This high level of agreement indicates a strong belief in the value and utility of incorporating BDA into hospital practices. While 1,30% of the respondents are not sure of this statement. The results also show that there are no participants who dispute this statement.

5 DISCUSSION OF THE RESULTS

The results showed a gender balance, and it is essential to ensure diverse perspectives in the study, particularly considering the potential impact of gender on attitudes and perceptions. Furthermore, age was explored to solicit a diverse opinion and capture a broad spectrum of experiences and viewpoints because different age groups may have different perceptions when it comes to the adoption of innovation in an organisation (Rogers, 2003). The results show that all genders and ages are aware that BDA will enhance decision-making to improve service delivery in rural-based hospitals. This is in support with McCarthy et al. (2021) and Mashau and Mokwena (2017) who indicated that awareness has a positive impact on the adoption of new innovation.

The results also showed a good balance of education level and computer literacy skills proficiency. This may positively impact the ability to adopt BDA in rural-based hospitals because their staff are well-equipped to engage and adopt new technologies such as big data analytics tools. Various scholars postulate that education and computer literacy are paramount when adopting new technologies (Mashau et al., 2021; Rogers, 2003; Yadegaridehkordi et al., 2019).

The data suggests a preference for a hybrid approach in rural-based hospitals for data collection, incorporating both traditional paper-based and digitalised data collection methods. An enormous amount of data is still collected using the traditional paper-based data collection method. This could be a hindrance to adopting BDA in rural-based hospitals. Various scholars highlight the need to automate processes to collect data and to analyse it for decision-making purposes (Gomes et al., 2022; McCarthy et al., 2021; Shafqat et al., 2020). Furthermore, 25,00% of rural-based hospitals' data is not centralised, which will result in wrong information. When analysing data, there is a need to centralise all collected data to ensure the accuracy of the information (Benzidia et al., 2021; Leow et al., 2023). Decentralisation of data could be the reason for the low usage of BDA in rural-based universities (Benzidia et al., 2021; Ramesh & Santhi, 2020).

The results also revealed that infrastructure is incompatible with BDA tools in rural-based hospitals. Thus, the literature postulates for the successful adoption of innovation, the infrastructure should be up to date (Mashau et al., 2021; Rehman et al., 2021). However, organisations (hospitals) may improve their infrastructure to accommodate innovation (Imran et al., 2021; Rehman et al., 2021). Lack of infrastructure is a main barrier to the adoption of innovation in most organisations (Mashau et al., 2021; Shafqat et al., 2020).

6 CONCLUSION AND RECOMMENDATIONS

This study explored the factors that affect the adoption of big data analytics in rural-based hospitals with a focus of improving service delivery. The insights gathered through the survey responses presented the current landscape by providing valuable information about the staff of rural-based hospitals. The demographic information revealed a diverse and well-educated sample with a balanced gender distribution. The majority of participants demonstrated a high level of computer literacy, a crucial factor for successful implementation of big data analytics tools in rural-based hospitals.

Furthermore, this study found that rural-based hospitals prefer a hybrid method to collect data from the sources. This was highlighted as one of the factors that impede the adoption of big data analytics in rural-based hospitals. In addition, this study also found that data is not centralised, which may result in inaccurate information. Centralised data may present potential benefits in terms of streamlined access, improved consistency and enhanced security, but it also necessitates careful consideration of governance and security measures. Lastly, this study found that infrastructure is still an issue in rural-based hospitals. In rural-based hospitals, the infrastructure must be upgraded to be compatible with big data analytics tools. Therefore, these findings of this study contribute to the body of knowledge by offering a deeper understanding of the factors influencing the adoption of big data analytics in rural hospitals, thereby informing strategies for enhancing healthcare service delivery and quality in rural areas.

This study recommends that rural-based hospitals should automate all their processes because it is difficult to clean and extract meaningful information from data that are in different forms. This will also assist rural-based hospitals in centralising their data, making it easier for knowledge workers to analyse it. In addition, this study recommends that rural-based hospitals should invest more in upgrading their infrastructure to adopt big data analytics successfully.

Since the healthcare landscape continues to evolve, the findings from this study serve as a foundation for healthcare managers, policymakers, decision-makers, administrators, and technology developers. Furthermore, healthcare stakeholders can leverage the insights gained from this study and navigate the complexities of adopting big data analytics in rural-based hospitals, ultimately contributing to more effective and patient-centric healthcare services. The recommendations derived from this study aim to guide future initiatives, ensuring that the integration of big data analytics aligns with the unique needs and challenges of rural-based hospitals.

Future studies may explore critical factors that can affect the implementation of modern digital infrastructure that will support big data analytics and Industry 4.0 in rural-based hospitals to enhance decision-making. Finally, it was significant to investigate the factors that affect the adoption of big data analytics in South African rural-based hospitals in order to assist them in addressing all key factors before implementing big data analytics to potentially address critical gaps in healthcare service delivery.

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Research Article

Contextualising Design: Aligning digital sharing economy platforms with local SMEs' sharing practices in resource-constrained countries

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ABSTRACT
This paper addresses the challenge of designing digital sharing platforms that align with the local sharing practices of SMEs in resource-constrained countries, with a specific focus on Ethiopian SMEs. The research utilises the elaborated action design research (EADR) methodology and begins with the diagnosis stage, employing thematic analysis with activity theory (AT) to gain an understanding of the local sharing practices. Results revealed elements such as activities, stakeholders, motives, resources, goals, actions, rules, and tools that inform the design requirements of the digital sharing platform. Building on the diagnosis stage, the design cycle established key principles and the architecture of 13 local sharing models that form the features of the platform. In the implementation cycle, the paper presented a specific instance of a "property rental package." Results indicated the positive acceptance of the digital platform. Factors such as technological compatibility, perceived direct benefit, ease of use, and perceived indirect benefit contributed to this acceptance. The study contributes to the existing literature by providing valuable insights on how to contextualise the design of digital platforms in the local sharing practice contexts. Additionally, it showcases the effective utilisation of the EADR methodology and activity theory.

Keywords Digital Sharing Platform, Contextualising designs, SMEs, Local Sharing Practices, Information System Design, Digital platform design

Categories • **Information Systems** ∼ **Computing platforms** • *General and reference* ∼ *Cross-computing tools and techniques, Design*

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1 INTRODUCTION

Although digital platforms offer unprecedented opportunities for economic sharing and collaboration, the utilisation of these platforms remains low among SMEs operating in resource-constrained countries (Bardhi & Eckhardt, 2012). Several factors contribute to this low adoption rate, including inadequate technological infrastructure (Myovella et al., 2020), lack of digital literacy and skills (Amornkitvikai et al., 2022), security and trust concerns (Ochinanwata & Ochinanwata, 2023), absence of contextually designed technology (Smidt & Jokonya,

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2021), and a lack of design knowledge (Atinaf et al., 2023). Particularly, studies indicated a significant research gap concerning the contextualisation of digital sharing platform design concerning the local sharing practices of SMEs within a community's local business ecosystem (Pankomera & van Greunen, 2019). While many existing platforms have primarily been designed based on the business models of major tech companies in the Western world (K. S. Rahman & Thelen, 2019), it is important to note that SMEs in resource-constrained economies frequently participate in a range of local sharing practices deeply rooted in the community's culture (DiBella et al., 2022). Hence, it is crucial to examine the design of digital platforms by exploring the local sharing practices of SMEs.

This study specifically investigated the design of a digital sharing economy platform within the context of local sharing practices among SMEs in Ethiopia. The research employed an elaborated action design research (EADR) methodology, chosen for its suitability in studying the designs of socio-technical systems. The study makes a contribution to the discourse on information systems (IS) by exemplifying how the design of digital platforms can be contextualised within the context of local sharing practices. It identifies essential design aspects that need to be taken into consideration when designing digital platforms for specific contexts and showcases the practical application of activity theory (AT) in exploring and analysing activities from local sharing practices and comprehending the design requirements of IS artefacts.

Moving forward, the structure of the remaining paper is as follows: The subsequent section presents a comprehensive review of the existing literature. This is followed by an in-depth explanation of the methodology employed. The later section delves into the discussion of the study's findings. Finally, the paper concludes by highlighting the key contributions of the research and its implications for theory, practice, and policymaking.

2 LITERATURE REVIEW

This section presents a comprehensive literature review covering key areas such as the sharing economy (SE), the design of digital platforms for SMEs, the contextualisation of digital platform design, and activity theory (AT).

2.1 Sharing Economy

There is no universally agreed definition for the SE (Govindan et al., 2020). Studies often describe the SE as an activity synonymous with collaboration consumption (Belk, 2014). It indicates online sharing activities such as bartering, swapping, lending, trading, renting, and donating economic resources (Ranjbari et al., 2018). Many studies also associate the SE with sharing activities in innovation, redistribution, co-finance, and co-creation (Upadhyay et al., 2021). The term has also been used to explain crowd-based networks and the new forms of "gig" work that are encroaching on traditional employment (Chen et al., 2019).

From this study's perspective, the term is used to indicate activities related to collaboration consumption, the circular economy, crowdsourcing, crowdfunding, and open innovation activities. The circular economy refers to an economic model that favours product maintenance, reuse, and recycling. It is an effective way to tackle the scarcity of resources in the value chain and reduces the cost of materials, thereby promoting a sustainable environment (Peng et al.,

2014). Crowdsourcing is a problem-solving model that enables enterprises to outsource jobs and assignments to networked people (Tiberius & Hauptmeijer, 2021). Crowdfunding refers to a model for gathering funds from crowds to connect a particular project and investors (Köhler et al., 2022). Finally, open innovation is a framework that promotes the adoption and generation of new technologies (Achtenhagen et al., 2013).

2.2 Designing digital platforms for SMEs

Despite the pivotal role of digital platforms in enabling SMEs to restructure and enhance their value-creation processes, and the intricate link between SMEs' value-creation processes and social activities, especially in resource-constrained countries (Rumanyika et al., 2021), few studies have recognised the critical importance of addressing the specific challenges associated with designing digital platforms for SMEs in their local practices context.

In this regard, a paper that reported the design of "Machinga" showcased the design process of a mobile application that supports local street traders in their problem of limited market access (Ameller et al., 2015). The study employed a participatory design approach, involving stakeholders in the requirement gathering, design, and evaluation stages. Other studies have also explored the features of digital platform designs within industrial associations, outlining requirements for SMEs' internationalisation and the establishment of a collaboration partner marketplace (Hirota et al., 2022). Similarly, a separate study was conducted focusing on designing platform-based circular economies by exploring the business patterns of a circular economy model (de Reuver et al., 2018). While these studies provide valuable insights into contextualising IS artefacts, it is important to note that designing digital platforms goes beyond individual applications that were primarily taken into account by those studies. Designing digital platforms requires a thorough comprehension of the design aspects involved, as they are complex systems that interact with heterogeneous actors and typically integrate multiple applications.

In this context, a digital actor engagement platform was designed to demonstrate the contextual design of a digital platform that supports local businesses in the high street threads industry (Bartelheimer et al., 2023). Using the action design research (ADR) method, it investigated the engagement of actors in the street markets. This study addressed the local practices and actor networks in the street trade (Bonina et al., 2021). However, it lacks contextual relevance for designing digital sharing platforms in the context of resource-constrained economies. Therefore, further research is necessary to gain a comprehensive understanding of how to contextualise the design of digital platforms based on the local sharing practices of SMEs in resource-constrained economies.

2.3 Design aspects for contextualising the design of digital platforms

Contextualising the design of a digital platform with local practices is crucial for its success. However, to achieve effective contextualisation, it is first essential to have a comprehensive understanding of the core constructs of digital platforms (Wulfert et al., 2022). In this respect, various design aspects come into play, including the purpose (Choudhary et al., 2021; Eisape, 2022), boundaries (Gawer, 2021b), components (Spagnoletti et al., 2015), structures/organisations (Hou & Shi, 2021), and contexts (Janowski, 2015) of these platforms

The purpose of digital platforms plays a crucial role in shaping their design, functionality, and overall direction. By their purpose, digital platforms can be innovation or transaction-oriented (Bonina et al., 2021). Achieving effective contextualisation in the design of digital platforms relies on obtaining a clear understanding of their purpose and its alignment with the motives and goals of the stakeholders. The boundary of platforms defines the scope of functionalities and services to be provided, as well as those that will be excluded (Gawer, 2021b). It is characterised by its scope, sides, and boundary resources (Gawer, 2021b). Defining the scope of the platform is essential for establishing the context of its operations and interactions. It is often defined by activities and resources the platform will manage (Gawer, 2021b). In this regard, it is necessary to examine the activities and resources that the platform will handle. Besides, platforms serve as a nexus that brings together two or more groups of actors and enables the exchange of value between them (Gastaldi et al., 2023). Understanding the characteristics and needs of the stakeholders involved is crucial to defining the boundaries of the platform (Gawer, 2021b). Moreover, contextualising the design of boundary resources is vital for defining the boundary of a digital platform. In this regard, gaining an understanding of the interactions within different activities in local practices can prove to be an effective approach for comprehending the design requirements of digital platforms and their boundary resources. Boundary resources are application interfaces (APIs) that facilitate interactions of several applications within the boundary of digital ecosystems (Gawer, 2021b).

Defining the components and organisation/structure of a digital platform is a also fundamental aspect of its design (Tura et al., 2017). It helps in shaping its architecture, functionalities, and overall user experience. Digital platforms often contain a set of stable cores, evolving peripherals, and interfacing components (de Reuver et al., 2018). While the core components of digital platforms serve as the pillars and provide generic services, the evolving peripheral components cater to the diverse and expanding functional needs of heterogeneous stakeholders (Spagnoletti et al., 2015). In this respect, it is common for digital platforms to have multiple interdependent or third-party components (Bartelheimer et al., 2023; Weiss et al., 2023). These components, closely interconnected with the actions of multiple actors involved in communication, collaboration, and collective action (Hein et al., 2019). Hence, designers need to understand the stakeholders' actions and interactions in creating effective platform experiences that align with objectives of different actors. By its structure, digital platforms are often seen as a digital ecosystem consisting of interconnected and interdependent components (Allen et al., 2021).

The context in which digital platforms operate is another aspect of the design of utmost importance when it comes to contextualising the design of their business processes, governance, and interfaces (Allen et al., 2021; Bartelheimer et al., 2023). This context encompasses the social, cultural, economic, and regulatory factors that shape the platform's development, operation and governance. Hence, designers must consider community structures, norms, regulations, cultural practices and tools to design platforms to the specific needs, preferences, and constraints of stakeholders.

In summary, contextualising the design of a digital platform for local practices requires considering various design aspects, including the platform's purpose, boundaries, components, structure/organisation, and contextual factors. To elicit the design requirements associated with these aspects, the design process should involve understanding the motives and goals of

local stakeholders, exploring the activities and resources involved, and analysing the actions and interactions of stakeholders within the local practices. Additionally, considering the social, cultural, linguistic, and regulatory context is crucial for tailoring the design of business processes and interfaces to suit the specific context. To effectively explore the elements, this study employed a structured approach to investigating activities in local sharing practices by utilising activity theory (AT) as a conceptual framework. AT offers a holistic perspective that enables the examination of purposeful human activities and their interactions within the sociocultural context. The following section presents a concise overview and discussion of activity theory (AT).

2.4 Activity Theory

AT is a theoretical framework for studying purposeful human activities (Kaptelinin & Nardi, 2017). AT represents human activities using an activity system diagram that includes a subject, objects, tools, community, norms/rules, and division of labour (DOL) (Engeström, 1993). Figure 1 shows the activity system diagram adopted from Engeström (1993). "Subject" refers to an "actor" who owns the activity. This paper uses the term actor instead of subject since the term actor is more familiar in information systems research. "Object" refers to the state of a thing (abstract, concrete, or people). This paper uses the term "resource" instead of object since resources are the central object of sharing activities. "Tool" is an instrument that mediates the interaction between an actor and resources. "Community" refers to the "stakeholders" in an activity. This paper uses the term stakeholders instead of community due to the familiarity of the term. "Rules/norms" refer to the community laws that govern an activity. Finally, "DOL/roles" refers to the distribution of roles among the stakeholders.

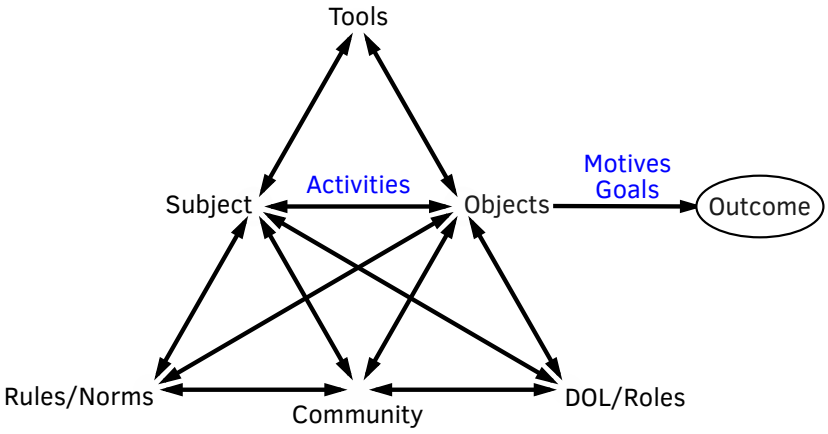

Figure 1: Activity system diagram[a]

[a] adopted from Engeström (1993)

AT has several principles that dictate the study of activities. While these principles generally emphasise the specification, design, and evaluation of technology to be accomplished within the context of an activity (Kaptelinin & Nardi, 2017) the "hierarchical principle" in

particular provides insights to study platform design by breaking down activities to smaller units (Engeström, 1993).

It depicts an activity using a three-level hierarchical abstraction comprising activity, actions, and operations. Activity is an abstraction parallel to motives (Kaptelinin & Nardi, 2017). Actions are abstractions of an activity parallel to the goal of an activity. Operations are actions performed within conditions/contexts. They refer to routines in the lower hierarchy of activities (Kaptelinin & Nardi, 2017).

3 METHODOLOGY

This research used the EADR process model (Mullarkey & Hevner, 2018). EADR is a process model for action design research consisting of diagnosis, design, implementation, and evolution (Mullarkey & Hevner, 2018). Figure 2 shows the EADR processes of the study.

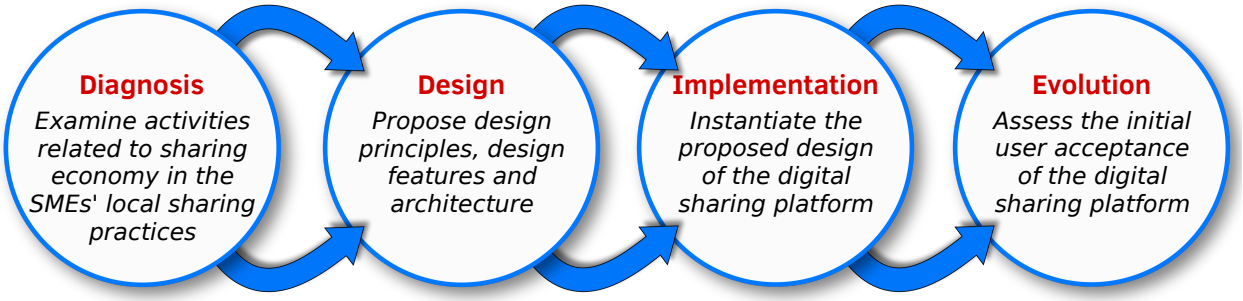

Figure 2: The EADR process and model[a]

[a] adopted from Mullarkey and Hevner (2018)

3.1 Diagnosis Cycle

The diagnosis cycle investigates the problem that needs to be addressed through practical design. In this research perspective, the diagnosis cycle examined SMEs' local sharing practices through thematic analysis. Ethiopian SMEs were used as a case study. Data was collected from 32 SMEs working in four cities in Ethiopia using semi-structured interviews. Interviews were conducted with SME owners or managers in key Ethiopian cities – Addis Ababa, Adama, Bahir Dar, and Gonder. Data collection sites covered a distance exceeding 800 kilometres. Table 1 outlines the diverse range of 18 product types across four sectors offered by these SMEs. The data was analysed in three stages using thematic analysis based on abductive reasoning. AT provided the lens to guide the thematic analysis. The first iteration investigated activities, stakeholders, resources, and motives in the local SMEs' sharing practices related to collaborative consumption, circular economy, crowdfunding, crowdsourcing, and open innovation. Based on the findings in the first iteration, the second iteration examined the goals and actions in the identified activities. In the third iteration, the analysis examined the rules, the DOL, and the tools used in the sharing practices.

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Table 1: Demography of respondents and SMEs

Sector	City	Main product	Enterprise age	Academic status
Manufacturing	Adama	Leather related	5-10 years	Technical School
Manufacturing	Adama	Furniture	1-5 years	Technical School
Manufacturing	Addis Ababa	Weaving	10-15 years	10th grade
Manufacturing	Addis Ababa	Leather	10-15 years	University
Manufacturing	Bahir Dar	Household	5-10 years	Technical School
Manufacturing	Bahir Dar	Garment	5-10 years	Technical School
Manufacturing	Gonder	Garment	5-10 years	Technical School
Manufacturing	Gonder	Furniture	1-5 years	Technical School
Construction	Adama	Mining	1-5 years	10th grade
Construction	Adama	Material production	5-10 years	10th grade
Construction	Addis Ababa	Machine rent	1-5 years	University
Construction	Addis Ababa	Material production	1-5 years	Technical School
Construction	Bahir Dar	Machine rent	5-10 years	University
Construction	Bahir Dar	Material production	5-10 years	Technical School
Construction	Gonder	Material production	1-5 years	10th grade
Construction	Gonder	Machine rent	1-5 years	University
Service	Adama	Hotel	$>$ 15 years	University
Service	Adama	Transport	1-5 years	10th grade
Service	Addis Ababa	Hotel	$>$ 15 years	10th grade
Service	Addis Ababa	Laundry	1-5 years	University
Service	Bahir Dar	Hotel	5-10 years	University
Service	Bahir Dar	Transport	$>$ 15 years	10th grade
Service	Gonder	Car rental	1-5 years	University
Service	Gonder	Freight	5-10 years	10th Grade
Trade	Adama	Electronics	5-10 years	Technical School
Trade	Adama	Stationery	5-10 years	Technical School
Trade	Addis Ababa	Electronics	1-5 years	Technical School
Trade	Addis Ababa	Pharmacy	1-5 years	University
Trade	Bahir Dar	Spice	5-10 years	Technical School
Trade	Bahir Dar	Spare part retails	1-5 years	Technical School
Trade	Gonder	Cleaning material	1-5 years	University
Trade	Gonder	Stationery	1-5 years	Technical School

3.1.1 Activities, Stakeholders, Resources, and Motives

Results of the first iteration show the SMEs' engagement in local sharing practices related to collaborative consumption (CC), circular economy (CE), crowdfunding (CF), and crowdsourcing (CS) activities. The findings did not show the SMEs' engagement in open innovation (OI) activities.

Private and public resources were the main drivers that attracted SMEs to the sharing activities. instance, the SMEs' major sharing activities were related to accessing private resources such as equipment, services, raw materials, and consumer products. Government support was also one aspect of the SMEs' sharing. Sharing practices were mainly done to ensure profitable businesses, minimise costs, obtain alternative finances, obtain access to raw materials, start

businesses, share investment costs, and access government support. Suppliers, consumers, complementary asset providers (CAPs), and regulators were the main stakeholders in the sharing activities. Figure 3 shows the SMEs' activities, actors, stakeholders, resources, and motives in their local sharing practices.

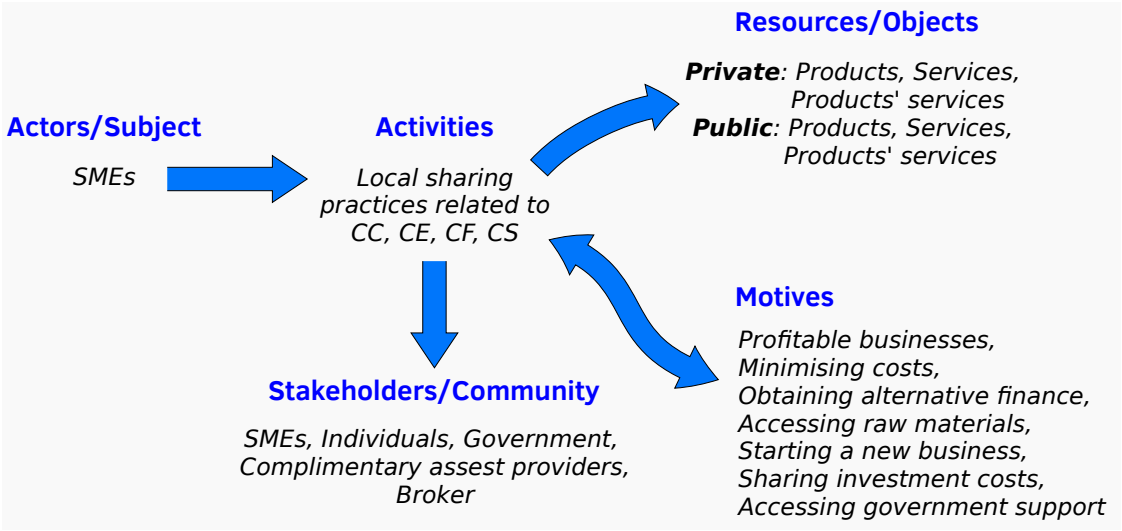

Figure 3: Activities, actors, stakeholders, resources and motives in SME's local sharing practices

3.1.2 Goals and Actions in the SMEs' Sharing Practices

Actions are sequences of tasks (goal-oriented activities) taken to achieve a higher-level motive-oriented activity (Kaptelinin & Nardi, 2017). In the second iteration of the thematic analysis, the study explored the goals of SMEs in their sharing practices and the corresponding actions taken by these SMEs to achieve those goals. Results show fourteen major goals that encompassed diverse areas such as purchasing services, products, and product services; selling services, products, and product services; accessing government support; engaging in equipment swapping with private owners; finance collaborations (peer-to-peer); joint purchasing initiatives; participating in joint investments; participating in savings and credit unions; buying used and leftover products; selling second-hand items; hiring permanent workers; hiring temporary workers per time; hiring workers on a result-based basis; and engaging in subcontract work.

Furthermore, the thematic analysis has revealed a variety of actions related to the identified goals in the context of SMEs' local sharing practices. For goals related to purchasing, major actions were preparing specifications, searching for resources, negotiating, providing price quotations, placing orders, validating deliveries, and settling payments. On the other hand, for goals related to selling, actions were preparing and promoting a catalogue, managing customer orders, delivering products/services, collecting payments, and handling feedback. Engaging in financial collaborations entails initiating and promoting collaborations, registering members, collecting and disbursing funds, auditing collaborations, and completing the process. Saving and credit activities encompass promoting services, registering members, collecting savings, managing loans and payments, auditing collaborations, and maintaining membership.

Joint investment activities involve initiating collaborations, registering collaborators, selling shares, facilitating share exchanges, settling payments, auditing collaborations, and managing dividends. Joint lease and procurement activities consist of initiating collaborations, registering collaborators, collecting funds, purchasing products, settling payments, distributing products, and auditing collaborations. Crowdsourcing activities revolve around hiring workers and subcontracting work. Actions in hiring workers include identifying human resource needs, selecting workers, negotiating terms, assigning jobs, validating completed work, settling payments, and managing employee information. Subcontracting work involves searching for providers, negotiating terms, accepting work orders, handing over assignments, and settling payments. Lastly, circular economy practices encompass buying and selling second-hand products. Buying actions involve identifying needs, finding products, settling payments, and maintaining relationships. Goals related to selling second-hand products include specifying and promoting products, managing customer orders, delivering products/services, collecting payments, and handling feedback. These actions provide a comprehensive overview of the steps involved in achieving the identified goals within SMEs' local sharing practices concerning the SE.

3.1.3 Rules, DOL, and Tools

According to AT, rules, DOL, and tools are the three elements that determine contexts in an activity (Engeström, 1993). Findings in the third iteration of the thematic analysis showed the existence of several rules/norms associated with:

i. trustful transactions and collaboration;

ii. payment accuracy, appropriateness, and timeliness;

iii. deliveries' quality, timeliness and appropriateness;

iv. participants' duties;

v. refunding for undelivered services/products; and

vi. many other business domain-specific rules concerning SMEs' sharing practices.

Findings have also shown the distribution of tasks among stakeholders in their local sharing practices. The result shows the role of SMEs as consumers, providers, collaborators, brokers, and employers. It also shows the government's role as a provider, consumer, and regulator. In addition, they show the non-governmental institutions' roles as providers and consumers. The financial institutions have a role in facilitating payments among the sharing actors.

Tools mediate human activities. AT classifies tools into technical (physical) and psychological (Kaptelinin & Nardi, 1997). Psychological tools are instruments such as languages and signs. Physical tools are external tools such as technological artefacts (Kaptelinin & Nardi, 1997). Results show the frequent utilisation of local languages and technical devices such as mobile phones in the SMEs' sharing practices.

3.2 Design Cycle

The design cycle was the second stage of the EADR. It examines the design principles, design features, and implementation methods (Mullarkey & Hevner, 2018). The major design activities concerning the design of the digital sharing economy platform were eliciting contextual design principles and proposing design features, and implementation methods.

3.2.1 Contextual Design Principles

The contextual design principles are formulated by taking into account two crucial factors: first, the objective of customising the design of a digital platform to suit the specific context of SMEs local sharing practices, and second, designing based on a comprehensive understanding of design aspects and core constructs that are inherent to digital platforms. The contextual design principles are:

Designing for a purpose Designing for specific purposes has been emphasised in multiple studies (Bonina et al., 2021). In this aspect, it is crucial to contextualise the purpose of the digital platform in the SMEs' motives and goals for their local sharing activities.

Design with boundary Designing with defined boundaries and interfaces is one aspect of designing digital platforms (Daradkeh, 2023; Gawer, 2021a). It is important to establish clear boundaries by investigating activities, resources, and stakeholders of the design of digital platforms.

Designing the components The studies emphasise the need to design both the core functionalities and peripheral components of a digital platform through the analysis of the actions of stakeholders (Bonina et al., 2021).

Designing for the context Context forms a critical facet in the design of various technologies. Its essence lies in ensuring that new designs seamlessly integrate into their context by consolidating data about social structure, cultural norms and environmental contexts (Murer et al., 2015; Stamps, 2014).

Design as an ecosystem IT emphasises the interconnectedness and interdependencies of various components of a platform (Engert et al., 2023).

Design for modularity and reusing This principle advocates for the design of modular components that facilitate the reuse of functionalities (Dai, 2023; Naik et al., 2020). Reusability enhances efficiency, reduces development time, and enables the adaptation of the platform to evolving needs.

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3.2.2 Features of the Digital Sharing Economy Platform

The proposed design described the features of the digital sharing economy platform by its purpose, boundaries, components, structure/organisation, and context.

Purpose The outcomes of the diagnosis cycle have revealed the motives driving local sharing activities among SMEs. Furthermore, the results have identified 14 specific goals that SMEs strive to accomplish through their local sharing practices. Building upon these findings, the purpose of the digital sharing economy platform has been defined in its design. Consequently, the platform's design was customised to meet the unique needs of SMEs, including initiating new businesses, streamlining transactions, enhancing access to raw materials, providing alternative finance options like peer-to-peer lending, promoting cost reduction through shared resources and bulk purchasing, facilitating collaborative investment opportunities, and connecting SMEs with valuable government support programs and resources.

Boundaries The digital sharing economy platform's boundary was set by defining its scope, sides, and boundary resources. The platform's scope was determined based on the knowledge acquired from the diagnosis cycle, which examined the goal-oriented activities and resources of SMEs involved in local sharing activities. Results in the diagnosis cycle showed 14 goal-oriented activities of the SMEs' local sharing activities. Moreover, they revealed varied types of products and services as primary resources of the SMEs' local sharing practices. Based on the information, initially, the design mapped the goal-oriented activities with six packages. Figure 4 shows platform packages mapped from the SMEs' goal-oriented activities.

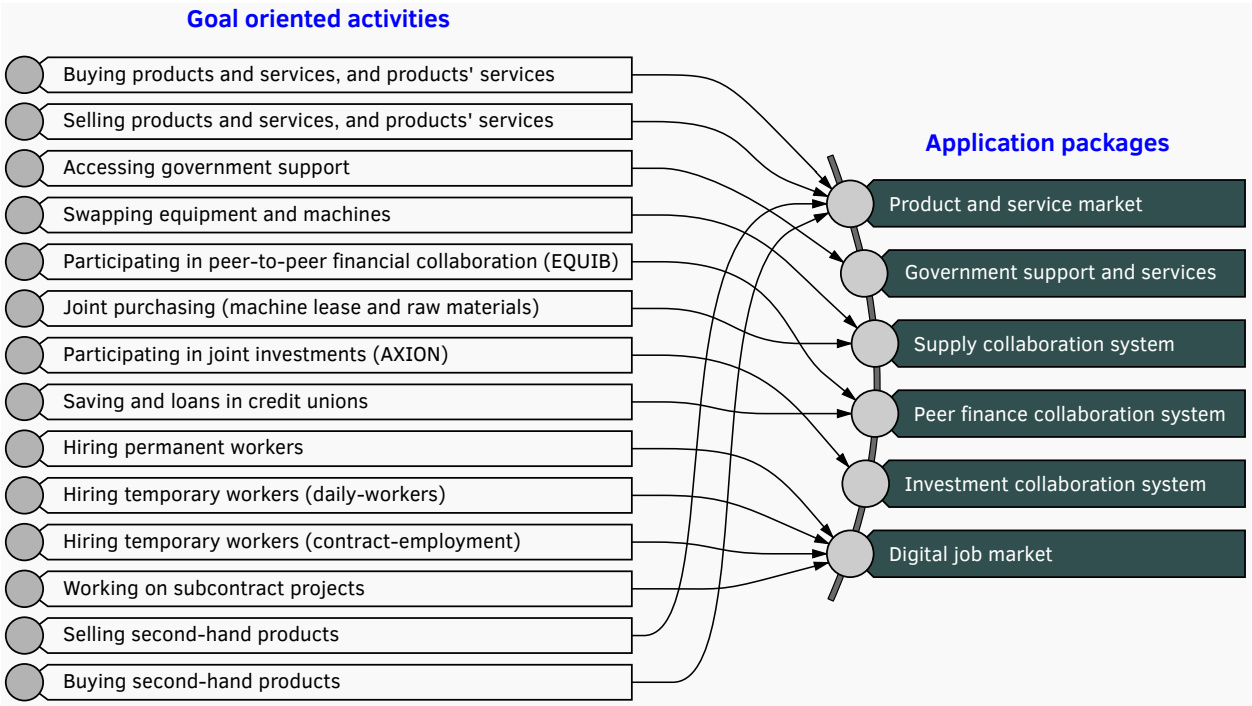

Figure 4: Sharing economy platform packages elicited from the SME's activities

Next, the design used knowledge about resources to define additional compartments of the packages. Accordingly, 13 sub-packages are proposed within the six main packages. The sides are modelled by analysing the DOL mong stakeholders. Results in the diagnosis cycle showed that SMEs, government, individuals, non-governmental organisations (NGOs), complementary asset providers (CAPs), and Brokers were the main stakeholders of the SMEs' local sharing practices. Figure 5 shows the boundary of the digital platform in terms of the activities, resources, and sides.

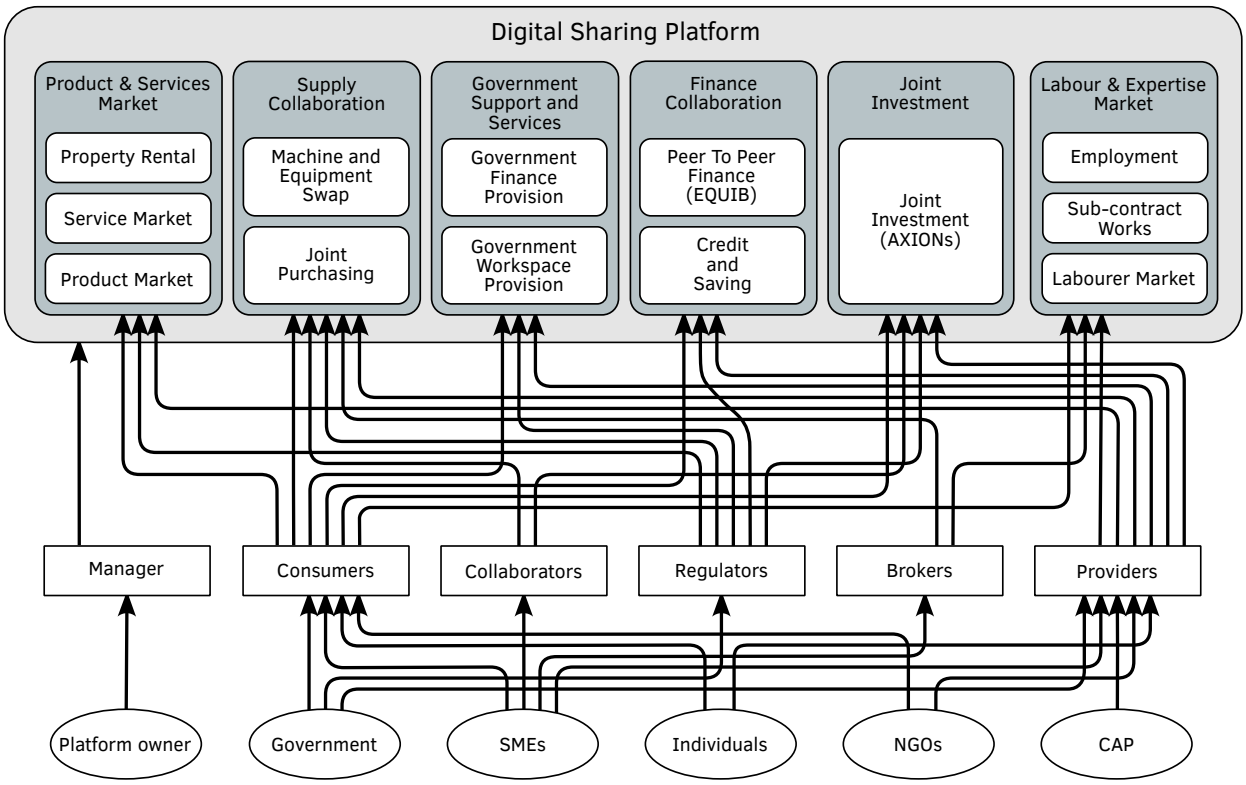

Figure 5: The boundary of the digital platform

The boundary resources are modelled by assessing the interaction and interdependence of various activities and actions. However, these resources are further refined during the component modelling stage by analysing the relationships and dependencies among different actions.

Components and Modules The design of components is influenced by goals and actions associated with local sharing practices. Findings on goals and actions have played a crucial role in determining the requirements for the platform's components. By understanding the actions undertaken by SMEs to achieve their key objectives, components were tailored to enable stakeholders to perform those actions. Furthermore, a modular design approach is recommended by several researchers (Dai, 2023). However, there is a lack of specific guidance on how to break down packages into modular components. This study addressed this gap by defining modules through the analysis of interrelated actions among actors involved in collaboration

processes. Collaboration is a dynamic process that encompasses various phases, including initiation, formation, collaboration, and finalisation (Twinomurinzi & Ayalew, 2022).

To design modules within each solution package, the study examines the actions performed by actors in each stage of the collaboration process. By analysing the interdependencies and relationships between these actions, the design of modular components within the packages is determined. For instance, in the PROPERTY-RENTAL activity, creating a rental property, listening to rental requests, agreeing on terms, receiving payments, managing property delivery, managing the return of the property, and viewing feedback are actions of the providers. In the other dimension, searching for rental property, creating rental requests, agreeing on terms, settling payments, validating and accepting properties, returning properties, and rating or complaining about the service delivered are actions of the consumers. Thus, the design process first organised the providers' and consumers' actions in the collaboration lifecycles diagram. Next, potential modules are abstracted by assessing related actions in each phase.

Figure 6 shows the analysis of modules based on actors' related actions in the collaboration stages. Table 2 shows a list of modules under the packages of the digital sharing economy platform.

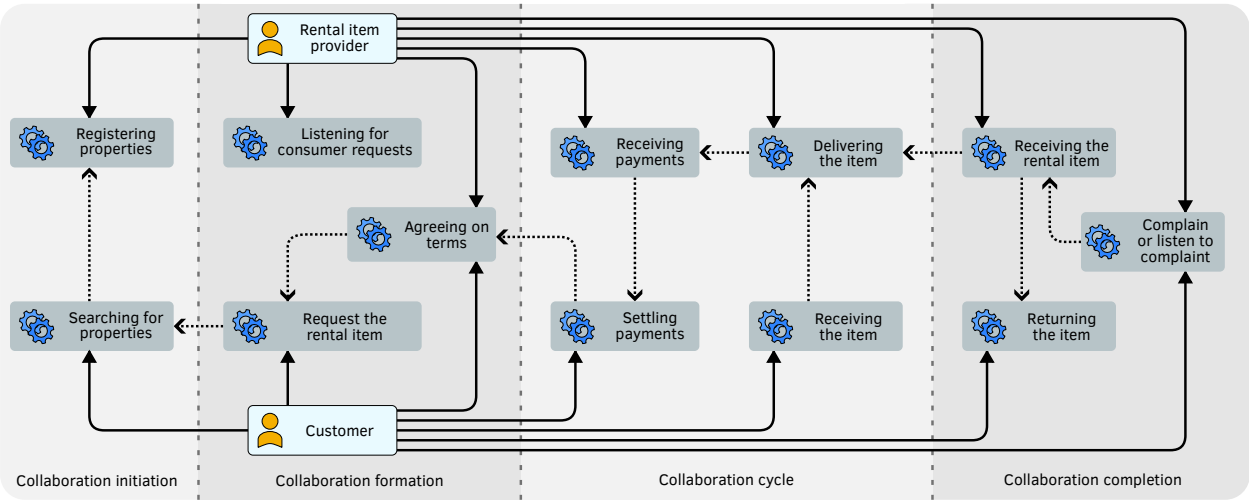

Figure 6: Example of module definition from property rental activity

Contexts Contextualising the digital platform largely depends on the extent in which designs incorporats local rules (norms), processes, structures, and interaction tools (such as languages and cultural tools). In this design context, each module is crafted with careful attention to integrating local business processes, community power structures, norms, and rules identified during the diagnosis stage that are prominent in local sharing practices. For instance, in property rental activities, local rules require the tenant to pay a certain amount of down-payments, known locally as 'qabd', after both parties have reached an agreement on the rental terms. This payment is typically considered a guarantee to uphold the agreement. Therefore, the "Agreement Management Module" should be designed to incorporate this and other similar rule. In general, designing the digital platform modules requires consideration of and incorporation of such local rules, which is an essential aspect of contextual design. Moreover, the

Table 2: List of Packages, Sub-Packages, and Modules

Package	Sub-Package	Modules
Product Service Market	Product Market	Product Registration, Search, Negotiation and Chatting, Order Management, Agreement Management, Payment Management, Sales Management, Delivery Management, Feedback and Compliant Management
	Service Market	Service Registration, Search, Negotiation Management, Booking, Agreement Management, Payment Management, Service Delivery Management, Feedback and Compliant Management
	Property Rental	Asset Registration, Rental Asset Search, Rental Request, Agreement Management, Rental Management, Payment Management, Feedback and Compliant Management
Government Support	Government's Finance Provision	Announcement Management, Application and Selection Management, Financial Provision Management, Payment Management, Follow-up Management
	Government's Workspaces Provision	Announcement Management, Application and Selection Management, Financial provision Management, Payment Management, Follow-up Management
Supply Collaboration	Machine and Equipment Swap	Equipment Registration, Search Management, Agreement Management, Swapping Management, Equipment Returning Management, Follow-up Management
	Joint Purchasing	Create Activity, Activity Announcement, Create Group, Payment Management, Purchasing Management, Distribution Management, Follow-up Management
Financial Collaboration	Peer-to-Peer Finance (EQUIB)	Initiate and Announce EQUIB, Application and Selection, Role Assignment, Collect Contribution, Identify Fund Recipients, Reimburse Funds, Payment, Audit EQUIB, Claim Settlement, Settle Dividend
	Saving and Credit Services	Initiate and Promote the Credit Union, Membership application and selection, Periodic saving management, Credit processes Management, Audit the credit unions, Resignation Management, Report Management
Investment Collaboration	Joint Investment (AXIONs)	Investment Initiation and Promotion Management, Shareholders Registration, Shareholders Assembly and Signature, Share Exchanges, Payments, Audit Management, Dividends Management, Report Management
	Employment	CV Management, Application Management, Talent Selection Management, Recruitment and Contract Management, Job Assignment Management, Payment Management
	Sub-Contract Work	Contract Work Registration Management, Application and Selection, Job Assignment Management, Contract Management, Payment Management

design took into account the importance of user interface (UI) design by considering the physical tools, such as users' experience with digital devices, as well as the psychological tools, such as language usage in local sharing practices.

Structures and Organisation The proposed design suggested a platform architecture that emphasises interoperability between the core components and the identified packages. Figure 7 shows the proposed architecture of the digital sharing platform. The core components were modelled by including user management, activity tracking and log management, secure authentication and authorisation mechanisms, communication and messaging features, and administrative tools.

The design organised each package as an independent layered collection of components containing data storage, business, and presentation logic. Separated databases are proposed for the platform core as well as for each solution package. Separating databases allows each package to perform autonomous operations with distinct data (Deryabin et al., 2023; Laigner

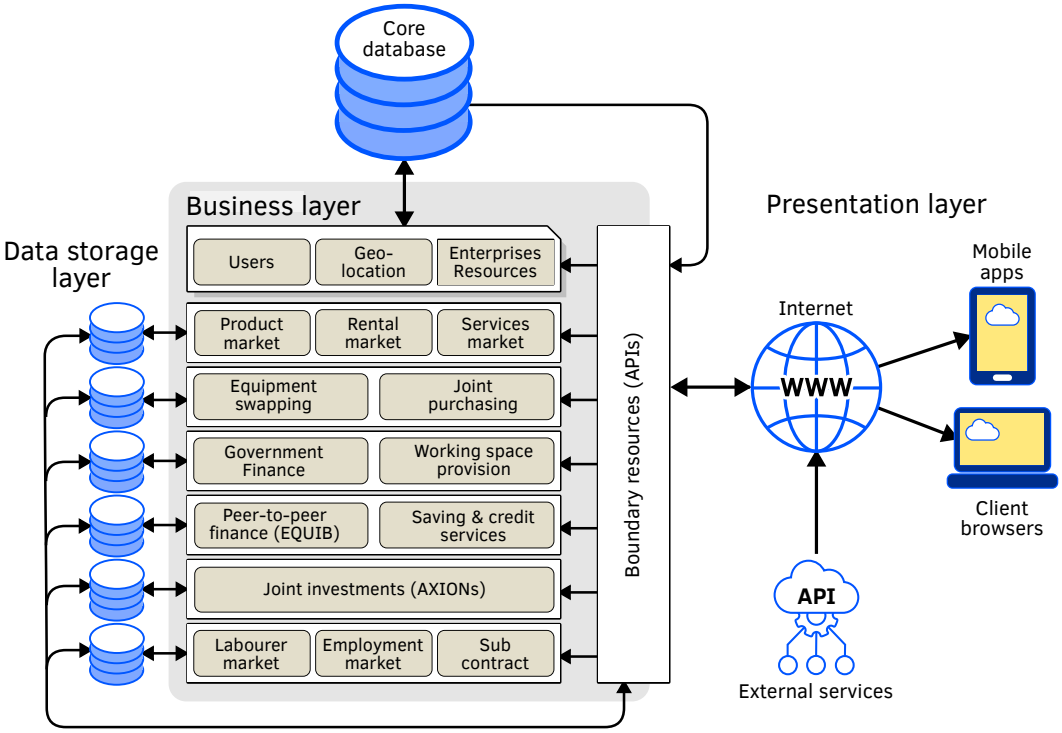

Figure 7: Architecture of the digital sharing platform

et al., 2021). Moreover, the design emphasised the inclusion of boundary resources (APIs) within both the core of the platform and each package. These boundary resources serve as interfaces that allow the core and packages to expose their functionalities to other components within the platform ecosystem. APIs may be internal or external to the platform. Internal APIs facilitate the interfacing between modular components or application packages in the platform core and other internally developed solution packages. External APIs often interface the platform with external applications. The presentation layers contain the user interfaces.

3.3 Implementation Cycle

In the implementation cycle of the EADR process, the emphasis is on instantiating artefacts. In this research, an incremental approach was adopted for the implementation process, allowing for ongoing improvement and refinement.

During the first iteration, the platform core modules were implemented. To accomplish this, the research utilised an open-source platform framework called DNN_Platform_9.12.1 Community Edition. This framework was selected for its inclusion of essential platform core modules that handle crucial tasks such as log management, message management, user account management, role management, and security. Furthermore, it provided the flexibility to develop modules as independent projects using Entity Framework 6.02 and MSSQL Express 8th edition or above. In addition to these basic modules, the implementation stage incorporated geographic locations, enterprises, activities, and resource modules as the core components of the digital platform.

Moving to the second iteration, the focus shifted to implementing the APIs for the platform

core. For the sake of simplicity, APIs are implemented as RESTful services. In the third iteration, this study focused on implementing modules that facilitate actions within SMEs' local sharing practices. Due to limitations in time and funding, it was not feasible to implement all of the solution packages. Consequently, the study prioritised the implementation of the 'property rental' package, as it is closely associated with SE and collaborative consumption activities. Figure 8 shows a snapshot of the home page for rental management packages.

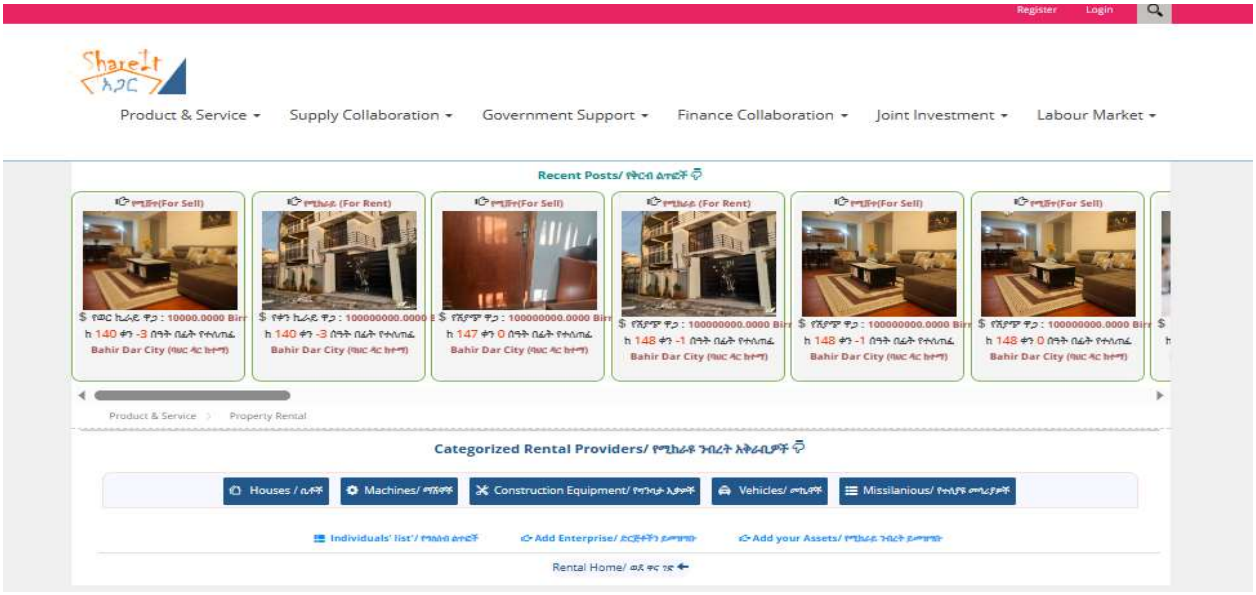

Figure 8: Property rental home page

The rental market solution contains 'asset registration', 'rental-asset-search', 'rental-requests', 'rental-agreement', 'rent-registration', payment, 'reminder', and 'feedbacks' modules. The 'asset registration' module allows providers (individuals or enterprises) to post, view, edit, and delete rental assets. 'Rental asset search' modules allow consumers to view details, search, and, 'create cart lists'. The module allows consumers to see the posted item based on the enterprise. The 'rental request' module allows consumers to create, view, modify, and delete rental requests. It additionally allows providers to approve or reject consumers' requests. The 'rental agreement' module permits providers to create, modify, delete, view, and print agreements. It also allows consumers to view, sign, and reject agreements. The 'payment' module allows consumers and providers to create, transfer, and view payments. The 'rent registration' module allows the provider to create, delete, modify, or view rental transaction information. The 'reminders' module allows providers to post, modify, or delete different reminders to consumers. It also allows the consumer to read the reminders. The 'feedback' module allows the consumer to create, delete, modify, and delete feedback. It also allows providers to view the feedback of the consumer.

3.4 Evolution Cycle

The final stage of the EADR focuses on analysing the evolution of the artefact over time, considering changes in the problem environment and the iterative development of the artefact

solution (Mullarkey & Hevner, 2018). Typically, this stage of the process spans a long-term project. However, in this study, the initial acceptance of the digital sharing platform was included as part of the evolution cycle.

The initial acceptance of the designed digital sharing economy platform is evaluated based on users' intention to use the services running on the digital sharing platforms.

Researchers have so far utilised theories such as the Technology Acceptance Model (TAM) (Kamal et al., 2020), the Theory of Planned Behaviour (TPB) (Shneor & Munim, 2019), the Unified Theory of Acceptance and Use of Technology (UTAUT) (S. A. Rahman et al., 2019), Diffusion of Innovation (DOI) (Attié & Meyer-Waarden, 2022), and the Technology, Organisation, and Environment (TOE) frameworks (Kouhizadeh et al., 2021) to evaluate technology acceptance related research. This research selected the TOE framework since it is suitable for evaluating technology acceptance in organisations including SMEs and allows us to see environmental as well as technological factors (Ghobakhloo & Ching, 2019).

3.4.1 Conceptual Model and Hypothesis

The TOE is a technology acceptance assessment framework that is based on organisational-level theory (Bokolo & Petersen, 2022). It incorporates technological, organisational, and environmental contexts as factors to evaluate the acceptance of technology in organisations. This study applied the TOE framework to test nine different factors under three separate contexts (technological, organisational, and environmental) in terms of their direct effect on SMEs' intention to use the designed digital sharing economy platform for their sharing activities. Figure 9 shows the property rental system's initial acceptance evaluation model.

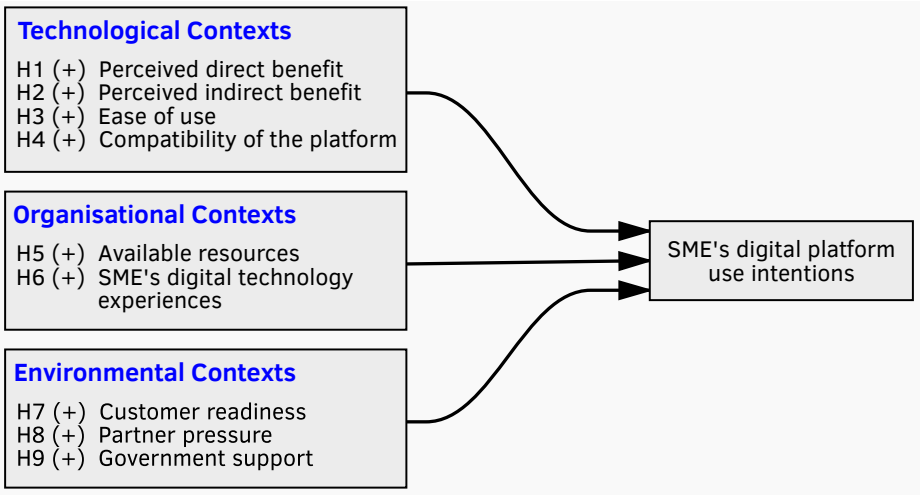

Figure 9: The 'property rental system's' initial acceptance evaluation model

The technological context indicates factors concerning the features of technologies that affect technology acceptance (Bokolo & Petersen, 2022). The complexity, compatibility, perceived direct benefit, and perceived indirect benefit are factors that affect technology acceptance (Abed, 2020). The perceived direct benefit indicates the potential of the platform to enhance operational efficiency and reduce operational costs. The perceived indirect benefits

indicate the anticipated improvements by the user in expanding relations and customer bases. Ease of use refers to the degree to which the user estimates being able to use the technology without much effort (Abed, 2020). Compatibility indicates the degree to which the technology is aligned with the values, rules, processes, cultures, and languages (Abed, 2020).

In the context of technological factors, four hypotheses were formulated regarding the designed digital sharing economy platform. The assumptions were as follows:

H1 The perceived direct benefits observed from the newly designed digital sharing platform have positively influenced individuals to use the technology for their local sharing activities.

H2 The perceived indirect benefits observed from the digital platform have positively influenced individuals to use the technology for their local sharing activities.

H3 The ease of use of the digital platform has positively influenced individuals to use the technology for their local sharing activities.

H4 The compatibility of the digital platform has positively influenced individuals to use the technology for their local sharing activities.

The organisational context indicates multiple institutional factors that affect the users' technology use intention (Abed, 2020). This study considered organisational factors that affect the use intentions of the designed digital sharing economy platform. In terms of this, the study produced two hypotheses as follows:

H5 The resources available in the SMEs have positively influenced the users' use intention of the designed sharing platform.

H6 The SMEs' previous digital technology experience has positively influenced the users' use intention of the designed sharing platform.

Lastly, the environmental context indicates factors such as consumer readiness, competitor pressure, and government support that can affect users' intention to use the designed digital sharing economy platform. In this respect, the study produced three hypotheses:

H7 The rent consumers' readiness and experiences on digital platforms have positively influenced the users' use intention of the designed sharing platform.

H8 The competition from other SMEs' digital platforms has positively influenced the users' use intention of the designed sharing platform.

H9 Government pressure has positively influenced the users' use intention of the designed sharing platform.

3.4.2 Sampling and Data Collection

Data was collected from a sample of 123 individuals, including SME owners or employees and rental consumers who had experience in providing or consuming rental properties. The participants were conveniently selected from the town of Bahir Dar, considering its proximity to the researchers and the ease of introducing them to the digital sharing economy platform. To gather the necessary information, standardised questionnaires comprising demographic questions and 28 5-Likert scale questions were prepared. Before completing the questionnaires, participants were given 20 days to explore and utilise the rental market application that operates on the digital sharing economy platform.

3.4.3 Participants

The results indicate that the majority of participants were male, aged between 22 and 30 years, with technical education backgrounds and business experience ranging from one to five years. The respondents were equally distributed across various sectors including trade, construction, manufacturing, and services. For further details, please refer to Figure 10, which presents the demographic characteristics of the participants.

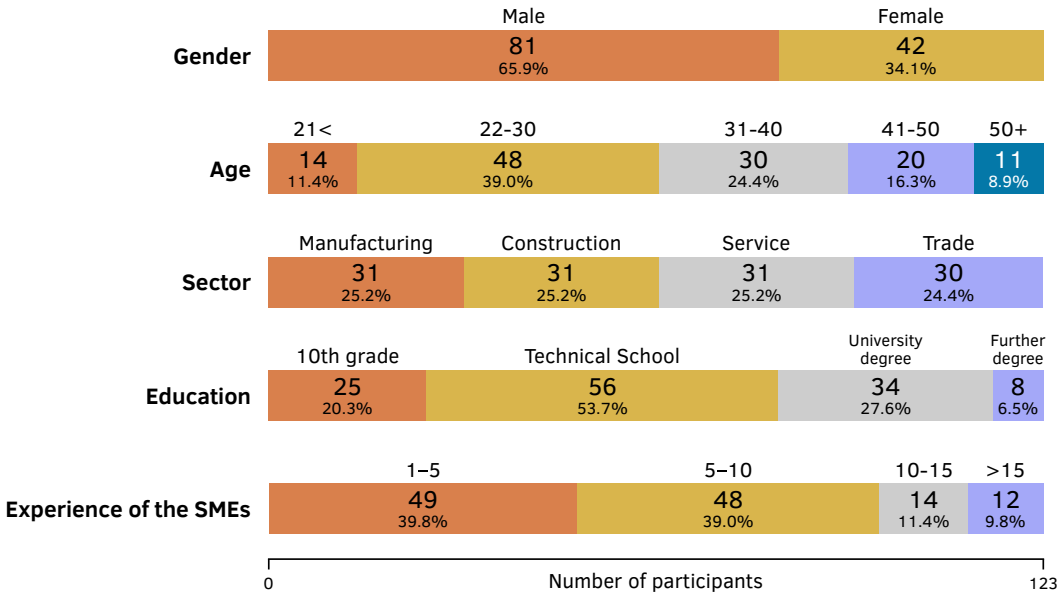

Figure 10: Demographic characteristics of the participants

3.4.4 Data Analysis

The study used a structural equation modelling (SEM) technique (Gupta & Shankar, 2022). The study specifically applied the partial least squares SEM (PLS-SEM) technique since it is suitable for research with a small sample size (Dash & Paul, 2021). It is suggested that the minimum number of participants in the study should be ten times the number of indicators associated with the most complex constructs or the number of antecedent constructs linked to an endogenous construct (Kock & Hadaya, 2016). In this study, the number of indicators

for the complex constructs and the number of antecedent constructs linking to an endogenous construct was six and nine respectively. Hence, the sample size of 123 was acceptable in terms of using the PLS-SEM technique (Hair et al., 2020). Analysis in PLS-SEM consists of measurement and structural modelling tasks (Hair et al., 2020).

3.4.5 Measurement Model

The measurement model examins the relationship between variables and their measures (Hair et al., 2020). It assesses the reliability and validity of instruments (Legate et al., 2021). Reliability indicates the consistency of the interpretation of the instrument's questions. The study assessed the internal consistency of the measurement using Cronbach-α and Composite Reliability (CR) scores (Legate et al., 2021). The minimum Cronbach-α score found in the study was 0.799, which is above the accepted value (0.5) (Vaske et al., 2016). CR measures the internal consistency of indicator loading on the latent variable (Vaske et al., 2016). The result showed a minimum CR (ρ-a) value of 0.800, which is also above the accepted value (0.7) (Vaske et al., 2016).

Convergent validity measures the closeness of the new scale with other variables and other measures of the same variable. Convergent validity is often measured by its factor loading and average variance extracted (AVE) score. The results show a minimum of 0.783 AVE score for a construct, that is above the threshold of the accepted score (0.5). The results also show that all outer factor loading scores are greater than 0.823 which is above the minimum accepted value of 0.7. The discriminant validity indicates the degree to which items differentiate a construct from other constructs and measure distinct concepts (Hwang et al., 2023). This research used the Hetrotrait–Monotrait ratio (HTM) matrix score to assess the discriminant values. The results show the maximum HTMT score value of 0.844, which is valid and less than the maximum threshold value of 0.85 (Hwang et al., 2023). Table 3 shows the reliability measures of Cronbach-α, CR, and AVE.

Table 3: Reliability measures according to Cronbach's α, CR, AVE

Contexts Type	Variables	Code	Items	Cronbach's α	CR	AVE
Technological	Perceived Direct Benefit	PDBft	5	0.938	0.949	0.787
Technological	Perceived Indirect Benefit	PIBft	2	0.874	0.940	0.887
Technological	Ease of Use	EseUs	5	0.933	0.948	0.783
Technological	Compatibility	Cmpty	4	0.912	0.938	0.791
Organisational	Enterprise Resources	ErRsrs	2	0.923	0.942	0.844
Organisational	Enterprise Experiences	ErExps	3	0.880	0.942	0.891
Environmental	Consumer Readiness	CmRds	2	0.800	0.909	0.833
Environmental	Competitor Pressure	CptPrss	2	0.904	0.952	0.908
Environmental	Government Pressure	GvPrss	2	0.921	0.962	0.926
Dependent Variable	Use Intentions	UseInt	2	0.914	0.958	0.919

3.4.6 Structural model

The structural model indicates the relationship between the independent and dependent variables. In this regard, the study first conducted hypothesis testing. The hypothesis testing estimated the significance of the relationships between the independent variables and dependent variables in each assumption using a critical t-value from the first-round bootstrap. Table 4 shows the first round of bootstrap results. The results show unacceptable relationships (>0.05) for two assumptions (A8 (0.173) and A9 (0.138) in H8 and H9). The structure was then remodelled by removing the two assumptions. The second-round bootstrap result shows significant relationships between the independent and the dependent variables in the remaining assumptions. Validity and reliability measures were again done for the new model and were found to be acceptable. An analysis of the remodelled structure was then done.

Table 4: First round bootstrap results

Paths	**T statistics** $\lvert O/\text{STDEV}\rvert$	**P Values**	**Status**
CmRds→UseInt	2.879	0.004	Accepted
Cmpty→UseInt	3.443	0.001	Accepted
ErExps→UseInt	2.950	0.003	Accepted
ErRsrs→UseInt	2.262	0.024	Accepted
EseUse→UseInt	3.353	0.001	Accepted
PDBft→UseInt	2.218	0.027	Accepted
PIBft→UseInt	2.442	0.015	Accepted
CptPrss→UseInt	1.485	0.138	**Rejected**
GvPrss→UseInt	1.361	0.173	**Rejected**

The coefficient of the determinant R^2 indicates the amount of variance in a dependent variable explained by the independent variable. The closer the R^2 value to one, the better the model's ability to predict the dependent variable. The findings show R^2 values of 0.879 for the dependent variable related to variables in the remaining assumptions. Similarly, the results of the path coefficient (β) values of each construct show the positive relationship between the independent and dependent variables. Table 5 shows the results of the structural model analysis. Figure 11 shows the structural model of the study with its R^2 and path coefficient (β) values.

3.4.7 Initial User Acceptance Assessment Results

Results show a positive association between the selected factors and the users' digital platform use intentions. Comparatively, technological factors influenced users to develop intentions to use the designed digital sharing economy platform for their rental activities. In particular, the compatibility of the digital platform ($\beta = 0.225$, $f^2 = 205$), the perceived direct benefit observed from the digital platform ($\beta = 0.207$, $f^2 = 132$), and the ease of use of the platform ($\beta = 0.186$, $f^2 = 109$) significantly influenced users to develop an intention to use the designed

Table 5: T Statistics, P Values, Path Coefficients (β)

Paths	**Sample Mean** M	**Standard Deviation** STDEV	**T statistics** |O/STDEV|	**P**	**Path coefficient** β	f^2	**Correlation**
CmrRds → UseInt	0.119	0.044	2.766	0.006	0.121	0.084	0.581
Cmpty → UseInt	0.225	0.069	3.279	0.001	0.225	0.205	0.770
ErExps → UseInt	0.155	0.061	2.535	0.011	0.154	0.107	0.717
ErRsrs → UseInt	0.183	0.061	2.996	0.003	0.184	0.153	0.706
EseUs → UseInt	0.191	0.058	3.184	0.001	0.186	0.109	0.782
PDBft → UseInt	0.208	0.079	2.614	0.009	0.207	0.132	0.790
PIBft → UseInt	0.148	0.042	3.634	0.000	0.152	0.140	0.565

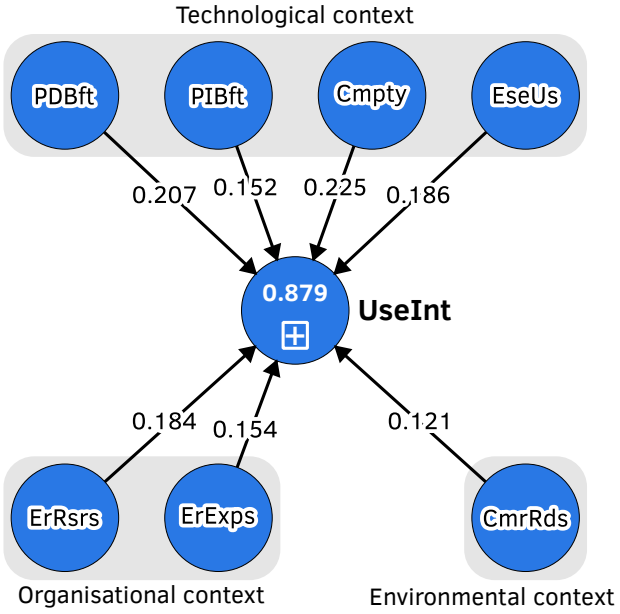

Figure 11: Structural model of the study with its R^2 and path coefficient variables, β.

digital sharing economy platform. Moreover, the indirect perceived benefit observed from the platform positively influenced (β = 0.152, $f^2 = 140$) the users' use intentions. Results also show the positive influence of organisational contexts. Enterprise resources (β = 0.184, $f^2 = 153$) and the users' previous experience (β = 0.154, $f^2 = 107$) show a positive association with the users' digital platform use intentions. Environmental contexts, however, showed little influence on the users' digital platform use intentions.

4 DISCUSSION

The goal of this study was to explore the design of a digital sharing economy platform for SMEs in resource-constrained countries. It specifically examined how these platforms can be tailored to meet the needs of SMEs based on their local sharing practices. While previous

research has highlighted the importance of the sharing economy and associated digital platforms in promoting collaboration and resource optimisation (Belk, 2014), this study addressed a significant gap: the need to adapt the sharing economy concept to the unique cultural and economic conditions of SMEs in developing countries. By analysing local sharing practices, this research connected these practices with the design of digital sharing platforms, offering new insights from Ethiopian SMEs to the literature on the sharing economy.

The study employed the Elaborated Action Design Research (EADR) methodology, which is effective for technology design (Mullarkey & Hevner, 2018). In the diagnosis phase of EADR, the research examined the activities involved in local sharing practices among SMEs, using Activity Theory (AT) as a guiding framework. Although AT is recognised for understanding social and technical systems (Kaptelinin & Nardi, 2017), this study uniquely utilised it to explore local sharing practices within Ethiopian SMEs. This approach can enrich existing literature by demonstrating how established theories like AT can enhance our understanding of activities in specific contexts, ultimately aiding in the design of digital platforms that fit local needs. This approach could enhance conventional participatory design methods, which often rely on inductive idea gathering through brainstorming without a solid theoretical foundation. By incorporating proven theories such as Activity Theory (AT) to guide the process, it becomes a more effective and structured approach.

Applying AT had several benefits. Firstly, it facilitated the identification of sharing practices unique to the local community, such as EQUIB (a traditional peer-to-peer collaboration practice), AXION (a local practice of joint investments), second-hand product exchanges, rental activities, labor market interactions, and savings and credit activities. Secondly, the theory provided valuable insights into the structural elements of these local practices, encompassing activities, actors, stakeholders, motives, resources, goals, actions, rules, and tools. Thirdly, AT emphasises that the specification, design, and evaluation of technology should occur within the context of an activity (Kaptelinin & Nardi, 2017), allowing for the direct elicitation of design requirements from the results of the activity analysis.

In the design cycle, the researchers elicited contextual design principles and defined the features of the proposed digital sharing economy platform. These principles were based on the local sharing practices of SMEs and the unique aspects of designing digital platforms. This approach allows the design process to consider both the users' context and the specific attributes of the technology. Assessing these contextual design principles helped to identify SMEs' requirements, which can then be translated into automated solutions within the digital platform. Investigating key design aspects – such as purpose, boundaries, components, and context – was also essential for understanding the constructs of the technology concerning the unique nature of digital platforms. While contextual design is typically viewed as user-centered, focusing on user interests, needs, and scenarios, this study expands the concept by incorporating the specific nature of technology and best practices in its design. These considerations align with existing literature that conceptualises digital platform technology in terms of its purpose, boundaries, components, and modularity (de Reuver et al., 2018).

Beyond the design principles, the characterisation of the digital platform was developed to support local sharing activities. Results from the diagnosis cycle informed the design requirements, including the platform's purpose, boundaries, components, structures, and contexts. Understanding the motives and goals of local sharing practices was crucial for aligning the

platform's purposes with these factors (Bonina et al., 2021). Knowledge about the types of sharing activities, resources, and stakeholders helped define the platform's scope and boundaries, contextualising its design (Gawer, 2021b). The findings regarding goals and actions were instrumental in eliciting requirements for the components, which are essential for facilitating collaboration and communication among stakeholders (Spagnoletti et al., 2015). In this context, the identification of 13 local sharing models provides a practical framework that has been largely absent in prior research, which often presents theoretical constructs without actionable insights. Additionally, the analysis of rules, tools, and norms was significant in contextualising the design of components that provide functionalities aligned with each stakeholder's actions.

Beyond the design principles, the characterisation of the digital platform's design was done in a way that supports the local sharing activities. Results obtained from the diagnosis cycle were utilised to inform the design requirements of the digital sharing economy platform, including its purpose, boundaries, components, structures, and contexts. Understanding the motives and goals in the local sharing practices was crucial for making informed decisions on the purposes of the digital sharing economy platform by aligning with these motives and goals. The knowledge about the type of sharing activities, resources, and stakeholders was crucial in defining the scope and sides of the platform, which helped to contextualise the boundary of the digital platform. The findings from the diagnosis cycle regarding goals and actions were instrumental in eliciting requirements for the components, as these components are crucial in offering functionalities closely linked to stakeholders' actions, facilitating collaboration, communication, and collective actions. In this aspect, the identification of 13 local sharing models offers a practical framework that has been largely absent in prior research, which often presents theoretical constructs. Furthermore, the analysis of rules, DOL, and tools played a significant role in contextualising the design of components that provide functionalities aligned with each stakeholder's actions.

During the implementation cycle, an incremental approach was adopted. The core modules of the platform were implemented in the first iteration, followed by the implementation of APIs in the second iteration. In the third and final iteration, modular components and APIs responsible for specific tasks related to SMEs' sharing practices were implemented.

The evolution cycle of the study focused on empirically assessing the initial acceptance of the designed digital sharing economy platform. This assessment was based on individuals' intentions to use the platform, specifically targeting the rental activity management solution integrated within its services. At this stage, the study adopted a Technology, Organisational, and Environmental (TOE) framework, which is typically used to assess technology acceptance within organisations. While the TOE framework is appropriate for evaluating technology acceptance, this study offers new insights by embedding it within the EADR process model to empirically assess the adoption of new designs. The results indicated that both the technological and organisational contexts positively influenced SMEs' willingness to use the digital platform.

In summary, the study's findings provided valuable insights into contextualising the design of digital sharing economy platforms through the EADR process model. This process model proved instrumental in conducting comprehensive investigations and incorporating diverse ideas, theories, and practices that were relevant to the research problem at hand.

5 LIMITATIONS

The study does have certain limitations that should be acknowledged. Firstly, the focus on understanding design requirements solely based on existing SMEs' sharing practices may have restricted the exploration of potential new sharing models derived from international best practices. This limitation suggests that there could be missed opportunities to introduce innovative sharing approaches that could benefit SMEs in resource-constrained countries.

Additionally, it is important to recognise the limitations of solely assessing the acceptance of the designed digital platform based on users' use intention. By solely relying on this measure, the study overlooks the indirect network effects that are often associated with digital platforms. These effects, such as the number of users on the platform, play a crucial role in shaping its overall quality and success. Therefore, it is essential to consider these indirect network effects when evaluating the acceptance and effectiveness of the designed digital platform. By incorporating a holistic assessment approach, researchers can gain a more comprehensive understanding of the platform's impact and potential for success.

Based on the limitations identified, the study recommends expanding future research to explore innovative sharing models from international best practices that could benefit SMEs in resource-constrained countries. It also highlights the importance of incorporating indirect network effects when assessing digital platform acceptance, advocating for a holistic evaluation that includes both qualitative and quantitative measures. Finally, engaging diverse stakeholders in the design process is recommended, as this can enhance the platform's relevance and usability, ultimately improving its effectiveness for SMEs.

6 CONCLUSION

This study explored the design of a digital sharing economy platform tailored for SMEs in resource-constrained countries, specifically focusing on Ethiopian local sharing practices. Employing the Elaborated Action Design Research (EADR) methodology, the research encompassed diagnosis, design, implementation, and evolution cycles. The findings revealed critical activities and goals in local sharing, leading to the development of a platform architecture that incorporates 13 innovative sharing models. The implementation phase demonstrated practical realisations of the platform, while the evolution phase indicated positive initial acceptance driven by technological and organisational factors. Overall, this study contributes a replicable methodology for designing context-specific digital sharing platforms and highlights policy implications that can guide interventions to support the digital transformation of SMEs, ultimately enhancing their competitiveness in the digital economy.

7 CONTRIBUTIONS

In practical terms, this study presents a replicable methodology for designing digital sharing platforms that can be tailored to specific local contexts. A key focus is placed on identifying core design aspects such as purpose, boundaries, components, structure/organisation, and contexts, which can be adapted to fit local requirements. By utilising Activity Theory (AT),

the study effectively investigates and understands local sharing practices, providing valuable insights to inform the design requirements of digital sharing economy platforms.

In terms of policy implications, the study identifies key areas where policymakers can intervene to facilitate the digital transformation of SMEs. By understanding the essential sharing areas highlighted in the study, policymakers can focus their efforts on supporting and promoting the development of digital sharing economy platforms within these specific domains. This insight can help policymakers shape policies and initiatives that foster the adoption and utilisation of digital platforms, ultimately empowering SMEs in their digital journey.

In summary, the study's contributions to the practice of IS and policy of digital transformation. The methodology it offers for investigating local sharing activities and designing digital platforms can guide practitioners in the field. Policymakers can leverage the study's insights to identify areas for intervention and support in the digital transformation of SMEs.

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The use of detective analytics for mitigating financial crimes: A South African perspective

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ABSTRACT
South African organisations are increasingly exploring the use of detective analytics in mitigating financial crimes. However, many organisations are struggling with how to employ the tool in detecting and preventing financial crimes. This study aimed to conceptualise how detective analytics can be used to mitigate financial crimes in organisations. Qualitative data were gathered from different sources, from peer-reviewed to grey literature. Actor-network theory (ANT) was employed as a lens, through its mantra 'follow the actors', to gain insights on how activities can be identified, traced, and tracked, in mitigating financial crime in institutions. The interpretive approach was applied. The findings revealed seamless integration of incidents, cybersecurity detection, in-house fraud detection, external infiltrate detection, and image-matching data into one cohesive system. The study highlights the need for gaining a deeper understanding of networks of actors, following the actors, and obligatory passage points within an organisation. The findings have significant implications for improving the efficiency and effectiveness of the use of detective analytics, from both technical and non-technical perspectives.

Keywords Actor-network theory, Detective analytics, Financial crime

Categories • **Information systems** ∼ **Cross-computing tools and techniques, Design**

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1 INTRODUCTION

Financial institutions play a very vital role in the economy of any country. Financial institutions include banking agencies that assist individuals and organisations with carrying out transactions at both national and international levels (Cole, 2023). The transactions include the exchanging of forex and assets, from small to large volumes (Sunio & Mendejar, 2022). Some of the transactions have severe implications and consequences for the actors or the representing agents involved. For example, when a transaction goes wrong on a large scale, an entire organisation can be declared liquidated, which affects the livelihoods of the employees and others connected with the organisation. It is therefore critical, to always guide against

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the transactions by being precautionary with the enabling facets, primarily, which are people, data, and technology.

Financial institutions rely on data for the processing of millions of transactions daily (Hasan & Rizvi, 2022). The data is enabled and supported using information technology (IT) solutions (Bataev, 2018). Furthermore, the manipulation, use and management of the data and IT solutions are carried out by people (Andrade-Rojas et al., 2024). Thus, financial institutions continue to build the security and protection of their assets and finances around these three facets. Financial institutions analyse data, to gain a better understanding and make better financial decisions and help prevent processing of suspicious transactions (Li et al., 2020). Despite the preventative, detective, precautionary and security measures, processes, and transactions are often in danger because of fraudulent activities, from unprecedented circumstances (Yamen et al., 2019). Some of the activities are from internal and external entities and agents including humans' actions, consciously or unconsciously.

In the last ten years, South Africa has been one of the most hit countries in the world by financial crime (Kempen, 2020). It is argued that financial crime is double in low-income countries than it is in high-income countries (Achim et al., 2021). This could be attributed to the sophistication of preventative, detective, and other security measures in high-income countries, using IT solutions. Some financial crimes are detected by financial institutions (Gombiro et al., 2015). However, there are loopholes in the current methods and approaches, hence, the rate of financial crime in South Africa is increasing (Macdonald, 2019). Thus, a different mechanism is required, to advance protection and security against financial crime in the country. This should allow and enable early detection of the crime before and as it happens, using the most appropriate mechanism such as detective analytics.

Detective analytics is classified in the group of data analytics, which includes diagnostics: descriptive, predictive, and prescriptive (Vanani & Shaabani, 2021). Data analytics are widely used to combat financial crimes and the most used analytics are predictive, prescriptive, and detective analytics (Menezes et al., 2019). Although there is closeness and a bit of overlap among the analytics tools (Lee et al., 2022), detective analytics uniquely focuses on identifying a problem in data, as and when it occurs (Poornima & Pushpalatha, 2020). In its advancement, detective analytics focuses on performing diagnostics on big data and small data (normal), uncovers and rectifies infeasible events including occurrences (Aliguliyev et al., 2016; Empl & Pernul, 2023). The few organisations that are using detective analytics do so because it is considered advanced analytics (Al-Banna et al., 2023; Menezes et al., 2022).

However, there remain two fundamental issues. Firstly, not many financial institutions use or know how to fully utilise the capabilities of detective analytics (Liu et al., 2021). Secondly, despite its advancement, challenges persist. Thus, the research objective is to gain a deeper understanding on how detective analytics can be applied to mitigate financial crimes in organisations. This prompts the research question, which is: *How can detective analytics be employed for mitigating financial crimes in organisations?* Actor-network theory (ANT) was employed as a lens, to examine human and non-human roles in applying detective analytics, to trace, track, and prevent financial crime in financial organisations.

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This paper is organised into six main sections. The first and second sections introduce and problematise the study, respectively. A review of the literature focusing on the core aspects of the study is presented in the third section. In the fourth, the theory, ANT that underpins the study is discussed. The methodology applied in the study is covered in the fifth section. The analysis and discussion are presented in the sixth section. A conclusion is drawn in the final section.

2 PROBLEMATISING THE STUDY

Like many organisations, financial institutions depend on data for their strategic and operational activities. Unfortunately, the data includes processes which are continually infiltrated or manipulated, consciously by actors in criminal activities, and unconsciously by human errors (Akinbowale et al., 2020). Some of these crimes are so severe that the organisation is affected and may shut down, which inevitably has an impact on the livelihood of employees. Thus, institutions are constantly exploring and employing tools and approaches to mitigate financial crimes, which is prohibitive to business continuity. Thus, IT solutions are increasingly relied upon for remedy.

Despite the IT security solutions and preventative tools such as the Financial Intelligence Centre Act (FICA), 2001 (Republic of South Africa [RSA], 2001); Banks Act, 1990 (RSA, 1990); and Inspection of Financial Institutions Act, 1998 (RSA, 1998) that have been deployed in layers, for mitigation purposes, financial crimes are on the increase in South Africa (Chitimira & Ncube, 2021; Sutherland, 2017). Economic crime remains significantly higher than the global average rate of 49% (Thomson, 2024; White, 2018). Consequently, many institutions continue to lose income to criminal activities, which affects their sustainability and competitiveness. Another negative effect is that the affected institutions suffer reputation damage, which takes considerable time to recover from (Kshetri, 2019). These highlighted problems derail economic development and growth and affect individuals' job security in the country. Thus, it is critical to find a fresh and more sophisticated solution to mitigating financial crimes for South African institutions.

3 LITERATURE REVIEW

3.1 Financial crime in institutions

Most financial institutions rely on data, and the growth of data is drastic throughout the whole world (Bataev, 2018). Hundreds of millions of financial transactions occur in financial institutions each day and all these transactions lead to data creation (Hasan & Rizvi, 2022). In this age of innovation and machine learning, data is seen as one of the most vital contributors in decision-making for most financial institutions. Consequently, financial institutions have been targets for financial crimes both internally and externally (Yamen et al., 2019). Internally by individuals who have access to transaction data and externally by individuals or organisations

that target specific individuals' information to commit financial crimes. Financial institutions have seen a high rise in financial crimes over the past ten years which negatively impacts the development and reliability of information systems (Hope, 2020). Financial crime is double in low-income countries compared with high-income countries (Achim et al., 2021). South Africa has been one of the leading countries exposed to financial crime (Kempen, 2020).

Financial crime is a widespread problem and has been reported to be very aggressive in African countries due to the high rate of poverty. The economic development minister in South Africa has claimed that over 76000 jobs are lost every year due to financial crime (Hope, 2020). The South African government has tried their best to implement strategies to combat crime in general and these strategies also include the regulation of laws relating to financial crime (De Koker, 2007; Kshetri, 2019). Activities of financial crime seem to be increasing in South Africa. In recent years many financial institutions in South Africa have experienced an increased rate of financial crimes due to the high demand for online transactions (van Niekerk, 2017). Notwithstanding the mitigating approaches implemented by some institutions, technological enhancements are used to commit many financial crimes (Coetzee, 2018).

3.2 Detective analytics

The use of data analytics has grown exponentially in the financial sector (Cockcroft & Russell, 2018). This can be attributed to its strengths of accurate reporting, cost reduction, enhanced decision making and operational benefits. Data analytics in the financial sector creates opportunities to advance financial management for both customers and organisations (Giebe et al., 2019; Nobanee, 2021). With advances in solutions, most financial problems that exist can be solved by examining the available data, which can be done using data analytics (Andriosopoulos et al., 2019). However, some researchers argue that the advancement of data analytics in the financial sector has not been thoroughly explored (López-Robles et al., 2019). The most explored data analytics methods in the financial sector are descriptive analytics, diagnostic analytics, predictive analytics and prescriptive analytics. However, detective analytics has little to no research conducted in finance literature.

Detective analytics focuses on the analytics (or analysis) of data, like other tools such as descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics. Descriptive analytics is used to understand what has occurred in the past using historical data (Janakiraman & Ayyanathan, 2022). While diagnostic analytics focuses on historical data, to gain a deeper understanding of the reason behind certain outcomes (Balali et al., 2020), hence it was mostly used to build insights into why certain events occurred in the way they do (Deshpande et al., 2019). Predictive analytics is used to determine patterns and themes to understand what could happen in the future (Jeble et al., 2018; Selvan & Balasundaram, 2021). From an organisation's perspective, to predict is to forecast a problem or a solution (De Jesús Liriano & Sevillano, 2019).

For many years, financial institutions have been using data analytics to derive patterns that lead to financial criminal activities (Andriosopoulos et al., 2019; Köseoğlu et al., 2022).

Data analytics help to collect relevant data, and to access and integrate the data in providing reports of deeper insights into business operations and productions (Fosso Wamba, 2017). Thus, like other sectors, the use of data analytics has enhanced and enabled the financial sector to make better decisions (Ranjan & Jeyanthi, 2020). Increasingly, many organisations can use data analytics, to explore and visualise data to a simple representation that can be easily understood by both users and managers (Hoang & Bui, 2023).

Despite the benefits that data analytics offers organisations, the financial sector continues to experience an increase in financial crimes (Holzenthal, 2017; Yeoh, 2019). Detective analytics is used to diagnose and detect a problem immediately as and when the problem occurs (Vanani & Majidian, 2021). However, not many financial institutions use or know how to fully utilise the capabilities of detective analytics (Liu et al., 2021). Therefore, detective analytics should be critically explored in the financial sector to help combat criminal activities within the institutions.

Among other things, detective analytics is used by organisations, to detect fraudulent activities (Abdallah et al., 2016). To detect means to discover and identify a problem before it occurs. The use of detective analytics is not only advantageous for future purposes but could also be used to detect traces and track incidents using historical data (Sun et al., 2011). Detective analytics is often described as the combination of predictive analytics and prescriptive analytics in the sense that it forecasts and recommends solutions to problems as and when they occur (Menezes et al., 2019). Fraud detection is used mostly to detect unknowns and known unknowns (Thornton et al., 2013). This makes detective analytics critical for organisations. Corroboratively, there seems to be an emphasis on the need for financial institutions to adopt effective fraud detection techniques such as detective analytics to reduce the number of fraud instances. The use of detective analytics is a needed mechanism for financial institutions due to most processes being data-driven (West & Bhattacharya, 2016).

4 UNDERPINNING THEORY

This study is underpinned by a sociotechnical theory, actor-network theory (ANT). The theory is selected to underpin the study based on three main reasons. Firstly, the nature of the study requires a sociotechnical view because, from technology alone, the challenges remain with the phenomenon. Secondly, in financial fraudulent activities, negotiations occur between humans, technologies, or humans and technology actors. One of the main focuses of ANT is understanding negotiation shifts among actors, consciously or unconsciously (Callon, 1986). Thirdly, the mantra ‘follow the actors’ of the theory helps to connect (or link) non-humans (activities) with humans through rules and networks including the tools used.

The complementarity of ANT and detective analytics bridges any possible gap, either in the analysis of the data or interpretation of the findings. A comprehensive justification and a guide for complementarily employing theories have been provided in the literature (Iyamu, 2021).

The ANT is a sociotechnical theory that is used by researchers to explain the relationship

between humans and non-human objects (Iyamu, 2024). There are further explanations on how and why ANT mostly focuses on the formation of networks, the relationship between actors, and shifting negotiation within the actor-network (Sage et al., 2011). This helps to understand how human and non-human actors are involved in an activity or incident (Gao, 2005). An actor-network is formed immediately when the actors have aligned interests (Walsham, 1997), and the actor-networks are formed consciously or unconsciously, based on common understanding (Latour, 1996). In summation, the theory focuses on how networks are built and maintained including what makes the network dissolve (Michael, 2017; Shim & Shin, 2016).

Applying ANT allows the researcher to follow the actors in their heterogeneous networks. This is because the theory offers methodological steps in the activities, actions, and interactions between actors in a network (Callon, 1986; Heeks & Stanforth, 2015). "ANT provides a platform which allows for the analysis of both human and non-human interaction in a network" (Iyamu, 2021, p. 73). This means that ANT is a resource for understanding the actions of humans. Congruently, a researcher can draw on ANT to trace information pathways that enable humans to access actions and connect with needed resources (Lefkowitz, 2022). Thus, ANT was employed to provide an underutilised post-humanist lens to understand the creation of collaborative connections between action-based interactions (Kumar & Tissenbaum, 2022).

Another strength of ANT that is critically useful in this study is the concept of translation. The translation in ANT is the process of creating a relationship with things, which did not exist, previously (Lezaun, 2017). Translation occurs when the human actors' interests are aligned with their actor-network (Walsham, 1997). The use of ANT has gained popularity in areas of IS research, in areas such as the adoption of technology, examination of healthcare systems and assessment of IT solutions that support and enable engineering, finance and education activities. Also, ANT is increasingly applied to gain a deeper understanding of processes and innovation of technology (Shim & Shin, 2016).

5 METHODOLOGICAL APPROACH

Based on the focus of the study, the qualitative method was employed. This is because the qualitative method allows an in-depth understanding of the phenomenon being studied (Morgan, 2022). Such understanding is achieved because it allows subjective reasoning and views of the data (Akyildiz & Ahmed, 2021). Additionally, a qualitative method is described as a method that enables an understanding of the factors influencing human behaviours and attitudes in a setting (Iyamu, 2024).

This allows the many realities about human behaviour including events and technology to be explored. The events and realities of this study are the existence of financial institutions, financial crimes, and detective analytics. Ontologically, detective analytics is understood and viewed from different perspectives. For example, detective analytics was used with the Internet of Things (IoT) to generate new insights (Empl & Pernul, 2023). Another reality is that detective analytics has been used to obtain accurate predictions by organisations (Menezes

et al., 2019). Also, there are various ways or approaches to the implementation or adoption of detective analytics. This includes the use of frameworks, policies, and models, some of which have been applied by organisations across the world (Broeders et al., 2017).

Existing materials (documents) were gathered using the document analysis technique. The technique allows the rationalisation of available literature, in the forms of books, newspaper articles, peer-reviewed articles, and technical reports (Morgan, 2022). The data were collected using a set of criteria, to ensure appropriateness. As shown in Table 1, the criteria consist of three groupings:

i. areas of focus,

ii. publication dates, and

iii. credible sources.

Each of the groups was further categorised. The areas of focus include crime in financial institutions, detective analytics and ANT, which are the core aspects of the study. The publication dates were vita, to imbibe context and relevance. Thus, articles published within ten years were considered, to gain insights into critical aspects such as the historical background and meanings associated with the phenomenon over time (Iyamu et al., 2016). For credibility purposes, the concentration was on peer-reviewed articles. Based on the newness of detective analytics, we could only gather a small-sized collection of literature that was most appropriate and relevant to the study. This type of circumstance is not new as it has been experienced and argued in many IS studies (Nyikana & Iyamu, 2023).

Materials published in journals, books, conference proceedings and the internet between 2013 and 2023 were gathered. A total of 255 articles were collected from databases such as Ebscohost, IEEE, AIS, and Emerald. The databases were used as sources because they host many computing articles and instil credibility and reliability in the data (Nyikana & Iyamu, 2023). Based on the focus and objective of the study, only 77 papers were relevant and used for the study. Table 1 presents a sample of the papers.

Guided by the objective of the study, which was to gain an understanding of how detective analytics can be applied to mitigate financial crimes in organisations, the data were processed, and meanings were associated in the context of the study. ANT was employed as a lens in the analysis of the data, to gain deeper insights into mitigating financial crimes in organisations. The analysis focuses on three fundamental areas:

i. to advance an understanding of evidence in the literature on how humans interact with systems and processes that are obligatory to commit financial crimes;

ii. by following the actors, to gain insights on how actor-networks are formed, consciously or unintended, that lead to financial crimes; and

iii. a better understanding of actors' relationships and how they interact in committing financial crimes in organisations.

Table 1: Data classification

Focus	Source		Type
Crime in financial institutions	The impact of national culture on financial crime	(Yamen et al., 2019)	Journal
	Channels of corruption in Africa: analytical review of trends in financial crimes	(Hope, 2020)	Journal
	Does technology matter for combating economic and financial crime? A panel data study	(Achim et al., 2021)	Journal
	The world of private investigators in South Africa	(Kempen, 2020)	Journal
	Financial crime in South Africa	(De Koker, 2007)	Journal
Detective analytics	Digital Transformation: Utilization of Analytics and Machine Learning in Smart Manufacturing	(Vanani & Shaabani, 2021)	Book chapter
	Fraud detection system: A survey	(Abdallah et al., 2016)	Journal
	Gross error detection and data reconciliation using historical data	(Sun et al., 2011)	Journal
	Predictive, prescriptive, and detective analytics for smart manufacturing in the information age	(Menezes et al., 2019)	Journal
	Intelligent financial fraud detection: a comprehensive review	(West & Bhattacharya, 2016)	Journal
Actor-network theory	Actor-network theory: Trial, trails, and translations	(Kumar & Tissenbaum, 2022)	Book chapter
	How actor-network theories can help in understanding project complexities	(Sage et al., 2011)	Journal
	Using actor-network theory to analyse strategy formulation	(Gao, 2005)	Journal
	Actor-network theory and IS research: current status and future prospects	(Walsham, 1997)	Conference proceedings
	On actor-network theory: A few clarifications	(Latour, 1996)	Journal
	Applying theories for information systems research	(Iyamu, 2021)	Book chapter

6 DATA ANALYSIS

As presented in the section that follows including Table 2 ANT is used to gain an understanding of how networks of actors (humans and non-humans) can be linked together in a crime-related event. This is primarily because ANT proposes and allows actors to be followed, to establish their roles in the processes and activities in finance transactions within an organisation. Table 2 reveals how ANT helps to gain a deeper understanding of the relationship that exists between the actors in the process of executing financial transactions. This includes committing a financial crime or attempting to mitigate the financial crime. In Table 3, the implications of the factors are explained. This includes how activities of financial transactions are connected and lead to crime.

From ANT, a social context perspective, five factors were found to be crucial points in

Table 2: Findings from the analysis

ANT Tenet	ANT Translative view	Factor
Actor-network	Detective analytics integrates multiple operations, scales, scenarios, and layers (Al-Banna et al., 2023). The multiplexity consists of actor-networks, of humans and non-humans. Both humans and non-humans are interwoven, which means that they cannot be separated. For example, humans and non-humans play roles for a financial transaction to occur. The actor-networks leverage automation of processes based on centralised data, to detect crime patterns across enterprise-wide.	Seamlessly integrates incident
Follow the actors	Detective analytics enacts real-time and offline operations, in detecting compromising incidents. Also, detective analytics generates new insights as non-human actors transform. From a cybersecurity perspective, some non-human actors commonly transform are signatures, processes, and rules (Empl & Pernul, 2023). The operations link various compromises to an incident by following the actors. This enhances the power to connect disparate data across an enterprise.	Cybersecurity detection
Obligatory passage points	The concept of obligatory passage point (OPP) infuses tacit knowledge into members of a unit (an actor-network), to maintain a common translation of fraud-related actions and gain a better understanding. OPP is used to facilitate and filter the appropriateness of action that is congruent with the agreed goals. The OPP is the result of "translations", in which the actors have no choice but to accept the dedicates (Callon, 1986). It is thus, an essential glue that brings together various links, in mitigating financial crimes. Thus, OPP brings a different dimension that reveals the roles and identities including recognition of the actors. The translation of obligated processes and rules are required, in following the actors (Latour, 1996). This is a crucial dynamic in the use of detective analytics for the diagnosis of evens, to induce consistency and accuracy.	In-house fraud detection
Black box	By following the actors, it can lead to opening a black box, to gain new insights. Transaction of the new insights leads to discovering of the links and interactions between human and non-human actors, in a financial transaction. Following the actors over time and across a multitude is an important means of analysis, to gain insights. Also, opening the black boxes and examining the ontology of the actor-networks can lead to the construction of new dynamics.	External infiltrate detection
Actor-network	Detective analytics expands the accuracy capability of IT solutions. Detective analytics induces a level of preciseness in its operations on veracity, volume, variety, and velocity of data (Menezes et al., 2022). It advances detective analytics to detect inconsistencies including image recognition in big data and small data.	Image-matching data into one cohesive system

following the actors to mitigate financial crime in an organisation. The factors are:

i. Seamless integration of incidents,

ii. Cybersecurity detection,

iii. In-house fraud detection,

iv. External infiltrate detection, and

v. Image-matching data into one cohesive system.

The discussion that follows should be read with Tables 2 and 3, to gain a better understanding.

Table 3: Implication of the study

Factor	Technical	Non-technical
Seamlessly integrates incident	It enables the automation of processes and resolves fragmentations. Also, it enables the synchronisation of processes in following the actors. By doing so, it removes manual monitoring and reactive response to fraudulent incidents.	Distinction of actors' roles and defining the communication channel within the structure of the environment. Incident management must be enabled using automated processes, to actively remediate reported incidents.
In-house fraud detection	It must promulgate a policy that allows connectivity to enable and support the centralisation of systems and processes. Thus, the detective approach can enable enterprise-wide and connect processes and databases.	Employees and relevant authorities must understand how to follow the actors. Thus, operations and investigations of fraudulent transactions and activities can be fortified. Requirements must be defined and used to follow.
Cybersecurity detection	Cyber activities involve nodes and networks of actors. Thus, it requires an understanding of the fundamentals of detecting and responding to cybersecurity incidents by following the actors.	Employees and relevant authorities must understand how to link activities and associated events. Therefore, documentation and reporting of cybersecurity incidents require a special approach for communicating security breaches.
External infiltrate detection	Employs tools for tracing external links that explore internal leaks. Response time finds millions of link connections per second and minute.	Social engineering attacks are human interactions used to manipulate security procedures. A process must be developed to mitigate this activity.
Image-matching data into one cohesive system	Following the actors early enough helps to detect when an actor transforms or impersonates himself or herself. Cohesiveness increases accuracy through its integrated approach to fraud prevention.	It requires the configuration of rules and intents within an organisation. Fraud categorisation-based rules help to ease processing and anomaly detection.

7 DISCUSSION OF THE FINDINGS

The factors revealed from the analysis: Seamless integration of incidents, Cybersecurity detection, In-house fraud detection, External infiltrate detection, and Image-matching data into one cohesive system are interrelated in committing or detecting financial crimes in organisations. Seamless integration refers to the smooth and efficient connection between processes and computer technology such as detective analytics. Seamless integration of technology has been demonstrated to eliminate insertion and mismatch of incidents, from internal and external intrusion to image matching. Cybersecurity detection is an aspect of IT solutions focusing on activities including images in cyberspace. The solution is intended to detect and recognise fraudulent activities as they occur within an organisation (Abdallah et al., 2016). Financial cybercrime could be orchestrated from in-house or externally. In-house fraud detection discovers and identifies fraudulent financial activities within an organisation. The detection system is used to follow and trace actors' financial activities as they try to enter an organisation's space and commit a crime.

Correspondingly, some activities and actions involved unregulated and unprecedented movements. Consequently, organisations are increasingly employing detective analytics to manage and promote their business efficacy (Iyamu, 2022). However, it is challenging to identify some hidden characters that manifest in many environments. Thus, the analysis of fraudulent or suspected incidents should not follow a fixed process. In our attempt to gain a

deeper understanding of how to employ detective analytics in the qualitative world for analysis purposes, we focus on the notion of 'actor-network', 'follow the actors', 'obligatory passage point' (OPP), and black box from ANT perspective.

Relationships between actors, humans and non-humans are informed by processes of association and translation that can be "material as well as social, physical as well as semiotic" (Michael, 2017, p. 41). ANT's mantra is "to follow the actors" (Boodhun & Jayabalan, 2018, p. 12) that are not exclusively human but non-human parts of interactions within networks. Actor-networks need to be unfolded, and the inherent black boxes offer insights into their ontologies and allow detailed accounts of these inner workings . The OPP characterises the dynamic convergence of the processes of network constitution and highlights crucial participatory roles and identities of various actors (Minniti & Magaudda, 2024).

Detective analytics focuses on performing the diagnostics on big data and small data (normal), uncovers and rectifies infeasible events and occurrences (Aliguliyev et al., 2016; Empl & Pernul, 2023). From this standpoint, OPP, in a detective analytics operation, helps to gain insights about actors' roles in activity by recognising their identities, how they transformed, and consolidating their alignments. Also, ANT proposes a relational ontology, to gain a deeper understanding of networks and existing syntax as enactments of associations between actors, human and non-human.

The syntax is discovered as we follow the actors . Complementarily, using detective analytics, explicitly, ensures the timeliness, consistency, and integration of big data, in recognising activities and traces of events in an environment (Menezes et al., 2022). In detective analytics, constraints are reduced, and the diagnosis eliminates and rectifies inappropriate values.

Across the world, governments of countries are trying various approaches to combat financial crimes in financial institutions. Yet, the situation has not eased, instead, it has increased. Revealed in the literature, there is evidence of financial crimes and it is argued that until corruption channels such as embezzlement, theft, bribes, kickbacks, money laundering, and illicit financial flow are thoroughly, investigated financial crime will continue to increase (Hope, 2020). The approach, "follow the actor" is consistently useful, as it spears the traces of the minds, processes, and occurrences, towards a fundamentally constructive decision. Among other things, this provides nuance and an in-depth assessment of the interrelatedness that exists between human actors and non-human actants along with their translation and participatory power. In 2021, during the lockdown caused by COVID-19, which resulted in more reliance on online transactions, financial crime in South Africa increased by 15.1%.

The perpetrators of financial crimes in organisations are either internal or external personnel. From the internal perspective, the crimes are usually intended or unconscious (human error) by employees who have access to internal procedures and data, while the external factors include fraudsters, phishing, and money laundering. The increase in financial crime is due to the emerging technologies that institutions adopt to enhance processes (West & Bhattacharya, 2016). Thus, there is a need to explore how the use of detective analytics as a mechanism can be used to detect financial crime.

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8 IMPLICATION OF THE STUDY

The factors that manifest from using ANT to examine the use of detective analytics are Seamless integration of incidents, In-house fraud detection, Cybersecurity detection; External infiltrate detection; and Image-matching data into one cohesive system. Each of the factors has both technical and non-technical implications, as tabulated in Table 3. Fundamentally, the implication can provide guidelines on how humans interpret and apply rules in carrying out financial transactions in an organisation. This includes how detective analytics integrate with other tools or systems, to mitigate financial crime.

9 CONTRIBUTION OF THE STUDY

This study is intended to serve as a comprehensive work and extend detective analytics for mitigating financial crimes, in the literature. This study focuses on articles published between 2013 and 2023. In lieu of the other studies on detective analytics available thus far in the literature, this study makes the following three main contributions:

i. It adds to the literature on detective analytics by providing a nuanced perspective on mitigating financial crimes, from both business and IT perspectives.

ii. It demonstrates the advancement of ANT, in gaining a better understanding of complex organisational phenomena.

iii. It reveals the need for a continual comprehensive investigation of advances in detecting and mitigating financial crimes in organisations. It thus suggests that organisations need to focus on advancing detection capability.

10 CONCLUSION

This study highlights the critical challenges faced by organisations in mitigating financial crime due to the constraint of following the actors. The findings reveal that Seamless integration of incidents, Cybersecurity detection, In-house fraud detection, External infiltrate detection, and Image-matching data into one cohesive system are major barriers to effectively mitigating financial crime in organisations. An understanding of these factors has the potential to address these challenges. However, the implementation of detective analytics would require significant efforts in terms of understanding the implications from both technical and non-technical perspectives. Nonetheless, the study also has some limitations, such as the focus on a non-empirical or case study approach. Future research should aim to validate the findings in organisational settings and explore the feasibility and impact of implementing detective analytics in a financial institution.

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Research Article

An investigation into the feasibility of using virtual environments as an induction method in SHIP® therapy

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ABSTRACT
Virtual reality contributes to the successful treatment of patients by assisting those who have difficulty with the process of imagining the required visual images needed during psychotherapy. SHIP® is a form of psychotherapy that suggests that spontaneous healing is a natural tendency that emerges from within a person. It identifies certain activator images as essential pathways for accessing unconscious trauma material that needs healing. The purpose of this study was to examine whether virtual reality can be used as a medium to induce memories through the utilisation of neutral images based on the SHIP® Frame. Two groups of participants were gathered: one group underwent a traditional SHIP® session while the other group underwent the virtual induction with the aid of a head mounted display. A random clinical trial was used to determine the level of induction and identify the helpful aspects that contributed to the induction. The results indicated that virtual reality was able to assist as a cognitive stimulus as well as a cognitive proxy in the overall process of SHIP®.

Keywords virtual reality, psychotherapy, exposure therapy, virtual environment, SHIP®

Categories • **Human-centred computing** ∼ **Human computer interaction** • *Applied computing* ∼ *Life and medical sciences*

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1 INTRODUCTION

Exposure therapy (ET) and spontaneous healing intra-systemic process (SHIP®) are both psychotherapeutic methods that are effective in treating individuals for various psychological disorders and/or trauma-spectrum manifestations (TSMs) (Bryant et al., 2019; Levinson et al., 2020; Steenkamp, 2018). If the patient is unable to visualise what the therapist requests them to, the treatment may be less effective, or it might not succeed at all (Friedrich, 2016; Steenkamp, 2018). Virtual reality (VR) could provide a solution to this problem by helping a patient see the requested stimuli.

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VR has already contributed to the successful treatment of psychotherapeutic patients when used in tandem with exposure therapy (Donker et al., 2019; Hodges et al., 1995). This success can be partly attributed to VR's ability to simulate virtual environments (VEs) within which to immerse patients (Vienne et al., 2020). This enables the user to feel present or have the sense of 'being there' (Høeg et al., 2021; Riva, 2022) which makes it a useful tool for psychotherapy, particularly in exposure-based treatments (Albakri et al., 2022; Wilson & Soranzo, 2015). However, exposure therapy and, by extension, virtual reality exposure therapy (VRET) are both based on systematic desensitisation therapy (Markowitz & Fanselow, 2020) and many post-traumatic stress disorder (PTSD) patients still do not benefit from it (Foa & Mclean, 2015; Markowitz & Fanselow, 2020). Another PTSD treatment method, SHIP®, differs from this approach and attempts to heal the client through completing a frozen traumatic memory (Steenkamp, 2018).

In the realm of VR as a psychotherapeutic tool, research tends to focus on VR exposure therapy and not on other forms of treatment. Through a random clinical trial (RCT) (Hariton & Locascio, 2018) this study attempteds to address this by investigating the efficacy of VR induction as a medium for facilitating the SHIP® process. By comparing two groups, where one underwent a standard SHIP® intervention and the other a VR intervention, data were collected and analysed to determine if the VR intervention was as assistive to the overall SHIP® process as the standard intervention. The analysis of the data was used to answer one main research question:

> *How can a simulated virtual environment stimulate and enhance the participant's image-creative neural-visual facility – i.e. the participant's imagination – to assist participants who find it difficult to imagine the requested images in SHIP®?*

The remainder of this paper answers the above research question through literature and empirical data to determine whether VR can be used in tandem with SHIP® to assist clients who have difficulty with imagining requested visual stimuli.

2 REVIEW OF LITERATURE

VR aims to create environments and situations that resemble reality or any fictitious reality (Albakri et al., 2022) and generate an experience that is immersive and that feels as engaging as reality when an individual is placed within it (Garrett et al., 2018). A VR experience can be understood with reference to Sherman and Craig's (2003) four main factors of a VR experience, with the addition of Muhanna's (2015) fifth, and are as follows:

1. Virtual world: The environment simulated through computer software (Albakri et al., 2022).
2. Sensory feedback: Input and output devices such as headphones and controllers (de Regt et al., 2020).

3. Interactivity: Having the ability to change a virtual world through manipulating it, such as picking up objects or turning them around (Muhanna, 2015; Sherman & Craig, 2003).
4. Participants: Having at least one person being present in the virtual environment and experiencing it (Muhanna, 2015).
5. Immersion: An objective account of its ability to simulate reality with high levels of fidelity (Wilson & Soranzo, 2015).

Because of the importance of immersion and how it is often confused with presence, it will be discussed in the next section in more detail.

2.1 Immersion and presence

When VR is able to supplant a user's senses with the sensory stimuli of a simulated world and metaphorically remove users from the real world, the VR is considered to be immersive (Riva, 2022). Immersion within a virtual world has been described in several ways, including system immersion (Lønne et al., 2023), mental immersion, physical immersion (Albakri et al., 2022; Sherman & Craig, 2003), and narrative immersion (Nilsson et al., 2016). Immersion can be quantified to a large extent and altered with regards to the level to which a user can explore the virtual world, how realistic it appears, and more technical aspects such as graphic frame rate (Kelly et al., 2023). Presence, on the other hand, comes from the degree to which an individual can respond naturally to the VE (Kober et al., 2012; Slater et al., 2009; Wilson & Soranzo, 2015) and makes the user feel like they are "there" in reality (Albakri et al., 2022; Botella et al., 2017; Wilson & Soranzo, 2015). The psychological response of a user to a simulated environment can be seen as the perceived presence by the user (Kelly et al., 2023; Slater et al., 2009; Wilson & Soranzo, 2015) and differs from immersion (Slater et al., 2009). In other words, depending on the user's specific state of mind, as well as other factors, different users might experience the same degree of immersion but not the same degree of presence within a VE (Slater et al., 2009; Wilson & Soranzo, 2015). If a user is self-aware within a VE and able to respond and manipulate their surroundings, they should be considered to be highly present within the VE (Kelly et al., 2023). Although immersion and presence differ from one another, a recent study suggests that immersive VR was more successful in instilling a sense of presence within learners than desktop VR because the participants felt as if they were *"actually there"* in the VE (Lønne et al., 2023).

VR generates a simulated environment within which a user can explore and interact as if it were the real world, forecasting the sensory inputs and experiences one might receive in reality (Riva et al., 2019). This is similar to predictive coding, a popular framework for comprehending how messages are passed around in our brains (Friston, 2012). The feeling of presence or "being there" is the characteristic that separates VR from other traditional media (Garrett et al., 2018; Høeg et al., 2021; Riva, 2022; Rizzo et al., 2015) and can help psychology in many different ways such as exposing a veteran who suffers from PTSD to a traumatic event in a safe and controlled environment (Albakri et al., 2022; Friedrich, 2016).

2.2 Virtual reality exposure therapy (VRET)

Exposure therapy, which is a particular form of cognitive behavioural therapy (CBT), is a psychotherapeutic treatment that has been proven to be effective in the treatment of various psychological disorders (Levinson et al., 2020; Olatunji et al., 2010; Opriş et al., 2012) and PTSD (Bryant et al., 2019). Exposure therapy focuses on changing pathological fear structures by repeatedly confronting the patient with the stimuli that trigger these fear structures and incorporating information that goes directly against the pathological elements inside the fear structure (Rauch & Foa, 2006). This is achieved either through real-life in vivo exposure, where the patient is immersed in real life within the environment that first caused the trauma (if possible), or imaginal exposure, where a patient imagines the events where fear and trauma are experienced (Friedrich, 2016). There are some shortfalls to exposure therapy (Beidel et al., 2019) such as some patients having difficulty with the process of imagining traumatic events (Friedrich, 2016) which motivates other approaches such as virtual reality exposure therapy (VRET) where the feared stimuli are generated through moving imagery, sounds, and sometimes through simulating other senses such as smell within VR (Eshuis et al., 2021). VRET offers an alternative to traditional exposure therapy, and has shown greater success in treating patients with PTSD who did not respond to prior therapies (Volovik et al., 2023).

VRET systems have been as successful as in vivo therapy in the treatment of various phobias (Donker et al., 2019; Suied et al., 2013), and PTSD in veterans of war (Volovik et al., 2023) or survivors of the World Trade Centre attacks in 2001 (Beidel et al., 2019; Friedrich, 2016). More novel interventions have also shown promise in treating PTSD in UK military veterans through multi-modular motion-assisted memory desensitisation and reconsolidation therapy (3MDR) (Hannigan et al., 2023). Where previous research has investigated the use of VR with the treatment of PTSD in war veterans such as the *Bravemind* system (Friedrich, 2016), more recent investigations have also attempted to enhance such systems with the introduction of smells (Freedman et al., 2024), and noninvasive electrical cranial stimulation (van't Wout-Frank et al., 2024).

The main problem with exposure therapy and, by extension, VRET, is that during this treatment, attempts are made to replace a reaction to feared stimuli with a more relaxed reaction by slowly exposing the patient to higher degrees of the feared stimuli while responding with the taught relaxation techniques (Davison, 1968; Markowitz & Fanselow, 2020). The treatment targets only the symptoms (Olatunji et al., 2010) or the elements of the trauma that are directly connected to it (Markowitz & Fanselow, 2020) and not the fundamental cause of the disorder. The efficacy of VRET thus falters because of the context within which the exposure takes place, i.e., the therapist's office, and could lead to returning fear reactions when facing the feared stimuli in a different setting (Markowitz & Fanselow, 2020). Other phobias such as social phobias also don't respond well to exposure therapy, because it assumes in most cases that the only cause of phobias is learning through association (Davison, 1968; McLeod, 2024).

2.3 Spontaneous Healing Intra-systemic Process

Spontaneous Healing Intra-systemic Process (SHIP®) is a psychotherapy for the healing of the above-mentioned pathological fear structures or, as referred to in SHIP®, for trauma-spectrum manifestations (TSMs) (Steenkamp, 2018). TSM is an integrated SHIP® diagnosis related to trauma (Steenkamp, 2018), which encompasses manifestations such as PTSD (Steenkamp, 2018). SHIP® concerns itself with generating awareness of internal processes within a client to facilitate change by validating those processes (Hoffman & Steyn, 2010). The role of the psychotherapist is thus to facilitate this internal spontaneous healing dialogue for it to move from a state of dysregulation (out of the space of tolerance) to a state of flow, i.e. being able to effectively regulate one's autonomic responses to the external world in an orderly manner (Steenkamp, 2018).

Trauma does not disappear and can resurface because of trauma-activating associations which are normally connected with the original traumatic event in some manner (Steenkamp et al., 2012). If the trauma-activating associations are triggered again, they could stimulate the unfreezing of trauma and present as spontaneous healing reactions (SHRs) (Steenkamp et al., 2012). SHRs are psychobiological responses that are seen as interactive, interconnected energy patterns consisting of the physical, mental, spiritual, and emotional (Kieser-Muller, 2016). SHRs are described as trauma-unfreezing and are a core part of the autonomic regulatory process in an individual's day-to-day experiences and reactions to external events (Steenkamp, 2018). Through trauma-unfreezing, the healing and integration of trauma-material can begin to help an individual to effectively regulate their autonomic responses to the external world (Steenkamp, 2018). The healing and the integration of trauma material have been experientially proven to result in flow and the reciprocal relief from TSM (Steenkamp, 2018).

The key differences between exposure therapy and SHIP® are what motivate this research. VRET leads to unsuccessful treatment in some cases because of its approach to treatment (as discussed in Section 2.2). SHIP®, however, does not aim to habituate the client to the trauma-associative triggers, but rather to allow the trauma to become unstuck and complete its natural process (Steenkamp, 2018). The similarities between exposure therapy and SHIP® motivate investigation into whether VR can be used alongside SHIP® to assist those who do not benefit from VRET.

3 THE SHIP® FRAME: THE DOOR

During the process of SHIP®, the facilitator can select appropriate trauma-activating associations, or activators, to induce opening of the trauma memory and subsequent motion completion/healing thereof (Steenkamp, 2018). The SHIP® Frame consists of a variety of inductively-derived images and contains a wealth of associative information relating to trauma-material, awhich isnd are used primarily used as an associative activators (Steenkamp, 2010). The SHIP® Frame is a medium to transport clients to their internal process of spontaneous healing and makes the process of psychotherapy faster (Steenkamp, 2010). One such image is known

as *"the door"*, which involves a client being asked to lie on a bed with their eyes closed and tasked with imagining a door with different words written on it such as the words *"Emotions"* or *"Identity"* (Steenkamp, 2010). This door image is used most frequently and the words written on the door can be substituted with any word that might help them reconnect with the disconnected emotions (Steenkamp, 2010). The client should experience all the emotions and sensations the image evokes, as well as any and all associations, whether it be from the past, present or future must also be identified and acknowledged (Steenkamp, 2010). In doing so, the imagined environment soon corrects itself in a way that the client can experience it in a positive light (Steenkamp, 2010). However, in some cases the client is unable to visualise the images requested during the phases (Steenkamp, 2010) which means that the feelings that were denied expression by the trauma-activating event are kept from completion leading to unsuccessful or ineffective treatment (Steenkamp, 2018). A simulated environment could thus be used as a tool for igniting subsequent layers of spontaneous healing when clients keep struggling to visualise the requested associative images.

3.1 Designing a VR system to assist in the SHIP® process

The first objective of a VR system to assist in the SHIP® process would be to successfully immerse a user into a VE and control the simulated environment remotely. VRET systems such as the *Bravemind* system (Friedrich, 2016), immerse patients into a controlled, simulated environment through the use of a head-mounted display (HMD) to expose them to their trauma. Because SHIP® relies on the visualisation of images from the SHIP® Frame (Kieser-Muller, 2016), a SHIP® VR system would also be able to utilise an HMD to immerse the client within a VE where the required stimuli can effectively be simulated. A simple, user-friendly interface similar to the sandbox-type public speaking anxiety treatment system (Lindner et al., 2021) would also allow a psychotherapist to control this VE remotely. The door image, as discussed above, can be a predefined scenario such as those designed for the Iraq/Afghanistan system (Rizzo et al., 2015).

Such a VR system would then have to successfully induce physiological and psychological responses from the user. Both SHIP® and VRET use visual associative triggers within a simulated/imagined environment to serve as disrupting activators in order to induce activation of the trauma state of dissociation of the client (Steenkamp, 2018). VRET systems such as the system for the treatment of acrophobia (Nabukenya et al., 2021) exposed users to disrupting activators, i.e., various height scenarios, to treat their fear of heights. For a SHIP® VR system to successfully induce such activation as mentioned above, images that fall under the client's current phase in the SHIP® Frame need to be simulated. For example, simulating something unique to the user on the door, such as their name, could successfully induce activation of frozen trauma (Steenkamp, 2010, 2018).

For a SHIP® VR system it is not enough to simply trigger certain experiences of the client, but the VE should also disrupt the existing TSMs. Various VRET systems are able to disrupt fear structures effectively and even change or replace them (da Costa et al., 2018; Gromer et al.,

2018). These disruptions have led to responses such as increased heart rate, and self-described discomfort (da Costa et al., 2018), suggesting that the existing fear structures were triggered. With one VRET system these symptoms became less severe as they progressed through more sessions suggesting that the fear structures were also altered so that the experienced anxiety became less severe (da Costa et al., 2018). Responses such as the ones described above are similar to SHRs experienced by clients as they undergo emotional processing during SHIP® sessions (as discussed in Section 2.3). This suggests that a similar VR system might be able to trigger the trauma to induce SHRs to "unfreeze" the trauma within the SHIP® process.

Because both SHIP® and exposure therapy rely on an individual's ability to imagine the necessary stimuli, it is reasonable to assume that SHIP® could share other limitations with exposure therapy. VR has been used in tandem with exposure therapy to effectively overcome some of these limitations, therefore this study set out to investigate whether VR can also assist in overcoming similar limitations in SHIP®.

4 RESEARCH METHODOLOGY

To determine the induction efficacy of VR within the process of SHIP®, a RCT design (Hariton & Locascio, 2018; Thiese, 2014) was followed with data gathered of each group's respective experiences through observation, giving this study a qualitative method approach (Pickard, 2013). A total of 28 Participants participants were randomly divided into two groups of 14 participants each, with one group receiving the VR SHIP® intervention and a Control group receiving the standard SHIP® intervention (Machin et al., 2021) and is, as discussed in detail in Section 4.1.

A SHIP® psychotherapist was recruited as facilitator to guide the participants through their sessions using their in-depth SHIP® training in the field of image activation in SHIP® clients. The facilitator was best suited to observe the participant responses during the sessions and in the unlikely event that the participant had an adverse reaction to the stimuli, the facilitator was capable of guiding the participant away from the stimuli and could assist the participant by referring them to the appropriate professional.

4.1 Participants

Purposive sampling was used to gather participants and was implemented twice: once for the initial group of participants, and again to select the low level of imaginative potential group from the initial group. For the initial group, the participants had to adhere to the following criteria to be considered:

1. no prior knowledge of SHIP®,
2. no history of undergoing SHIP®, and
3. no prior trauma or mental disorders.

This sample was used to reduce the differences between the participants to ensure that the data were more significant (Hariton & Locascio, 2018; Thiese, 2014) and to exclude any potential participants who might experience adverse reactions during their sessions. All participants provided their informed consent before the commencement of the study and the study was approved by the institutional ethics review committee (protocol number: EBIT/30/2022). Clearance was not granted to collect demographic information such as gender and age.

The desired population consisted of participants who exhibited the lowest level of imaginative potential of the initial group, i.e., individuals who struggled to imagine requested stimuli the most. To determine the imaginative potential for each of the participants, an imagination exercise was developed and administered by the facilitator for this specific study using their in-depth knowledge of SHIP®. Because this method was designed specifically for this study, no benchmark existed for what was to be considered a low imaginative potential score. Therefore the facilitator and researcher decided to recruit the 20 participants from the initial group with the lowest levels of imaginative potential for the remainder of the study. During the imagination exercise, each participant was given a score out of 10 for three different criteria deemed necessary by the facilitator to be viable SHIP® candidates:

1. level of engagement,
2. level of authenticity, and
3. level of consistency.

In total, 28 individuals took part in the preliminary imagination exercise. The overall process of the imagination exercise administered to the initial group by the facilitator can be seen in Appendix A. Some of the participants were uncomfortable with lying down flat on the air mattress provided, therefore, the participants were given the option to either lie down on the air mattress flat, sit on the air mattress with their backs against the wall, or sit in the office chair opposite the facilitator. They were also allowed to keep their eyes open during the exercise if they preferred it. This allowed for the participants to feel more in control of the session to encourage higher engagement with the SHIP® activities.

Six participants from the initial group were excluded from consideration to take further part in the study. These exclusions were as a result of previous exposure to SHIP®, unavailability during the designated time frame for the RCT, or exhibiting signs of past or present trauma. Thus, 22 participants were considered for the remainder of the study. The 20 participants who exhibited the lowest levels of visualisation capability were randomly divided up into two groups, namely a ‘standard’ group – who partook in a standard SHIP® session – and a ‘VR’ group – who partook in a VR SHIP® session. The randomisation of the groups was repeated until the mean level of the imaginative potential ratings of the groups were within an acceptable threshold of each other, to ensure that no known difference between the groups existed except for the intervention itself (Thiese, 2014). These groups can be seen in Table 1:

Table 1: The final group divided into two groups based on level of imaginative potential (LIP) rating

Control Group		**VR Group**	
Participant	**LIP Rating**	**Participant**	**LIP Rating**
P31 (C01)	8.6	P29 (V01)	7.6
P21 (C02)	4.6	P02 (V02)	9.3
P33 (C03)	8.0	P24 (V03)	8.3
P04 (C04)	9.3	P18 (V04)	8.6
P28 (C05)	8.0	P32 (V05)	8.6
P08 (C06)	9.3	P06 (V06)	6.3
P05 (C07)	8.3	P09 (V07)	9.7
P30 (C08)	9.3	P13 (V08)	2.3
P22 (C09)	5.0	P20 (V09)	9.3
P19 (C10)	8.0	P11 (V10)	6.6
Average	**7.84**	**Average**	**7.66**

4.2 Materials

The PENSIEVE prototype, designed and developed for this study, consisted of a Meta Quest 2 HMD which ran a VR application using Unreal Engine 4 (UE4) via a Windows PC and was controlled using a simple graphical user interface (GUI) as shown in Figure 1.

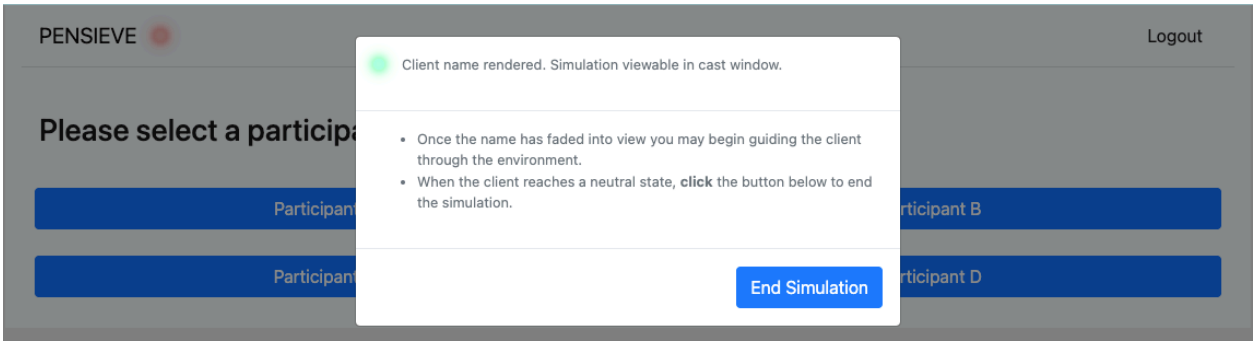

Figure 1: GUI used by the facilitator to start and end the simulation

The facilitator would click on a participant's name via the GUI, and control the VE through a series of prompts, culminating in the door with the participant's name on it fading from view and into black.

The VE was designed using a VR template and starter content, i.e., a door 3D model, provided by UE4. The application was passive (Vergara et al., 2017) in nature and did not allow for any interaction with the simulated world and did not include audio output.

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The main structure of the VE consisted of four walls, a ceiling and a floor that were differentiated through different materials. The main goal of the VE was to instil a high level of presence so as to have the participant respond naturally to it. This was achieved by simulating a realistic 3D model of a door with the participant's name rendered on it and can be seen in Figure 2.

Figure 2: Realistic 3D door with primary investigator's name rendered in large letters

4.3 Procedure

Data were collected via the following procedure: each participant in the initial group was given a written consent form to sign, denoting the potential risks associated with the imagination exercise. The final 20 participants for the RCT trial were recruited after the imagination exercise was given to the initial group. They were given another consent form to sign also explaining the potential risks, and gave permission for the recording of various data throughout the RCT. The participants were informed about the main goal of the RCT. It is important to note that no form of psychotherapeutic treatment was administered to any of the participants.

For the sessions, only a single image out of the SHIP® frame was chosen, namely the door image with the participant's name either imagined or simulated on it. Other images in the SHIP® Frame were considered to be too ambiguous and might not trigger unique experiences within every participant. The general process followed by the facilitator during the sessions once the participant was seated or lying down was as follows:

1. The facilitator asked them to close their eyes and imagine a door.

2. They were then asked if they could see the door, or the door was faded into view. They were then asked if they were able to identify any experienced emotions.
3. The facilitator then requested that they imagine their name on the door or rendered a simulation of their name on the door – again the facilitator asked if they were able to identify any specific emotion.
4. If they were able to identify an emotion, they were asked where in their bodies they felt it.
5. If they were able to pinpoint the feeling, they were tasked with focusing on that specific feeling.
6. During this the facilitator would periodically ask what thoughts, memories, or sensations they became aware of.
7. If they were unable to identify any emotions or sensations, they were asked to just keep focusing on the visualised door or the simulation.

Sessions tended to last between 20 to 30 minutes and varied between participants.

The VR group sessions followed the same process as the Control group's session differing only with regards to the door simulation fading in from black once asked to imagine a door, and fading in the participant's name on the door once asked to imagine their name on the door. The rest of the process as outlined above was then followed.

During each participant's session the facilitator would observe all the responses to fill in a helpful aspects of therapy form (HAT). This questionnaire typically consists of seven open-ended questions given to the client after a therapy session (Elliott, 2002, 2008) and was used, with incorporated VR terminology, to identify assistive or hindering events to the SHIP® process that occurred during therapy sessions. The HAT form used for each session can be found in Appendix B.

A month after the RCT sessions were completed, the first author conducted a semi-structured interview with the facilitator, henceforth referred to as the change interview. A month was chosen to allow the researcher to examine all the HAT forms and transcribe all the audio recordings of the sessions prior to the change interview. The purpose of this interview was to gather insights about the assistive or hindering events observed, what led to these events, and what characteristics were considered to be helpful or hindering (Elliott, 2002). The question list used during the change interview can be found in Appendix C.

The collected data were analysed using thematic analysis by repeatedly going through the collected data, familiarisation with it, generating initial codes, and searching and reviewing recurring themes that appear within the data (Kiger & Varpio, 2020; Nowell et al., 2017; Terry et al., 2017). The full details of how the data were collected and analysed can be found at (Malan, 2024).

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5 RESULTS

Within both the control group and the VR group it was observed that all of the participants experienced some form of emotional, physical, or mental response towards the imagined/simulated stimuli. The emotional responses ranged from feelings of euphoria and empowerment to anxiety and fear, the physical responses included sensations felt in the chest, shoulders, hands, and head, and the mental responses included unique memories and thoughts as well as other unique sensory experiences such as sound. Each participant was kept anonymous and denoted with a letter corresponding to their group and a number. For example C01 refers to the first participant in the control group. Some of the most notable responses of the two groups are illustrated in Tables 2 and 3.

Table 2: Notable responses from Control group

Participant	Response	Quote
Emotional Responses		
C02	Euphoria	*"I guess happy or excited, this particular door's from when I was on holiday, so it was an exciting time"*
C09	Fear	*"I think one thought that comes to mind is, like, unsure and scared to open the door"*
Mental Responses		
C02	Memories	*"Well this particular door was a church door and I loved visiting churches when we were in Paris. Um, but this one was in Dusseldorf"*
C01	Sensory	*"Hearing crackling sounds of the wood"*
Physical Responses		
C01	Chest: comfort	*"You know, just sort of like in the chest area"*
C08	Hands: fear	*"It's almost more in the hands now"*

Table 3: Notable responses from VR group

Participant	Response	Quote
Emotional Responses		
V09	Euphoria	*"joy"*
V05	Fear	*"fear, uncertainty. I'm too hesitant. Cautious, worried that it might make it worse"*
Mental Responses		
V07	Memories	*"My dad passed away, like, two years ago …"*
V04	Sensory	*"I think of, like, the sounds that you hear, like the birds, but also of the mosquitoes, I was thinking of the itching now"*
Physical Responses		
V10	Shoulders: unease	*"I think in my shoulders and in my chest"*
V02	Arms: empowered	*"In my chest, and my upper arms"*

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It is important to note that even if a participant was able to identify specific emotions, or physical sensations, or experience unique mental responses, it does not necessarily imply an effective SHIP® session. To determine which responses were assistive to the overall process of SHIP® and which ones were hindering, thematic analysis was applied to the HAT forms as well as to the data gathered from the change interview. With regards to the HAT forms, the facilitator scored each session according to the following guidelines:

- 1–4 was considered to be not a useful session at all.
- 5–7 was considered to be a neutral session that didn't advance nor hindered the process of SHIP®.
- 8–10 was considered to be an extremely useful session to the process of SHIP®.

The results of the HAT forms are illustrated in Table 4.

Table 4: HAT session usefulness ratings

Control Group		**VR Group**	
Participant	**Score**	**Participant**	**Score**
C01	7	V01	7
C02	6	V02	8
C03	6	V03	8
C04	8	V04	7
C05	5	V05	9
C06	7	V06	7
C07	8	V07	7
C08	9	V08	9
C09	9	V09	10
C10	7	V10	6
Average	**7.2**	**Average**	**7.8**

Table 4 illustrates that the facilitator experienced both treatment methods as being assistive to the overall process of SHIP® with no one method clearly perceived as superior by the facilitator. However, the HAT scores also provide insight into the individual experiences had by participants, what aspects of VR and the traditional SHIP® process led to these experiences and why the facilitator perceived them to be assistive or not.

5.1 Assistive aspects of VR

The assistive events observed by the facilitator were categorised into two main categories, i.e., induced responses and VR attributes. Induced responses included all the responses directly

associated with the assistive events and were categorised as emotional, physical, and mental responses. Attributes of the VR system that were directly associated with assistive events were categorised as simulation and headset. The induced responses and specified VR attributes are seen as assistive aspects of the VR method and are illustrated as all connecting to assist the process of SHIP® in Figure 3

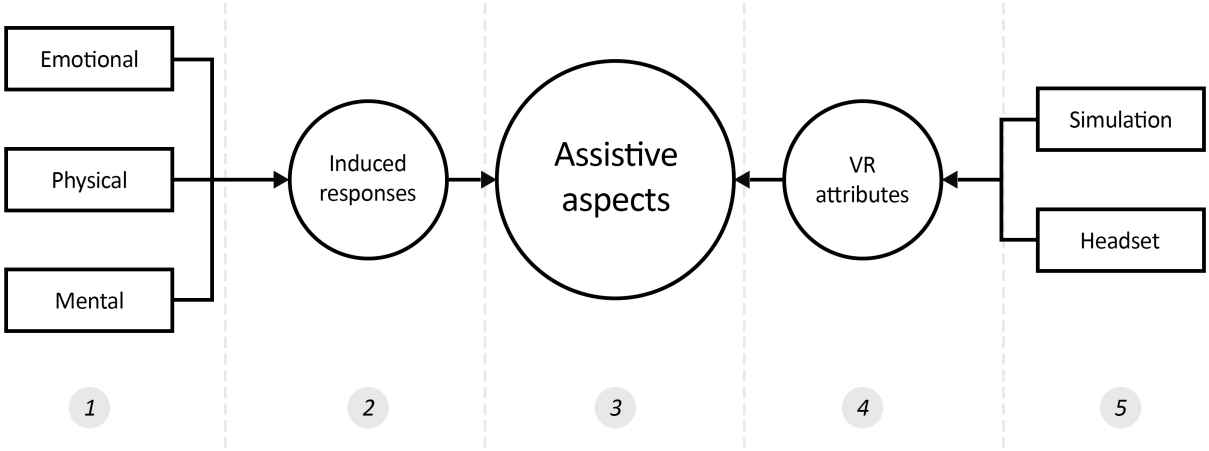

Figure 3: Assistive aspects of the VR group

In the sessions of participants V05, V07, and V09, emotional processing (or disruption as discussed in Section 3.1) took place because the initial emotion that was experienced gradually changed or faded as the session progressed. In the case of participant V05, the facilitator noted that: *"the door visual (VR) stimulated or triggered a memory of a rugby injury that still brings up fear, disappointment, uncertainty … We were able to use SHIP techniques to process the fear which actualised as restlessness in their legs"*.

Participant V09 *"had a limited experience …"* during their imagination exercise, however during their SHIP® session they *"had a significantly richer and deeper experience"*. The facilitator explained that *"The VR visual seemed to serve as a cognitive stimulus to bring up emotion, memories, or reflections that were less accessible to this particular client in the first round of sessions"*. Within the HAT form, the facilitator stated the following: *"I have a sense that the VR headset or visual does not shape the entire SHIP® process but rather acts as a stimulus to initiate a chain of thought, emotions, or reflections …"*. The facilitator explained this visual stimulation during the change interview as being one of the most helpful aspects of the VR group sessions and that it allowed the VR to function as a tool that led to deeper engagement and an enhanced experience

During the imagination exercise of participant C03, the facilitator noted that their description was *"authentic"* and *"detailed"*, although *"rather to the point"* meaning that they *"[might] not have a high visual processing ability"*. This participant received a high level of imaginative potential rating as their description was *"authentic"* and it allowed them to engage the SHIP® activities completely. However, during the Control group sessions, the facilitator noted that participant C03 was *"not expressive by nature"* and that this *"limits the SHIP® process because we*

can express deeply only if we allow ourselves to be vulnerable". Although an inexpressive nature is not directly linked to the success of a traditional SHIP® process, it is worth noting that an individual who is unable to effectively express themselves, as well as being unable to formulate more vivid visualisations, could lead to a very ineffective SHIP® session. Participant V08 was also inexpressive by nature and struggled with visualising the requested stimuli during the imagination exercise. Participant V08's HAT form reads: *"This participant could not visualise a door the first time, this time they could"* referring to the participant's VR SHIP® session. They were able to identify a physical sensation towards the end of their session noting that it *"Actually feels as if my hands and feet are getting numb"*. Participant V08 had a richer experience with the VR intervention than during the imagination exercise. The participant mentioned to the facilitator: *"… I'm not searching for an image, you have the image and you just focus on that"* and during the change interview the facilitator explained that VR *"cut out the physical world … and it forced your conscious mind to get immersed to be present in the virtual reality world … and then your energy becomes more concentrated on the task in front of you … going through all the SHIP processes basically"*. This is mainly because there was no need for the participant to focus their full concentration on imagining the requested stimuli, but only focus and engage with the SHIP® activities posed by the facilitator.

5.2 Hindering aspects

Similar to the assistive events that were discussed above, only the responses and/or attributes of the VR system that were identified to be directly associated with the hindering events, were categorised into induced responses and VR attributes. These categories in turn are what hinder the overall SHIP® process, making it less effective. The outcome of this process of identification and categorisation is illustrated in Figure 4. The main hindering aspects of the VR treatment method for SHIP®, in some cases, was that of the low fidelity of the VE, the point-of-view of the simulation, and the actual VR technology being a distraction for some participants.

Participant V02 noted during their session that *"when I open my eyes and I see this picture, it's, like, such a boring door …"* and agreed with the facilitator that when they closed their eyes, the door they were able to visualise was much more *"vibrant"*. The facilitator noted in the HAT form that the participant was *"often tempted to close their eyes"*. This event was only described as slightly hindering by the facilitator, but nonetheless the lack of a vibrant, more visually appealing simulation reduced the immersion levels, reducing presence, and could result in their responses to the SHIP® activities being less authentic and spontaneous. This could have led to less effective emotional processing.

Additionally, the actual VR hardware seemed to be a distraction in some cases. Throughout the session of participant V07, the weight of the headset started to loosen the straps and caused the headset to sag down on the participant's face. This resulted in the participant having to physically hold up the headset to see the simulation properly. Within the participant's HAT form the facilitator wrote the following: *"Participant preferred to sit up on a chair. The headset*

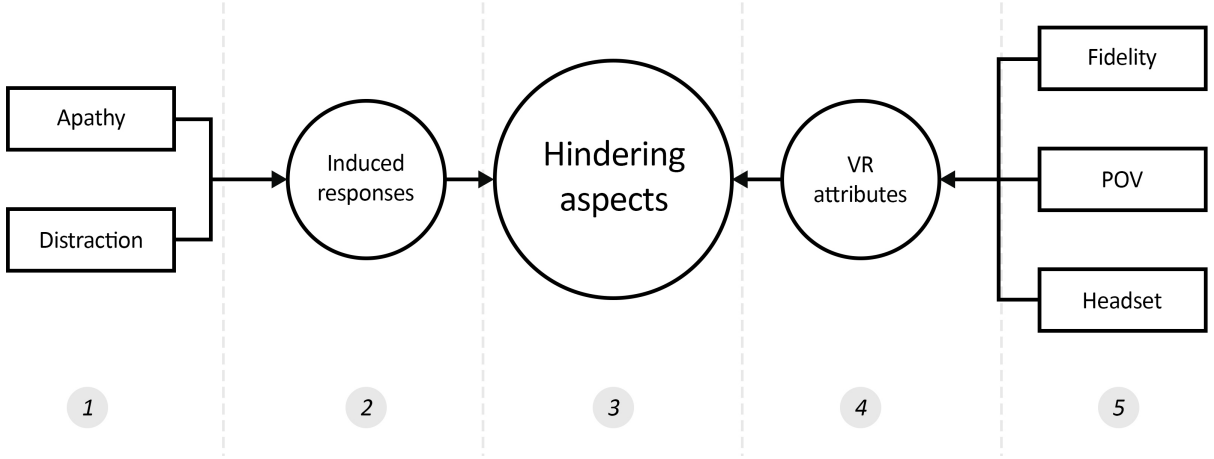

Figure 4: Hindering aspects of the VR group

needed to physically be held in place, because of its weight, to keep the door image orientated. This may have distracted them from the SHIP activities by shifting their focus". Other distractions related to the VR technology that were noted by the facilitator included a power outage experienced by participant V04, the *"anxious anticipation"* towards VR technology in general by participant V10, and the point-of-view (POV) of participant V05 where they experienced the door as being skewed in the VE instead of upright.

During the change interview the facilitator explained that although the distractions were hindering, they weren't hindering to such an extent that it would completely nullify a SHIP® session. The facilitator said that in practice *"What I try to do with clients is identify the distractor … Whether it's a headset being too heavy that you need to prop up or it's unexpected and avoidable things … I think in real life as within VR you need to be prepared to cope with unexpected things because that is the nature of the human experience"*.

However, the most hindering aspect observed by the facilitator, on a psychological level, was considered to be the height of the air mattress the participants were asked to lie down or sit on. During the change interview the facilitator stated that: *"if you think of very caveman, fight-or-flight- type of thinking [sic], if you are on the floor, you're not safe. Because if you need to respond to a risk or a threat, it takes a long time to stand up before you can fight"*. With regards to the control group the facilitator noted that some participants *"feel a little bit self-conscious about lying there with their eyes closed … It's a vulnerable position"*. This hindering aspect was however not the case with the VR group according to the facilitator as the VR headset was effective at removing the participant from their immediate reality. VR's ability to 'cut-off' participants from the external world, was beneficial to the SHIP® process and is discussed in more detail in the following section.

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5.3 Immersion, presence, and engagement

The facilitator suggested that the VR group experienced higher levels of immersion, and felt that it was the VE simulated by the VR headset that contributed to this. They noted that they *"…found that the VR group was able to go a little bit deeper … that is accounted for by the additional brain stimulation that the VR headset provided"*. Thus, when considering the most hindering aspect noted by the facilitator across both groups, i.e. the height of the air mattress, it suggests that the hindering aspects of both groups were, in a sense, experienced more vividly by the Control group than the VR group. The VR group was able to escape those hindrances more effectively because of the visual simulation and the nature of the VR headset. Because of the physical nature of the HMD, it effectively *"cuts off"* the user's peripheral vision, removing them from their immediate surroundings.

One implication of 'removing the participant from the real world' was that it empowers an individual to become fully present in the VE. As discussed in Section 5.1, it allows one to focus all one's energy onto the task at hand, in this case the SHIP® activities. According to the facilitator, the VR headset and the simulation were the most helpful contributors to the SHIP® process: *"I think the VR goggles served as almost a healthy distraction because it allowed them to immerse themselves into the VR world"*. The facilitator also noted that *"reducing your consciousness to the VR world, I think that was helpful in enhancing presence"*. In Section 2.1, it was discussed that an individual's level of presence experienced comes from the degree to which they can respond naturally in virtual environments. It stands to reason then that if an individual experiences a greater sense of presence, they are more likely to respond more naturally to the simulated environment. Being *"cut-off"* from the distractions of the physical world leads to a greater feeling of *"being there"* within the simulated environment. In the context of SHIP® (as discussed in Section 3), this heightened sense of presence would allow the participants to respond more naturally to the SHIP® activities. It is important to note that successful emotional processing in the context of SHIP® is not solely dependent on the level of the engagement with the imagined stimuli, but also on the authenticity of the spontaneous responses to the SHIP® activities administered in tandem with a client's experience with the imagined stimuli. Thus, the more naturally a client can respond to their environment, the more authentic their responses are towards the SHIP® activities which could lead to successful emotional processing.

5.4 VR as therapeutic tool

According to the facilitator, both groups engaged the SHIP® activities to *"the best of their ability"* and that the level of engagement was good overall. This is largely due to the role of therapeutic alliance in psychotherapy. The facilitator said during the change interview that *"Therapy requires vulnerability, the therapeutic alliance facilitates the vulnerability … therapeutic alliance, you'll find that it's a massive contribution to absolutely any therapeutic process …"*. This contribution was noted during participant C04's session, where the participant was very honest about not experiencing any emotions or sensations at the start of the session. According to

the facilitator, this admission allowed them to *"build a good therapeutic alliance"*. This enabled the facilitator to engage the participant more honestly, and the participant was then able to engage in the SHIP® activities better as the session progressed, which allowed them to effectively process their emotions that eventually came up.

This therapeutic alliance existed between the facilitator and the participants in the VR group as well. For example, in the session with participant V01, the facilitator noted that the participant was *"very much at ease or safe during the session"* within the VE and therapeutic space. This feeling, in combination with the therapeutic alliance, led to the participant sharing *"personal information or thoughts and reflections"*. This therapeutic alliance could also have been enhanced by the physical nature of VR *"cutting off"* the external world. The facilitator elaborated that *"... they don't know what I'm seeing and it's not a shared experience, and that maybe allows them to feel a sense of, of psychological safety"*. The facilitator is alluding to the possibility that a client might experience images and thoughts that are private, and being removed from their immediate environment makes them feel as though their private thoughts stay private. Therapeutic alliance existed between the facilitator and the participants in the VR group similar to the control group, despite the added unfamiliarity of the VR technology.

During this section it was clearly outlined how the VR intervention was able to foster the same level of therapeutic alliance as the traditional SHIP® method. Section 5.2 revealed that the most hindering aspect of both methods was psychological in nature, but that the impact of this hindering aspect was lessened by the technological and physical characteristics of VR as examined in Section 5.1. Why these characteristics were able to reduce the impact was then explored in Section 5.3 and it was found that the physical nature of the HMD and the VE simulated were directly responsible for reducing the impact of the psychological hindrances. VR was thus able to overcome a psychological obstacle faced by the traditional SHIP® method. This, along with the proven induction efficacy of unique memories of the VR group as stated by the facilitator, namely *"the VR induction was able to allow us to stimulate very significant memories"* leads to the notion of VR potentially being used as a tool to assist the existing SHIP® process rather than shaping it.

6 LIMITATIONS

While the prototype successfully achieved its goal of inducing unique memories, and physiological and psychological responses, the sample for the current study, the simplistic nature of the imagination exercise, and the chosen SHIP® Frame limited the results of the study somewhat from preventing to determineby making it difficult to determine which of the two intervention methods were more assistive to the overall SHIP® process. These limitations impacted the results as follows:

- *Small sample size*: the final group of 20 participants that took part in the RCT were recruited from a small initial group of 22 individuals. This prevented the researcher from recruiting only participants who truly had difficulty with imagining requested stimuli.

As a result mostly participants who did not really have any visualisation deficiencies took part in the RCT which lessened the credibility of the results.

- *Simplistic imagination exercise*: the researcher determined that the oversimplified imagination exercise is what led to most of the participants obtaining high levels of imaginative potential scores. As a result the *"low"* level of imaginative potential group consisted mostly of participants who did not have trouble visualising the requested stimuli. This lessened the credibility of the results as we could not effectively measure an improvement between a participant's ability to visualise before and after the RCT.
- *Shallow SHIP® Frame*: the door image chosen for the current study is quite general, even with the addition of the participant's name on the door. Thus, it is this researcher's belief that a more personalised VE would have garnered even richer data.

These limitations outlined above assist in identifying the key areas that warrant further research and are discussed in the following section.

7 CONCLUSION AND FUTURE WORK

This paper describes the PENSIEVE prototype, a software intervention that allowed a SHIP® facilitator to immerse participants into a VE to experience specific stimuli based on the SHIP® Frame. Qualitative data were gathered of participants' physiological and psychological responses to the imagined or simulated stimuli during a SHIP® session. The results of this study suggests that VR has the potential to stimulate and enhance the visualisation capabilities of the client or act as a proxy for a client's imagination. In other words, VR can aid participants who have difficulty visualising requested images and in doing so aid them in engaging with the SHIP® activities and successfully progressing through the process of SHIP®. Thus, a key difference to consider between the two methods is that the induction of unique memories would be impossible for SHIP® clients with visualisation deficiencies, an obstacle that was overcome by the PENSIEVE prototype.

Simulating a virtual world through the use of an HMD effectively *"cut off"* participants from their immediate environment. Distractions and other hindering aspects identified were reduced or completely removed for participants. This enhanced the existing therapeutic alliance between the facilitator and the participant, leading to high levels of presence, and allowing participants to experience authentic responses towards the stimuli and SHIP® activities. In addition to this, the prototype was able to replicate every aspect of the traditional SHIP® process that is needed for successful treatment. Thus, the prototype was successful in simulating a VE that was able to induce unique memories and responses necessary for the SHIP® process.

Further research might include investigating the extent of VR's role as cognitive proxy for a SHIP® client's imagination by recruiting a larger sample via a more complex imagination exercise to ensure only participants who cannot visualise effectively take part in the study. Other research avenues might include, but are not limited to, a purely experimental approach based

on the induction potential of both interventions and compare them directly with one another. A quantitative study such as this can also take the form of a pre- and post-test comparison to determine if there was any improvement in the imaginative state of a participant. Lastly, a more extensive study could also be carried out focusing on the improvement of a client's disorder by observing the client over the span of multiple SHIP® sessions, while each client is experiencing a personalised virtual world developed specifically for said client. A study such as this would provide valuable insights into the extent to which VR is able to improve a client's specific mental disorder. Another consideration for such an investigation is to determine to what extent collaboration would be necessary between the psychologist and the VR developer/operator. The integration limitations such as the therapeutic space i.e. the psychologist's office (or wherever they administer treatment) and the psychologist's technical capabilities (with regards to operating a VR system) would also warrant thorough investigation.

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A IMAGINATION EXERCISE PROCESS

Step 1: The facilitator asked the participant to lie down on an air mattress and relax their bodies and to try and become aware of themselves within the space.

Step 2: Once the participant was relaxed, the facilitator asked them to imagine a door.

Step 3: After a couple of minutes, the facilitator asked the participant to describe the door in as much detail as possible.

Step 4: Once the participant had finished with their description, they were asked to just relax and keep imagining their door.

Step 5: After about 10 minutes the facilitator asked the participant to describe the door again.

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B HAT FORM

We are interested in determining whether virtual environments are able to induce memories in the same manner as a traditional, imaginal SHIP® session. The questions are applicable to the type of session you just facilitated. This means that if you just facilitated a VR session, all the questions will refer to that specific method of treatment and ONLY that method of treatment.

We use the term "EVENT(S)" to refer to anything that happened during the session with the participant, be it a physiological or psychological response, something the participant said, or anything else they might do that is a result of the specific treatment being administered. It will be up to you to use your insights as a trained SHIP® therapist to observe and identify any and all of these events that might be considered useful or hindering.

There is a single Likert scale question at the beginning of the questionnaire, followed by 6 open ended questions. There are no right or wrong answers. Any event that you consider to be useful or hindering must be listed and described in as much detail as possible. This questionnaire should not be shared with the participant and should only be seen and filled in by you, the facilitator.

1. **To what extent was the session useful to the process of SHIP®?**
   Rate it on the following scale. (Put an "X" at the appropriate point)

Not at all useful		Neutral					Extremely useful		
1	2	3	4	5	6	7	8	9	10

2. **Of the events which occurred in this session, which one do you feel was the most important or helpful with regards to facilitating the session?** (By "event" we mean something that happened in the session related to the type of treatment administered i.e., VR or standard. It might be something the participant said or did, or something you said or did.)

3. **Please describe what made this event important/helpful and what it helped achieve in the context of the SHIP® session.**

4. **During which section of the session did this event occur?**

5. **How long did the event last?**

6. **Did anything else particularly helpful happen during this session that was related to the treatment method administered i.e. VR or standard?** (Put an "X" at the appropriate box)

YES	
NO	

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(a) If yes, please rate how helpful this event was: (Put an "X" at the appropriate box)

Slightly		Moderately		Greatly		Extremely	

(b) Please describe the event briefly and explain why you consider it helpful.

7. **Did anything happen during the session which might have been hindering that was related to the treatment method administered i.e. VR or standard?** (Put an "X" at the appropriate box)

YES	
NO	

(a) If yes, please rate how hindering this event was: (Put an "X" at the appropriate box)

Slightly		Moderately		Greatly		Extremely	

(b) Please describe the event briefly and explain why you consider it hindering.

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C APPENDIX: CHANGE INTERVIEW QUESTIONS

Note:

- The interview will be semi-structured with the questions listed below.
- The interview will only be conducted once with the facilitator that facilitated all the sessions.
- The interview will take place in the SHIP® facilitator's office and the audio of the interview will be recorded.
- Refreshments will be given to the facilitator and researcher before the interview commences.
- Information regarding the helpful aspects of the two treatments will be gathered from the HAT forms filled in by the facilitator after each session to assist in the interview and to help guide it to uncover new information and to compare the two treatments effectively.

Instructions to be read to the interviewee before the interview starts:

Just to reiterate, we are interested in the overall experience of each of the treatment methods and which aspects of each lead to your experience. The focus is on comparing the helpful and hindering aspects of both treatments to determine the viability of utilizing a virtual environment in the context of the SHIP® process. There are no incorrect answers during this interview. The only correct answers are your experiences of each treatment based on your professional opinion as a trained SHIP® therapist.

Section A: General experience

Question 1

The HAT forms you filled in for the standard induction indicated that you experienced the sessions as X*. Can you please explain this overall experience of the standard induction?

*X *will refer to the overall perceived usefulness of the standard induction as indicated on the HAT forms Likert scale*

Question 2

The HAT forms also indicated that you experienced the VR induction sessions as Y*. Can you please explain this overall experience of the VR induction?

*Y *will refer to the overall perceived usefulness of the VR induction as indicated on the HAT forms Likert scale*

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Section B: Attributions

Question 3

What events occurred during the standard induction sessions that attributed to this overall experience?

Question 4

What events occurred during the VR induction sessions that attributed to your overall experience of the VR sessions?

Section C: Helpful aspects

Question 5

What were the most helpful aspects of the standard induction? Why were they helpful?

Question 6

What were the most helpful aspects of the VR induction? Why were they helpful?

Section D: Hindering aspects or lacking aspects

Question 7

What were the most hindering aspects of the standard induction, or did you find any aspects missing during the standard induction?

Question 8

What were the most hindering aspects of the VR induction, or did you find any aspects missing during the VR induction?

Question 9

What aspects of the standard induction made the process more difficult, but that you still perceived as helpful or "OK"?

Question 10

What aspects of the VR induction made the process more difficult, but that you still perceived as helpful or "OK"?

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Section E: Immersion, presence, and level of descriptive detail

Question 11

What differences did you experience between the standard and VR induction in terms of the level of immersion of the participants?

Question 12

During which treatment do you think the participants were more involved/engaged with the imagined/simulated stimuli during the sessions?

Question 13

What aspects of the chosen treatment at Q12 do you think contributed to this?

Question 14

On a scale of 1 to 10, how well did the participants describe their emotional or physiological responses experienced during the standard induction? Please explain your answer.

Question 15

On a scale of 1 to 10, how well did the participants describe their emotional or physiological responses experienced during the VR induction? Please explain your answer.

Section F: Effects on the induction of memories

Question 16

What effect on the induction of unique memories did the standard induction have on participants?

Question 17

What effect on the induction of unique memories did the VR induction have on participants?

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Section G: Final thoughts

Question 18

Do you have any suggestions regarding the research or the VR treatment as to how to improve it?

a) Research:

- The participant sessions.
- The virtual environment.
- The sample size and recruitment criteria.

b) The VR induction

Question 19

In your professional opinion, how successful do you think the VR induction is compared to the standard induction?

Question 20

Is there anything else that you would like to add?

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Research Article

A multilevel analysis of digital technology to support teachers to improve their professional practice

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ABSTRACT
Within the education sector, digital technology has increasingly entered into school subjects, curricula, assessment and teaching methods. The common features of technology-orientated and supported programmes are the independence from geographic boundaries and time constraints. Covid-19 pandemic accelerated the debates about digitalisation in the education sector. Therefore, the purpose of this study was to conduct a multilevel analysis of evidence from a large-scale randomised control trial complemented with the systematic collection of implementation information to compare the impact of a conventional structured pedagogic programme to that of a pedagogically similar programme built with a digital technology overlay. The technology acceptance model framed our analysis. Results from the multilevel analysis provided an opportunity to advance knowledge about teachers' acceptance of digital technology to improve student learning and their professional practice. The evidence pointed to two hypotheses: While much of the literature on teachers' acceptance of digital technology concentrated on the subjective element of teachers' behavioural intentions, the current study suggests the extent to which professional accountability may be a key factor in successful digital technology interventions for teachers; and the results points to substantial differentiated uptake that is not linked to either perceived usefulness or perceived ease of use.

Keywords Digital Technology Intervention, Randomised Control Trial, Structured Pedagogical Programme, Technology Acceptance Model, Virtual Coaching

Categories • **Applied computing** ∼ **Education** • *Applied computing* ∼ *Digitalisation*

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1 INTRODUCTION

Computers, and more generally digital technology, permeate all aspects of our contemporary world. Within the education sector, information and communication technology (ICT) has increasingly entered into school subjects, curricula, assessment, teaching methods, and pedagogy. Specifically, few education systems can avoid the pressure to include computer literacy

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as a new aim of schooling. The Covid-19 pandemic accelerated the debates about the use of digital technology to connect learners at a distance and providing support to teachers to improve their practice. Digital technology is *"viewed as a solution to systemic inequalities"* (Mhlongo & Dlamini, 2022, p. 1). Within the field of computers and education, one of the main research concerns is the challenges that teachers face adopting technology in their classrooms (Dlamini, 2022). Within this field, the conceptual framework, the technology acceptance model (TAM), has gained considerable ground. TAM research is focused on better understanding how perceived usefulness and ease of use influence the adoption of technology in the workplace. Systematic review and meta-analysis of TAM for teachers largely confirmed earlier individual studies of the usefulness of an analysis of the TAM variables to explain the uneven uptake in the education sector (Scherer et al., 2019).

This paper contributes to the knowledge base of the conditions under which teachers teaching in poor communities in the Global South take up digital technology as a means to improve learning outcomes. The uneven take-up of technology is often attributed to issues of access in digital resource-constrained conditions (Brown & Czerniewicz, 2010). Using evidence from a large-scale randomised control trial (RCT), the aim of which was to compare the impact of a conventional structured pedagogic programme (CSPP) to a pedagogically similar programme built with a digital technology overlay, the study provided an opportunity to advance knowledge about teachers' acceptance of digital technology as a means to improve student learning. The original RCT study found that after three years, average student performance was significantly higher in the schools that received the CSPP relative to the control schools, but that average student performance in the digital technology intervention schools was only marginally higher than the average performance in the control schools (Cilliers et al., 2021). Given the initial positive findings in the first year and the considerable interest in the use of digital technology to improve teaching, it is not sufficient to know that the intervention had minimal impact; it is critical to know why and to better understand why the digital technology component did not add value. Deaton and Cartwright (2018, p. 2) noted the following:

> *RCTs can play a role in building scientific knowledge and useful predictions but they can only do so as part of a cumulative programme, combining with other methods, including conceptual and theoretical development, to discover not 'what works', but 'why things work.'*

The purpose of this paper was thus to analyse the evidence that may explain why the digital technology intervention, which showed initial promise, came up short. Two hypotheses are offered in this paper. Firstly, while much of the literature on teachers' acceptance of digital technology concentrated on the subjective element of their behavioural intentions, the evidence in this study pointed to the centrality of professional accountability in the digital technology interventions. The second hypothesis points to the need to better understand factors associated with differential uptake not linked to either perceived usefulness or ease of use.

The paper is divided into four sections. The first section reviews the literature of both structured pedagogic programme models and the emerging literature on the use of digital technology in instructional coaching. This literature provides a useful context against which

the study is framed. The second section of the paper describes the original research study itself, particularly the context and the methodology used in the design and implementation of the study. Although the main study focused on comparing learning outcomes in the three research groups, the current paper uses extensive implementation data to better understand teachers' engagement with digital technology. The third section revisits the main findings but concentrates on an analysis of both the quantitative and qualitative secondary findings on the uptake of technology and links to changes in instructional practices, and, ultimately, to learning outcomes. This is followed by the fourth section, which discusses these findings and hypothesis building.

2 LITERATURE REVIEW

While the scale of the early grade reading crisis was highlighted recently (Azevedo et al., 2019), significant advances have been made in understanding the problem of early learning in low- and lower middle-income country contexts. Recent reviews of research consistently and convincingly demonstrated that structured pedagogic programmes are likely to be the most effective approaches to improving early grade reading outcomes and possibly early mathematics as well (Evans & Popova, 2016; Hoadley, 2024; Snilstveit et al., 2016). Current research in South Africa, Kenya, and Haiti confirmed these indings (Angrist et al., 2023; Cilliers, Fleisch, Kotze et al., 2019; Fleisch, 2018; Guzmán et al., 2021; Piper et al., 2018). Within the structured pedagogic approach, studies pointed to the importance of CSPP as the optimal method for teacher in-service professional development (Kraft et al., 2018; Popova et al., 2022). Cilliers, Fleisch, Kotze et al. (2019) showed that when traditional training in a centralised venue is compared to training plus onsite instructional coaching, which is consistently more expensive, the latter is nonetheless more cost effective. This is evidenced not only by effects immediately after the end of the intervention but also by the persisting effects (Cilliers et al., 2022). Majerowicz and Montero (2018) found similar persistence in their study in Peru. These findings expand on Piper and Zuilkowski's (2015) coaching study that provided valuable evidence on the relative cost-effectiveness of different coach-teacher ratios.

However, it must be asked whether other forms or modes of structured pedagogy, particularly structured pedagogy programmes that use digital technology, could be effective. As part of a structured pedagogic model, could e-coaching be as effective as conventional coaching? There is a small but growing body of research that suggested this may be true. Although the study by Piper et al. (2016) on ICT interventions designed to improve early grade reading in Kenya provided an important baseline, it did not really engage with the idea that technology could be harnessed for virtual coaching. The literature on using digital technology for coaching has been around for the past decade, primarily in developed system contexts. Rock et al. (2014) were among the pioneers in e-coaching, or virtual coaching, particularly in relation to bug-in-ear technology. Their earlier study (Rock et al., 2014) focused on using virtual coaching with pre-service student teachers. Rock et al. (2013) tested Skype and how teachers could develop their classroom management skills through virtual coaching. Geissler

et al. (2014) presented original empirical findings on virtual coaching programmes that combined telephone coaching with an internet-based coaching platform, and although the study was small in scale (14 participants who received three coaching sessions), they found positive results.

Stapleton et al. (2017) tested virtual coaching software to assess the potential of linking principal candidates with teacher candidates to ascertain whether the technology would allow principals to give teachers live feedback on their classroom practices. A new direction that this research is taking is to tackle the problem of scaling up. Hennessy et al. (2022) and Rodriguez-Segura (2022) in a research synthesis showed benefits of ICT for teachers, but there is limited evidence that the technology is sustainable, cost-effective or impactful on student outcome. Uribe-Banda et al. (2023) in their comparative study of teacher professional development found few outcome differences between technology-based versus blended equivalent, save that teachers preferred the blended version. Shal et al. (2025), exploring professional development not with direct training but via webinars, adds important insights into wider approaches to teacher education using technology. El-Serafy et al. (2022) have extended this literature into emergency settings where the use of technology for teacher professional development has a distinct advantage. Layton's (2023) work is important as it begins to explore possible mechanism involved in technology in effective e-coaching for teachers.

While this research provided an important point of departure, given the substantive difference in the context of teachers' work in relatively affluent systems compared to teachers' work in low-income contexts in the Global South, the evidence that emerged speaks to the realities of resource-constraint contexts. Bruns et al.'s (2018) study was one of the first of its kind that described the impact of a Skype coaching intervention on secondary school teachers in Brazil. Possibly the most important is the study by Jukes et al. (2017). They used a combined model with multiple components, including training workshops, semi-scripted lesson plans, and weekly text support for teachers, and conducted a cluster randomised trial involving 51 primary schools in Kenya.

The results of this experiment showed that the combined intervention model, which included text message support, improved Grade 2 student literacy outcomes. While Jukes et al. (2017) provided strong support for the viability of using an ICT type intervention to support coaching teachers in their classrooms, they did not answer the following key questions: Is an ICT/digital technology bundled intervention with virtual or e-coaching (digital technology structured pedagogical programme [DTSPP]) as effective as a CSPP? If so, what are the impact mechanisms of the digital technology component on early grade reading outcomes?

2.1 Conceptual Framework

TAM (Davis, 1989) framed our analysis of the mechanisms of DTSPP. In terms of the framework, acceptance refers to the extent to which new digital technology is perceived to be useful and easy to use. According to Marangunić and Granić (2015, p. 81), the TAM *"has evolved to become a key model in understanding predictors of human behaviour toward potential acceptance or*

rejection of the technology". However, our use of the conceptual framework was less concerned with the specific operational aspects of the model and more concerned with how it differentiates between potential users' views of its usefulness on the one hand, ease of use on the other, and the relationship between these two perceptions and actual system use in practice. Figure 1 presents the core variables of the TAM, namely perceived usefulness, perceived ease of use, attitude, and behavioural intention, which could contribute to attitude, and by extension, to teachers' behavioural intentions to accept or reject technology. This study was premised on the TAM and the DeLone and McLean (2003) information systems success model. The interplay between the TAM and the DeLone and McLean information systems success model provided a lens to completely understand the complex dependent variables of technology-orientated operations in schools.

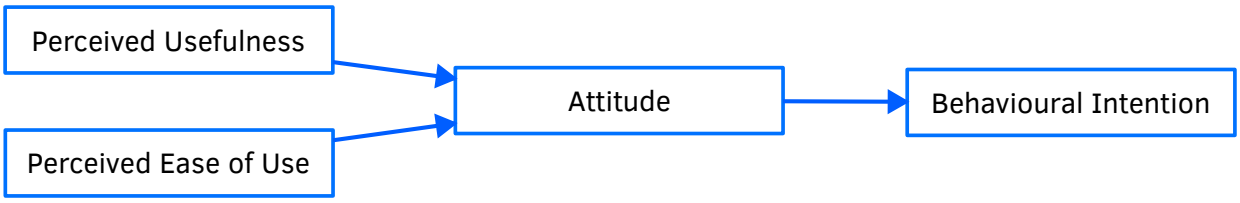

Figure 1: Modified TAM[a]

[a] Davis (1989)

Accordingly, the DeLone and McLean information systems success model allowed us to explore complex dependent variables in the positioning of digital technologies in the teaching profession in order to draw meaningful conclusions. DeLone and McLean defined *"six distinct dimensions of information systems success: system quality, information quality, use, user satisfaction, individual impact, and organisational impact"* (Urbach & Müller, 2012, p. 3). The six dimensions of information systems success are consistent with the TAM's construct, and their complementarity provided an integrated view on technology-orientated support of teachers to improve their professional practice. While much of the literature on teachers' acceptance of digital technology concentrated on the subjective element of the findings, the current study suggests the extent to which professional accountability may be a key factor in successful digital technology interventions for teachers and points to substantial differentiated uptake that is not linked to either perceived usefulness or perceived ease of use. Although systems quality contributes to behavioural intention and user satisfaction, the current study extended the theoretical framework with the additional dimension of professional accountability.

The increased affordances offered by digital technologies have become an attractive trend in the education sector to improve teachers' professional practices, but the quality of the support teachers receive is also a factor. Therefore, it is important for education leaders to pursue digital strategic plans to support teachers and enhance their professional practices. The TAM has been used to understand acceptance of new technologies by users in developed system contexts (Marangunić & Granić, 2015; Wingo et al., 2017), but the current study positioned

the TAM and the DeLone and McLean information systems success model core variables in a developing and resource-constrained context. It was also important to consider the individual impact and organisational impact beyond the perceived usefulness and perceived ease of use constructs. The interplay between the TAM and the DeLone and McLean information systems success model provided us with the lens to explore the multidimensional relationship and interdependencies among the different constructs in developing and resource-constrained contexts.

3 RESEARCH STUDY

Over the past ten years, the Early Grade Reading Study has been advancing knowledge on system-wide improvement of early grade reading in both African languages and English as a second language in South Africa (Cilliers, Fleisch, Kotze et al., 2019; Cilliers, Fleisch, Prinsloo & Taylor, 2019; Fleisch, 2018). Much of this new knowledge centres on the effectiveness and the mechanisms of a basic structured pedagogic change model, which is a combination of detailed daily lesson plans, high-quality educational materials, and centralised training, otherwise referred to as the CSPP. The current research showed that the approach is a cost effective and sustainable way to improve early grade reading teaching system-wide. The South African research confirmed new insights from similar research programmes in India (Banerji & Chavan, 2016) and Kenya (Piper et al., 2018). These unique government and university research programmes are committed to building evidence-based knowledge through long-term cumulative research that integrates experimental and quasi-experimental research (RCTs and regression discontinuity designs), large-scale classroom observations, and in-depth qualitative case studies.

While there is a general agreement that structured pedagogy programme models are effective, concerns have been raised about the relatively high cost of the onsite instructional coaching component and the size of the pool of high-quality coaches available, particularly for remote rural areas in the Global South. To address these concerns, the original Early Grade Reading Study II investigated the viability and cost-effectiveness of an alternative model that involved a combination of components using digital technology. In this instance, the digital technology involved a mixture of low-cost Android tablets, a custom-built lesson plan application, a library of short video-clips, cell phone voice calls, text messaging, and virtual competitions. Preliminary findings from the first year of the intervention suggested that both conventional and digital technology versions were equally effective in improving early grade reading outcomes in English as a second language (Kotze et al., 2019). However, the learning outcome results at the end of the third year of the interventions revealed very different findings.

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3.1 The Intervention Models

Both intervention models consisted of the following three core components:

1. detailed daily lesson plans;
2. integrated learning and teaching materials; and
3. professional development, which included both coaching and centralised training.

The first intervention model consisted of printed paper versions of the lesson plans, one-on-one onsite coaching, and cluster needs-based workshops after school. In the digital technology model, the teachers received a low-cost 10-inch Android tablet with electronic versions of the lesson plans in the form of a simple application. The tablet also included various audio-visual resources. Coaching was provided either on the tablet or on the teachers' smart phones (or both) via cell phone calls and WhatsApp messaging, which included text, voice, and video messages. The electronic lesson plan application was custom-developed for the study. This and all other electronic resources were available offline to ensure functionality without Wi-Fi or mobile data.

The additional electronic resources included short videos demonstrating good classroom practice; sound clips of the phonics sounds and songs and rhymes that appear in the learning and teaching materials; and PDF examples of learners' work. Teachers in both interventions were trained in a residential setting at the start of each term. Those in the conventional intervention group were trained for two days, and those in the digital technology group received an additional day to orientate themselves to the tablet and Android applications. In addition, both groups of teachers attended one-day cluster training sessions in small groups. If any teachers did not attend a training session, the onsite coaches organised a makeup session to ensure that the teachers had the learning and teaching materials and understood the instructional practices. Teachers in the conventional version of the intervention received visits from specialist reading coaches about once a month for the duration of the school year.

During these visits, the coaches modelled, observed, supported, and evaluated teachers' classroom practices and monitored learners' exercise books. Coaching in digital interventions involved a phone conversation with each teacher once every two weeks, regular text messages, and the establishment of virtual communities of practice. In the conventional version of the intervention, the specialist reading coaches modelled professional practice to educators during their visits, but the virtual reading coaches used WhatsApp for weekly motivational messages and also sent teaching tips to answer questions on the lessons. While the virtual coach also ran biweekly competitions for teachers to showcase their work to the wider group, the absence of embodied simulation in the digital intervention could be the reason why the digital technology did not improve early grade reading. Embodied cognition theory shows that simulation (modelling) works best when it is face-to-face because of all the bodily-based moments of recognition that occur (Soylu et al., 2014). Table 1 is a comparison between the conventional version of the intervention and the digital intervention.

Table 1: Comparison of conventional and digital interventions

	Conventional **Paper-Based**	**Digital Technology** **Electronic application on a tablet**
Coaching	Coaches visit teachers in their classroom once every three weeks.	Coach contacts the teacher via telephone calls and WhatsApp once every two weeks.
Training	*Initial training*: Two-day block training. *Quarterly training*: One day at the start of each term. *Needs-based training*: Biweekly competitions.	*Initial training*: Three-day block training. *Quarterly training*: One day at the start of each term.
Core Methodologies	Paper-based instructional manual	Application-based instructions that include videos, sounds clips, and photos of example writing.

3.2 The Randomised Control Trial and Complementary Implementation Data

The original Early Grade Reading Study II (a cluster RCT with two intervention arms, in the Mpumalanga province, South Africa) was designed to test the viability and cost-effectiveness of two different intervention models. Alongside the core baseline endline data collection, the study team collected extensive information about teachers' use of the technology and their beliefs about and attitudes towards digital technology in the classroom. The core instrument to assess the change in the average levels of learning was a modified version of the Early Grade Reading Assessment (Dubeck & Gove, 2015). Learner data were collected at the beginning of Grade 1, end of Grade 1, end of Grade 2, and end of Grade 3 (each was regarded as a data collection wave). Implementation data were collected at various points through the three years of implementation, particularly during the teacher training points and during onsite and virtual coaching sessions. Data on teacher use of the tablets were collected annually. The original sampling frame included 180 primary schools in two of the four districts in the Mpumalanga province, South Africa. Schools were included if they were designated in the three poorest quintiles on the national index and used either of two local languages, isiZulu or siSwati, as the home language in Grades 1–3.

The 2 684 learners who were assessed with the oral instrument and the slightly small number who were assessed with the written instrument were the same learners assessed at the original baseline assessment at the beginning of Grade 1. These learners included repeaters, mostly in Grade 2, and a handful of learners that appeared to be in Grade 4. Each successive set of instruments was designed in collaboration with language experts with the intention that the instruments would provide core information about learners' literacy skills in the home

language and their language and literacy skills in English, as the additional language. The school groups were mostly balanced on the various subtests at baseline. There were only two imbalances out of the 10 subtests, and both of these were on items that had either strong ceiling or floor effects. In the 2019 testing, there was balance in terms of learner age, gender, and principal component analysis (PCA) sub-score standardised to control (Table 2).

Table 2: Balance on learner age, gender, and PCA sub-score standard

Variables	(1) Best possible learner age based on response and date of birth	(2) Learner Gender: Boy = 1	(3) PCA: Sub-Scores Standardised to Control
Onsite Coach	0.0330 (±0.0536)	0.0158 (±0.0204)	-0.000198 (±0.070800)
Virtual Coach	0.0248 (±0.0594)	0.0133 (±0.0241)	0.1100 (±0.0709)
Observations	2684	2684	2684
R-Squared	0.016	0.002	0.025
Control Mean	6.093	0.535	0.00525

Of the 3 327 learners that were tested at baseline, 2 684 were retested at the end of Grade 3, yielding an attrition rate of about 19.3%. When we regressed the intervention assignment on the probability of attrition and controlling for the gender and language dummies, the results showed that there was no bias in attrition in any of the intervention groups. As part of the pilot study in 2015, the research team worked with a group of eight teachers in schools that were not part of the full trial to field test the tablet and the application, and the team also observed classrooms and did extensive in-depth interviews to ascertain potential weaknesses or flaws in the tablets, virtual coaching processes, and the lesson plan application. As such, the qualitative data generated in the pilot phase were incorporated into the analysis. Administrative data collected as part of the implementation of the large-scale trial provided extensive information about attendance at face-to-face training sessions and the condition of tablets at the end of the intervention. One unanticipated source of key evidence emerged from an analysis of the data downloaded from the applications at the end of Term 3, Year 3.

The extraction of data was originally designed to help the application designers better understand usage patterns. Data from 56 Grade 3 teachers' tablets were accessed, and this data were derived from records of the frequency, time, and types of files accessed on the tablets. Several variables were prepared after cleaning the data and anatomizing the records. These included average time spent on the videos, audio files, examples, and PDF files of explanations. This data provided invaluable information on the patterns and prevalence of tablet use. Special attention was paid to the pattern of use of the various lesson plan pages on the tablet application. An inverse cumulative density function opened for at least five seconds was calculated, which allowed individual slides to be counted every time they were accessed for more than five seconds. The data on tablet use provided insights into actual ease of use and the distribution of use between teachers.

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4 FINDINGS

The main findings provide a picture of the impact of the interventions, relative to the control group, on learning outcomes after a full three years of implementation. In Table 3, we only provide the results for the overall impact of the interventions for learners who were enrolled in Grade 3 (for the results for the full sample, which does not differ significantly, see Cilliers et al. (2021). Table 3 shows that learners in the conventional intervention model group performed better on both the oral proficiency and the decoding components of the assessment. This was not the case for learners in the digital technology group. The finding is congruent with other studies (Dlamini, 2022; Dlamini & Rafiki, 2022; Mhlongo & Dlamini, 2022) on digital skills deficit among teachers to pedagogically integrate technology in their professional practice. Although these learners did a little better in the oral English tasks, they were substantially below the oral language proficiency levels of learners in the conventional intervention group and did no better than the learners in the control group in English reading aggregate statistics (PCA).

Table 3: Main results for English First Additional Language, Grade 3 only

Variables	**(1) Oral Prof.**	**(2) Reading**	**(3) Vocab**	**(4) L. Compr.**	**(5) Word Recog.**	**(6) Read Fluency**	**(7) Read Compr.**	**(8) W. Compr.**
Conventional Model								
	0.356*	0.179†	0.258*	0.351*	0.176*	0.122‡	0.271*	0.104
	(±0.078)	(±0.072)	(±0.064)	(±0.084)	(±0.067)	(±0.071)	(±0.085)	(±0.075)
Digital Technology Model								
	0.149‡	-0.015	0.086	0.170‡	-0.031	0.016	0.106	-0.033
	(±0.078)	(±0.076)	(±0.068)	(±0.082)	(±0.072)	(±0.075)	(±0.078)	(±0.069)
Observations	2148	2109	2148	2148	2148	2148	2148	2109
R-squared	0.27	0.273	0.248	0.213	0.24	0.241	0.248	0.183
P-value	0.0223	0.0208	0.0185	0.0614	0.00786	0.187	0.0835	0.1
Control Mean	0.139	0.17	0.13	0.108	0.159	0.152	0.126	0.161

* $p < 0.01$
† $p < 0.05$
‡ $p < 0.1$

4.1 Why did the digital technology model fail to help students make gains?

Why would researchers be concerned with or pay close attention to the reasons for the failure of a digital technology-based innovation designed for early grade teachers and their students? Is it not sufficient that we know that it had limited impact? The evidence of the failure of a promising innovation is always likely to add to the wider body of knowledge, but if we take Deaton and Cartwright's (2018) insight about the 'why' of innovation, we discover that the mechanisms of both success and failure are of paramount importance in our efforts to better

understand how digital technology can contribute to improving learning outcomes. This was not in anyway failure of the digital technology, however digital skills gap among in-service teachers is a reality (Dlamini & Mbatha, 2018; Dlamini & Rafiki, 2022). The RCT was never designed explicitly to furnish rigorous evidence of possible reasons for innovation failure. As such, an excavation of the various layers of the intervention would at best yield hypotheses or working theories that future work could corroborate. The methodology of the excavation began with the most straightforward surface questions: Was the digital technology ever actually delivered to the teachers? Was the technology operational? Once we have established this, we can proceed with questions that go deeper into the implementation process.

4.2 First layer: Functionality

Did the digital intervention fail for simple reasons, such as the teachers did not get the tablets; they did not get training on how to use the tablets; they did not have Wi-Fi or power to charge the tablets; or they did not have data to communicate effectively with the virtual coach? We hazarded a guess that in many digital technology interventions in schools in the Global South one needs to look no further than the first layer to discover the causes of intervention failure.

According to the administrative data from the main service provider, the teachers all reported receiving functioning tablets, and they did not seem to have any problems with either access to data or electricity to recharge the devices. The teachers all received training on both the technology and the content of the material on the tablet. In other words, there was close to comprehensive delivery of the basic technical infrastructure and training in the project (Table 4).

Table 4: Implementation data: Teacher attendance at training and resources received for July–November 2019

		#Teachers	#Teachers Fully Trained	#Teachers Fully Resourced
Term 1	**CSPP**	86	83 (97%)	86 (100%)
	DTSPP	85	84 (98%)	85 (100%)
Term 2	**CSPP**	86	85 (99%)	86 (100%)
	DTSPP	83	83 (100%)	83 (100%)
Term 3	**CSPP**	86	85 (99%)	86 (100%)
	DTSPP	82	82 (100%)	82 (100%)
Term 4	**CSPP**	86	79 (92%)	86 (100%)
	DTSPP	82	80 (98%)	82 (100%)

In terms of the virtual coaching itself, the administrative data suggested that in addition to the regularly scheduled contacts, there were additional virtual coach-initiated coaching sessions. For example, in Term 3, 2019, teachers received, on average, two individual coaching

session each. Table 5 reveals that the Android tablet was remarkably robust and that teachers did not have serious problems with damage or theft. All teachers in all three cohorts had operational tablets at the end of the intervention year, and 88% of Grade 1 teachers had working tablets 24 months after their participation in the intervention had ended. Two possible interpretations could be offered for the durability of the tablets. Firstly, the teachers valued the devices, and thus, kept them in safe, good working order, or secondly, they seldom used them.

Table 5: Tablet status at the end of the intervention period

Issues	DTSPP (Tablet Provision)
No. of tablets distributed to Grade 1 teachers in 2017	90
No. of Grade 1 tablets operational at end 2017	90
No. of Grade 1 tablets operational at end 2019	79
No. of tablets distributed to Grade 2 teachers in 2018	80
No. of Grade 2 tablets operational at end 2018	80
No. of Grade 2 tablets operational at end 2019	77
No. of tablets distributed to Grade 3 teachers in 2019	82
No. of Grade 3 tablets operational at end 2019	82
Total no. of tablets distributed	252
Total no. of tablets operational at end 2019	238

4.3 Second Layer: Technology Acceptance Model

The second layer relates to subjective aspects. Even if the digital technology was delivered, teachers were trained in how to use it, and it remained in working order for the duration of the project, emotional responses to the technology can either encourage or inhibit it being used effectively. The basic framework to understand these subjective factors is the TAM. The model assumes that if individuals perceive the technology not to be useful in the workplace and as difficult to use, the technology is unlikely to be accepted and used. Conversely, if the technology is viewed as useful and easy to use, then take-up is likely to be high.

In the pilot study in preparation for the larger trial, the research team tested out the prototype tablet and related application with 11 schools that did not form part of the larger study. The focus of the pilot was on teachers' perceptions, their self-reported competencies with digital technology, the quality of the training, and detailed elements of the working of the application as it related to early grade reading methodologies. The key findings of the pilot were that most of the teachers owned smart phones but few had any experience with computers. All but one teacher reported that it was the first time they used a tablet. Despite

the limited familiarity or experience with digital technology in general, five weeks into using the tablet and application almost all interviewed teachers reported agreeing or strongly agreeing that the tablet and the application were easy to use and that they were useful in their teaching. Hence, there was no question on the pedagogical affordances of tablets and the application in their professional practice (Mhlongo et al., 2023). While, the pedagogical affordances of digital technologies have been well researched and documented, the education sector in South Africa continues to struggle in the adoption and leveraging of digital education innovations (Dlamini & Ndzinisa, 2020; Ndibalema, 2022; Ndzinisa & Dlamini, 2022).

Overall, most teachers found the instructions on how to use the application clear and said that the training enabled ease of navigation. They found the font size to be adequate and the colour coding of activities clear and easy to follow. A few teachers reported being confused by the colour coding on the activities and word charts. Overall, the teachers in the pilot study reported a preference for the tablet and the lesson plan application to a conventional paper version. The reasons given where that the tablet is easier to take home, portable, and more convenient than paper versions (it fits into a handbag). They described the tablet as user-friendly and used phrases such as *"everything is in"*. As one teacher suggested, *"We are tired of paper!"* Another teacher preferred the digital technology, saying, *"The tablet, because the paper can be lost, torn easier"*. Another teacher said the following:

> *I don't carry a big file. At home, I open it and I know I have prepared for the next day. It is so easy. I don't have to read and have many books. It is easy to take home. Before, I was intimidated by the technology, but now it has opened my mind.*

There were some less sanguine observations. One teacher observed, *"I only use in preparation. We don't need it in the classroom, just in prep mode."* That said, this teacher indicated that she did use the tablet *"when I teach."* Another teacher described reviewing the tablet application in preparation mode in the evening before the lesson. A number of teachers questioned the sound quality. As noted below, a number of teachers used the audio directly with the whole class, notwithstanding the fact that the tablet speaker was not intended for this purpose. One teacher said, *"Mostly we used preparation mode. It is easy to understand and present to learners. The learners can listen to the songs; the learners understand the meaning of the song"*.

One teacher identified the songs and the flashcards as the two most valuable components of the digital programme, saying, *"I use all audios, because they help to learn the tunes of the songs"*. On the resources in the preparation mode, some teachers indicated that they particularly liked specific features such as the videos. As one teacher put it, *"It helped me set up my charts and with questions."* This particular teacher indicated that she watched the video numerous times. Other teachers reported only watching the videos once, and one teacher never found the video button. One teacher found the questions of the day video most helpful: *"I don't know how to question learners, but through the videos I am able to do it."* One teacher singled out the video guide to improving classroom management, which demonstrated how to manage children while teaching. Unlike most teachers, one teacher insisted that *"there are no videos."* Another teacher admitted, *"I haven't checked the videos as yet. I forgot about them"*, and a third said,

"Never used them." On the WhatsApp group, one teacher said, *"I used the WhatsApp group, but the data finished at the end of October."* Another teacher noted, *"I don't receive any messages from the group."* One teacher raised a concern that *"the tablet consumes lots of airtime [data]."*

The researchers observed teachers using the tablet and the application in the classroom, and none of them appeared to be using them for the first time. Most had the tablet on at the start of the lesson. While some used in-class mode, most used preparation mode. A few teachers started the tablet from an off position. There was considerable variation about where teachers placed the tablet. Some placed it on their desks and moved back and forth to consult it between activities. Others held the tablet in their hands and read from it consistently throughout the lesson. One teacher struggled to find the reading 'Lucky's Taxi', and the researcher helped the teacher locate the story. There was considerable variation between teachers in the types of activities where the application was used intensively. Some teachers used the application to help guide the questions of the day, and others used it for specific sections of the shared reading activity. Some used it only to read aloud. Although we did not observe this, it was evident from the interviews that a significant portion of the teachers used the audio clips with the learners, which explains why they suggested stronger speakers for the tablets. With a few exceptions, teachers using the tablet and application were either confident and competent or very confident and very competent. One teacher got stuck navigating between preparation mode and in-class mode. Another played a song and wished to play it again but was unable to navigate to it a second time. In an informal interview with a principal, it emerged that a teacher did not understand the time allocation on each of the pages and that the total number of minutes was not for the screen but for the entire activity, which may have multiple screens.

In Term 3, 2019 teachers accessed slides between July and September for lesson planning and preparation. There is evidence that at the beginning of the term the digital technology group accessed slides to guide their teaching, however towards the end of the term there is evidence that less teacher referred to the slides. This is an indication that the lesson plan is a roadmap of what should be learned and allow teachers to develop appropriate pedagogical activities. All the teachers in the digital technology group opened at least one of the lesson plan slides; about 65% reached at least 40% slide coverage; and 27% covered more than 60% of the term's slides. This data indicates that some teachers treat lesson plans as add-ons instead of a critical resource for their instructional planning.

The breakdown of slide coverage of Term 3, 2019, week-by-week provides evidence that slides access dependent on the term period. Earlier in the term about 64% of the slides were covered, while towards the end of the term, in week 10 about 19% of the slides were covered. Week 7 was particularly well covered, which was almost certainly because this was the week in which the official curriculum prescribed assessment task took place. Teachers were expected to upload assessment results onto the government-wide school management system into which teachers have to upload various learner assessment data. It is also interesting that aside from Week 7, there seems to be a pattern of better coverage earlier in the term (Weeks 1, 2 and 3) with a steady decline in coverage until Weeks 9 and 10, which had the lowest levels of coverage. This indicates that some topics were not comprehensively covered and is a concern to us that

teachers lack understanding of the importance of lesson plans. Yet, lesson plans needs to be checked continuously as a roadmap, resource and historical document for teachers to reflect on their teaching and content coverage.

Again, from the perspective of ease of use of the digitized lesson plans, teachers are encouraged to always think and reflect on the slides weekly instead of using the application when there is a bureaucratic requirement to post assessment results. At the outset, teachers are encouraged to think of instructional activities appropriate for their classroom and the slides are appropriate application for their planning and reflection.

The second year case study report noted that *"virtual coaches and tablets are a successful mode of delivery for the EFAL [English First Additional Language] programme and teachers in this study were unequivocally positive about it."* The second year case study concentrated on interviews and observations of eight teachers, so the claim was based on a very small sample of teachers in the study. Botha and Schollar (2018) identified the specific reason teachers were *"unequivocally positive"*: The teachers who got the tablets and the application particularly liked the audio files that gave second language teachers access to standard English pronunciation of both sounds and words.

4.4 Third Layer: Differentiated Uptake

To answer the question about the failure of the digital technology intervention to improve learning outcomes, we explored the possibilities that the technology and related training were either not delivered at the outset; the technology and related training were of uneven quality; or that during the life of the project, the digital technology failed to function, got damaged, or was stolen. The available evidence suggests that none of these applied. The second layer of evidence related to the subjective or affective responses of teachers to the digital technology intervention. Following the TAM, we examined the available qualitative and quantitative evidence on the digital technology's ease of use and usefulness in daily work. Although a TAM survey was not conducted, an analysis of existing evidence suggested that, as a sample, the teachers in the intervention found the digital technology deployed in this experiment (the tablet and the application) relatively easy to learn to use and easy to use. They found the tablet and the virtual coaching useful in their work as teachers, particularly for some core functions.

Could it then be that differences between types of teachers could explain the lack of impact? Put another way, could it be that a small groups of teachers really benefitted from the digital technology component of the intervention programme (as suggested by the case study teachers in the Year 2 evaluation) and improved their practice, which had a strong positive impact on their learners' learning outcomes, but that most teachers, who could use the technology and did so but to a very limited extent, failed to get ignited by the technology, and therefore, it had little effect on their practice, leading to the absence of gains in learning outcomes. A differential teacher effect hypothesis raised three questions. Firstly, are there clearly discernible initial characteristics associated with teachers who responded to the technology in

a particular way? Then, the more complex question: What are the mechanisms associated with the digital technology component? What works for some types of teachers but not for many others? Lastly, why would the conventional intervention model work for different types of teachers?

One of the common assumptions is that age could explain different levels of engagement with a digital technology intervention. It is often assumed that digital natives (adults who grew up with digital technology) are substantially more open to using digital technology in a reading teaching intervention than digital immigrants (see Prensky (2001) for definitions of the categories). The most obvious factor that differentiates digital natives from digital immigrants is age. However, Brown and Czerniewicz (2010) clearly showed that this idea has limited validity in the South African context. The evidence from the Early Grade Reading Study II does not support this hypothesis. As the statistics in Table 6 show, in the subsample of teachers for whom we have tablet usage evidence, younger teachers (below 45) and older teachers (over 55) were more likely to spend time on the tablets than teachers in the middle age band. In terms of the total number of slides covered during the term, the numbers were very similar across the three age bands, even though the middle age band group of teachers covered less of the prescribed work in Term 3 on their tablets.

Table 6: Tablet usage by teacher age

	#Teachers	Average Hours	Total Slides Covered	Average Coverage of Term 3
Younger than 45	9	17.6	567.5	50.1
45–54 years old	26	13.6	550.1	43.7
Older than 55	10	22.9	559.9	53.4

A potentially useful avenue via which to explore differential teacher engagement was analysing the teachers' responses to the virtual coach's competition. To get a better sense of how teachers were implementing the core methodologies, the virtual coach introduced small competitions around specific themes. For instance, in Term 3, 2019, she focused on phonics and asked all her teachers to submit a photo via WhatsApp video of one of their phonics activities. She then chose the best teacher based on the image or video in each of the teacher groups. The teachers won airtime as a prize. The competitions allowed the virtual coach to see into the classroom and to gather evidence about what teachers considered their best practice in their classrooms to be. Table 7 shows the variability of teacher participation in the competitions. Just under a quarter of the teachers entered every competition. At the other end of the spectrum, 22% of teachers were completely inactive. Given that teachers were allowed discretion to enter or not, the pattern of participation may be a proxy indicator of motivation and commitment. The assumption is that those who did not enter at all were overall less likely to be engaging meaningfully with the digital technology and those who participated in every competition thrived in the new technology space.

Table 7: Participation in virtual coach competitions

#Competitions	#Teachers	% Teachers
0	18	21.69
1	18	21.69
2	16	19.28
3	12	14.46
4	19	22.89
Total	**83**	**100%**

Teachers in both the conventional and the digital technology interventions attended the early grade reading training at roughly the same rate: close to full participation. While all school heads of department and other members of the school leadership teams were invited to the training sessions, attendance at these was substantially lower for the digital technology schools, especially in the second half of the year (Table 8). One possible explanation is that the conventional approach (paper-based and onsite one-on-one coaching) involved regular visits to schools during which the coach interacted with both other foundation phase teachers and school managers, thus strengthening the school communities of practice. In contrast, the technology intervention tended to focus more directly on the relationship of the virtual coach with the individual teachers and did not trigger conversations between teachers and management team members at school level.

Table 8: Implementation data: Senior Management Team (SMT) member attendance at training

		SMT members trained
Term 1	**CSPP**	38 (76%)
	DTSPP	31 (63%)
Term 2	**CSPP**	85 (99%)
	DTSPP	25 (51%)
Term 3	**CSPP**	36 (72%)
	DTSPP	19 (39%)
Term 4	**CSPP**	32 (64%)
	DTSPP	14 (29%)

The following observation that the virtual coach made regarding the lower levels of enthusiasm on the part of some school leadership teams and links to teacher engagement confirmed this insight:

> *Yeah, it's really difficult. A lot of the time I have to like phone the SMT and say like, "Listen, I've been trying to get a hold of your teacher, please make sure that, you know, they've got*

> *their tablet switched on and they check their WhatsApp's and things like that". A lot of the time you'll find that if a teacher is one of those teachers, they come from a school where the SMT isn't very active, so it's difficult.*

In the final report from the implementing agents, the evidence that *"innovative programs that allow meaningful support to teachers at a large scale must continue"* (Cilliers et al., 2022, p. 29). In the second year school case studies, Botha and Schollar (2018) reported distinct advantages and disadvantages of the conventional model compared to the digital model. They found that three of the teachers in the digital technology case studies were not well prepared, were more dependent on the lesson plans on the tablets during teaching, and did not pay as close attention to pacing in the lessons. The 2019 case study researcher (Fleisch & Alsofrom, 2022) gave the following analysis:

> *The tech-based intervention inherently includes distance, the barrier to success may be self-motivation. Teachers still feel supported, but there is not a strong enough accountability mechanism. …it was successful primarily for teachers who were motivated enough to drive their own development process. Basically, it is teachers who are self-motivated (or are perhaps in an already functional school environment where accountability is provided through principal or colleagues interactions) where the technological intervention seems likely to be most impactful.*

A pattern emerged when we compare and contrast the diverse evidence. There was substantial variability in the uptake of the digital technology intervention among teachers in the study sample, with roughly a quarter of them fully engaged and another quarter not engaged at all. Unlike an onsite coaching approach that involves visiting schools and talking to teachers face-to-face, the virtual coach struggled to hold teachers accountable and mobilise the wider school management team to support and monitor compliance with the intervention requirements. More broadly, the virtual coaching model was less successful with relationship building and creating professional accountability linked to the new instructional practices associated with improved reading outcomes.

Figure 2 presents the distribution of average school Oral Reading Fluency (ORF) from lowest to highest for the conventional (blue) compared to the digital technology (red) intervention schools. There is a high degree of overlap of the box-and-whisker plots, indicating that there is no significant difference between the two interventions. Although no causal inferences can be made from this graph, it is suggestive that both interventions appear to have a roughly equal proportion of successful schools, but that for average and below average schools, receiving the conventional intervention model benefitted these schools more than the digital technology intervention.

5 DISCUSSION

Given the limitations associated with intervention administrative data, purposively chosen case studies, and information from the tablet logs, the insights presented here should be viewed

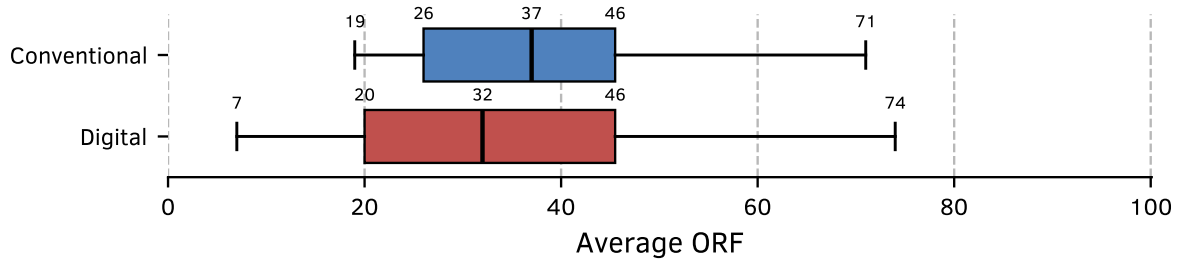

Figure 2: Distribution of Average School ORF, English First Additional Language

as hypothesis building. Nested in a cluster randomised study of two similarly structured pedagogic programmes of which one used a conventional model of paper lesson plans and onsite coaching and the other used tablets and an application with virtual coaching, the study provided an opportunity to excavate the multiple layers required to understand how digital technology can become a tool to improve learning outcomes at scale. By a process of elimination, we were able to establish that it is unlikely that the digital technology hardware or software could explain the slow improvement. The evidence suggests that the devices were durable and that the custom-developed software had few glitches and was easy to master. Using the TAM framework and interpreting available evidence showed that there is reason to believe the slow progress should not be attributed to teachers' negative perceptions of its usefulness and ease of use.

We suggest the following alternative hypothesis: The teachers were not a homogeneous group but were diverse in their beliefs, attitudes, and take-up of the digital innovation. Smagorinsky et al. (2002) had this insight about various positions and responses imposed by top-down curriculum reforms. In this study, teachers adopted one of three diverse responses to reform/innovation: open resistance, accommodation, and acquiescence. For our purposes, we think an alternative set of positions or responses is more appropriate: technology avoiders, minimalists, and technology enthusiasts (Zur & Walker, 2011). Technology avoiders are teachers who may not actively resist the reform innovation but who do not engage with the technology and associated tasks required of them. Minimalists, on the other hand, make an effort to appear to be engaged but only do so to save face or avoid sanction. At the other end of the spectrum, technology enthusiasts engage fully with the innovations and find ways to adapt and internalise them. These three positions/responses must be seen as heuristic devices rather than sharp, well-defined, and empirically proven categories. Although these are suitable categories for the purposes of better understanding mechanisms of change, teachers' responses exist on a spectrum rather than as distinct, clearly bounded groups.

The second assumption we make is that these groups/categories are likely present in any reform intervention, whether conventional or digital. The critical difference, however, between conventional and digital interventions in this case was that the conventional onsite coaching intervention did not allow minimalist teachers to get away without showing change in their classroom practices. Teachers accustomed to minimalist approaches in the conventional re-

form needed to save face, avoid humiliation or embarrassment, and preserve their dignity by showing some of the reform work. This explains why the average school performance was more or less similar at the top end and different at the middle and lower ends with conventional intervention schools on average outperforming comparable digital technology intervention schools.

This observation adds credibility to the hypothesis that the slow progress of the digital technology intervention was: (a) on the interpersonal and emotional side of the change process, and (b) due to the difficulty that the virtual coaches had accessing actual teacher work in the classroom. In other words, face-to-face conventional interactions are more likely to improve trust and allow for professional accountability.

6 CONCLUSION

One of the key issues for discussion is not whether the digital technology intervention model works (i.e. that it provides consistent and statistically significant evidence of cost-effectiveness) but whether the intervention model helps reduce what the World Bank (Azevedo et al., 2019) called *"learning poverty"* fast enough to achieve the 2030 Sustainable Development Goal in education. Although eliminating learning poverty is generally associated with the ability to read by the end of primary school, the benchmark of reading for meaning in English at the end of Grade 3 is an appropriate benchmark in South Africa because English is the language of instruction from Grade 4 onward for the majority of learners and it is the de facto language of government and the economy. If escaping learning poverty is associated with being able to comprehend a simple story, the structured pedagogic programme with the CSPP model works. However, more research is needed to understand how a digital technology version of the structured pedagogic programme could be more successful.

The starting point of this paper was the following question: Why did the ICT intervention fail to improve learning outcomes in South Africa's Early Grade Reading Study? At its most basic, the TAM suggests that acceptance of digital technology is a function of a combination of individuals' perceptions of the usefulness of the technology and of the relative ease of use. If individuals perceived that the technology is useful in their work and/or personal lives and that the technology is easy to learn and use, they are likely to accept and adopt the new technology. In accordance with Zhang et al. (2019, p. 208), the perceived usefulness, perceived ease of use, and attitude constructs *"are antecedents of technology acceptance."* However, the evidence in this study points to the following key findings:

- The centrality of professional accountability in successful digital technology interventions for teachers; and
- There is substantial differentiated uptake not linked to either perceived usefulness or perceived ease of use.

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This is significant for developing and resource-constrained contexts. Both attitude and behavioural intention constructs are dependent variables in Figure 1, and in this case the differentiated uptake is dependent on professional accountability. According to UNESCO (2017, p. 1), accountability is *"a process, aimed at helping actors meet responsibilities and …goals."* Although attitude influences users' behavioural intention to adopt and appropriate digital technologies in their professional practice, in this study there was no evidence associated with the differentiated uptake as a means to improve learning outcomes. The converse applied: If individuals come to think of the technology as not particularly helpful or useful and difficult to learn and use, once they have mastered how it works, they are unlikely to accept and ultimately adopt the new technology. Acceptance exists on a spectrum, and high usefulness and high ease of use are on the one end of the spectrum and low usefulness and low ease of use are on the other. Most individuals and groups fall at different points along the continuum.

We did not do a survey of teachers' perception of the digital technology intervention, which would have told us where they fit on the TAM spectrum. The evidence suggests three critical insights. Firstly, there was considerable variability in teachers' engagement with the digital technology intervention. Secondly, this variability was not driven by teachers' perception of the usefulness or ease of use of the various components of the digital technology intervention. Thirdly, the digital technology intervention did not allow the intervention into the classroom nor did it mobilise communities of practice at school level. The latter two insights suggest that trust and technology may be critical to understanding successful digital technology interventions in schools.

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Research Article

Generative AI: Concerns, usage, challenges, opportunities and sentiments

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ABSTRACT
Despite widespread adoption and enthusiasm, Generative AI faces persistent technical challenges, prompting the need to understand its broader impact. This study employed bibliometric analysis to examine scholarly discourse and key drivers of Generative AI adoption. The findings reveal the key factor driving adoption as transdisciplinary collaboration regardless of region; the concerns relate to inconsistent accuracy, demanding infrastructure, and ethical and privacy issues. Generative AI's rapid proliferation, spurred by ChatGPT, marked a post-digital era marked by transformative innovations across multiple fields. The scholarly discourse has grown by 3,164%, reflecting its significant influence on research and disciplinary progress. Education, medical, and biomedical sectors lead in adoption, to enhance teaching experiences, diagnostics, personalised medicine, and pandemic responses. However, the digital divide persists, leaving certain demographics and regions unable to access its benefits equally. The absence of robust ethical, legal, and regulatory frameworks further exacerbates these challenges. This study reveals Generative AI's transformative potential and its ability to bridge disciplines despite technical hurdles. The study makes recommendations for education reform to embrace new curricula, for practitioners and policymakers to create flexible workforce options, to proactively address important ethical, legal, and regulatory considerations; and to be intentional about bridging the widening digital divide.

Keywords artificial intelligence, generative AI, ChatGPT, bibliometric, ethics, scoping review, sentiment analysis, transdisciplinarity, post digital theory

Categories • **Applied computing** ∼ **Computers in other domains** • *Computing methodologies* ∼ *Artificial Intelligence*

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1 INTRODUCTION

Machine Learning (ML), Artificial Intelligence (AI), and Natural Language Processing (NLP) have advanced rapidly in recent years, enabling the creation of powerful platforms like ChatGPT and other Generative AI (GenAI) models, which are collectively referred to as Large Language Models (LLMs). While AI embraces a broad spectrum of technologies aimed at simulating human intelligence, GenAI specifically focuses on generating new content such as text,

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images, or code by learning patterns from existing data (Hagos et al., 2024). GenAI technologies were initially discovered and developed in the mid-2010s but their widespread recognition surged from November 2022, following the launch of ChatGPT by OpenAI. ChatGPT reached over a million users within just five days of its launch, marking a pivotal moment that demonstrated the practical applications of GenAI and accelerated its widespread acceptance. This paper builds on preliminary findings presented at the South African Institute of Computer Scientists and Information Technologists (SAICSIT) 2023 Conference, extending the analysis to provide a more comprehensive exploration of GenAI's transformative potential, challenges, and societal implications (Twinomurinzi & Gumbo, 2023).

The core components of ChatGPT, and by extension other GenAI models, are constructed on three foundational building blocks; the transformer architecture, pre-training process, and fine-tuning process (Iskender, 2023). The transformer architecture utilises a neural network that is able to analyse large datasets at scale to allow for parallel processing of input data. Previously, the transformer model relied on self-attention mechanisms, which enhanced its ability to process sequential data efficiently. This foundational concept was later significantly advanced and expanded upon with the development of the Generative Pre-trained Transformer (GPT) series which used generative pre-training to learn language patterns from extensive text data. GPT-2 advanced the technology with multi-task training, improving the model's ability to generalise across various tasks. GPT-3 increased the model size, improving its fluency and comprehension capabilities (Iskender, 2023). With InstructGPT, the focus shifted towards integrating human feedback into the training process, resulting in more accurate and context-aware responses. The development of ChatGPT and GPT-4, meant GenAI was not only scaling up in size, but also integrating human feedback mechanisms (prompts) and the capacity to process image inputs (Iskender, 2023; OpenAI, 2025; Temsah et al., 2024; Zhong et al., 2024). Building upon these advancements, OpenAI also recently introduced the o1 model, which includes enhanced reasoning capabilities to reduce hallucinations and instances where AI generates incorrect or fabricated information (OpenAI, 2025). This improvement is particularly crucial in fields like healthcare, where accuracy is critical. For example, o1 has demonstrated superior performance in generating coherent and accurate radiology reports, outperforming other evaluated models (Temsah et al., 2024; Zhong et al., 2024).

GenAIs are versatile and, therefore, extend to a wide range of use cases, with about 75% of their value projected across the four key areas of customer operations, marketing and sales, software engineering, and R&D (McKinsey & Company, 2023). In customer operations, GenAI enhances customer experience and agent productivity. In marketing and sales, GenAI revolutionises content creation and personalisation. It facilitates the generation of personalised messages and marketing materials suited to individual customer preferences, behaviours, and interests. GenAI's capability extends to creating advertisements, social media posts, and product descriptions, substantially enhancing the productivity and creativity of marketing functions. In software engineering, GenAI is redefining the coding process by treating computer languages as natural languages. This transformation allows software developers to complete tasks 56% faster (McKinsey & Company, 2023). GenAI's influence in R&D is significant, particularly in

accelerating the development of new drugs and materials. For example, in the life sciences and chemical industries, GenAI foundation models are being used to generate candidate molecules, significantly speeding up the R&D process (McKinsey & Company, 2023). These advancements across different sectors illustrate the extensive impact of GenAI, not just in enhancing current practices but also in paving the way for novel approaches and efficiencies in various sectors. The technology's ability to understand and generate natural language plays a pivotal role in this transformation, marking a significant leap in automation and innovation potential. These examples highlight the versatility and potential of GenAIs to enhance productivity, streamline content creation, and improve the efficiency of text-related tasks in various domains. However, to ensure their responsible and ethical deployment in real-world applications, it is important to carefully consider the ethical implications and technological challenges associated with the use of GenAI. There are, therefore, divergent discourses surrounding the use of GenAI tools such as ChatGPT and similar GenAI. For example, Italy initially banned ChatGPT citing privacy and data infringement concern (McCallum, 2023).

The main objective of this study was to provide a holistic view of the usage, concerns, challenges, and optimisms of GenAI. A bibliometric analysis was done using the Scopus and Web of Science (WoS) databases, and the identified publications were analysed and visualised using Bibliometrix® and VOSViewer® tools (Aria & Cuccurullo, 2017; VOSviewer, 2025). Specifically, the study sought to answer the following research question:

> *How are prevalent patterns of GenAI usage represented in scholarly discourse, and what key factors are identified as driving the adoption of these technologies?*

The study contributes to our understanding of GenAI integration and its societal impact. Firstly, it provides insights into the transdisciplinary dynamics shaping GenAI adoption across diverse sectors, highlighting the complex relationships between technological advancements, ethical considerations, regulatory frameworks, and societal values. Secondly, it offers an analysis of the ethical challenges inherent in GenAI development and deployment, shedding light on issues of bias, fairness, transparency, and accountability, and proposing strategies to navigate these ethical dilemmas responsibly. Thirdly, the study contributes to the discourse on regulatory governance and policy interventions necessary to ensure the responsible and equitable integration of GenAI, emphasising the importance of adaptive regulatory approaches that balance innovation incentives with societal values and individual rights. Lastly, the research underscores the need for inclusive and participatory approaches to GenAI development and deployment, emphasising the importance of engaging diverse stakeholders in transparent and informed discussions about the opportunities, risks, and ethical implications of GenAI.

This study distinguishes itself from other similar bibliometric reviews of GenAI by adopting a broad, cross-disciplinary lens to explore the impacts, going beyond domain-specific focuses like ChatGPT's role in healthcare (Lopes, 2024) or education (Liu et al., 2024). Unlike Khan et al. (2024), which emphasises general trends and geographic analyses, or R. Dwivedi and Elluri (2024), which limits its scope to technical fields and topic modelling, our study employs inductive thematic analysis to uncover richer insights across disciplines. Also, by separating pre- and post-ChatGPT trends and addressing GenAI's role in stimulating new fields and

educational reform, this study offers a unique and forward-looking perspective on GenAI's transformative potential.

The remainder of the study is structured as follows: The next section provides an overview of the methodology employed to conduct the study followed by the results and discussion. Finally, the contributions, limitations, conclusions of the study, and proposed research agenda are presented.

2 RESEARCH METHODOLOGY

Bibliometric analyses are increasingly popular as a means to identify trends in data, such as the influence of authors, the most cited articles, and top contributing countries (Aria & Cuccurullo, 2017). In this study, we employed the method to explore the scholarly discourse on GenAI, focusing on its usage, challenges, opportunities, concerns and sentiments. The process involved collecting, analysing and visualising data, and then reporting the findings and inferences.

For the data, we conducted a search of Scopus and WoS on 9 November 2023 using the search string: ('Generative AI' OR 'generative artificial intelligence' OR 'AI generation' OR 'GenAI' OR 'ChatGPT' OR 'large language models'). We used WoS and Scopus because they are compatible with bibliometric tools like Bibliometrix®, ensure high-quality data, and currently represent the most practical options. Grey literature was not included to maintain a focus on peer-reviewed, high-quality, and standardised academic sources, which are critical for ensuring rigour and replicability.

We retrieved 3320 articles from Scopus and 1869 articles from WoS. Since we preferred peer-reviewed publications, we narrowed down the list to include only refereed journal articles and conference publications. We also included journal articles in press. Additionally, we limited the search to only those in the English language resulting in 1987 articles on Scopus and 1211 on WoS. After merging the two datasets, removing duplicate articles, and a peer review of each abstract and title, we found 1314 documents with missing abstracts or unrelated to GenAI leaving a total of 1884 documents. Biblioshiny, an online interface for Bibliometrix®, was used to analyse and visually represent the bibliometric data. We also conducted the thematic analysis manually, and sentiment and usage analyses using OpenAI's interface guided by the results of the manual analysis. Figure 1 gives a visual representation of the method.

3 RESULTS AND DISCUSSION

3.1 Main Information

In the scoping review shown in Table 1, we manually delineated the document analysis into two distinct periods: 2012–2022, specifically 30 November 2022 when ChatGPT was released, and 01 December 2022–2024, to capture the evolving dynamics of GenAI, particularly highlighting the pivotal role of ChatGPT's emergence as a significant turning point (Twinomurinzi

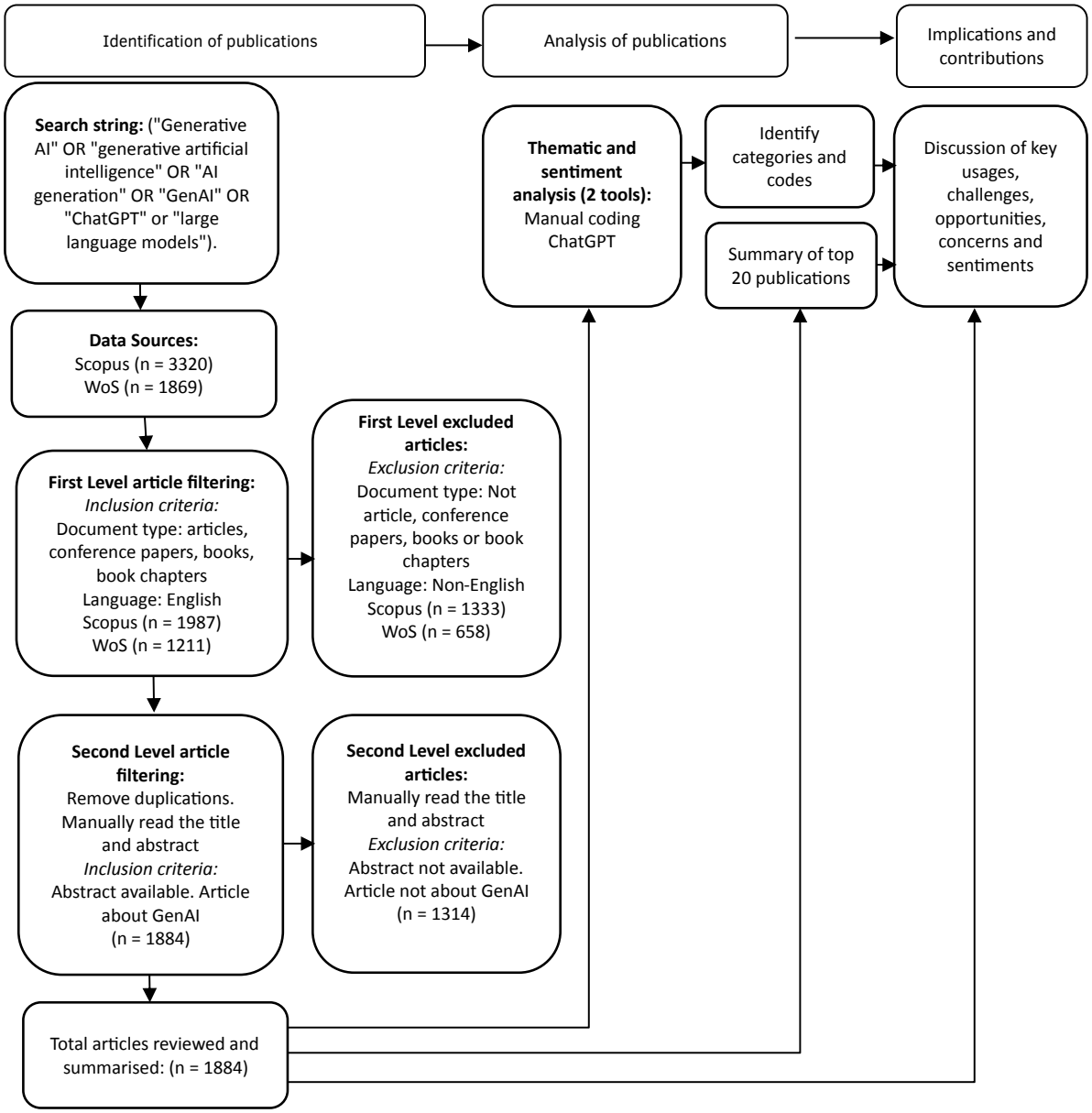

Figure 1: Schema for identification of research articles and analysis of results

& Gumbo, 2023). The first period, 2012–2022, had 56 documents from 34 sources, with a steady growth rate of 37.97%, an average number of 4.39 co-authors per document, and 26.79% in international collaboration.

The second period, 2022–2024, revealed a sharp increase in research activity, with 1828 documents from 941 sources. The interest and research output grew exponentially by 3,164%, and with the number of authors surging to 6283. The average co-authors per document was 4.01, and a slightly lower rate of international collaboration at 22.98%. This period also saw

Table 1: Summary of the documents analysed

	Results		
Main information about data	**Overall**	**Period 1**	**Period 2**
Timespan	*2012–2024*	*2012–2022*	*2022–2024*
Sources (Journals, Books, etc.)	962	34	941
Documents	1884	56	1828
Annual Growth Rate %	*25.99%*	*37.97%*	*3164.29%*
Authors			
Authors	6423	184	6283
Authors collaboration			
Single-authored docs	336	5	320
Co-authors per document	4.02	4.39	4.01
International co-authorships %	*23.09%*	*26.79%*	*22.98%*
Document types			
article	1256	13	1243
article; early access	40	0	40
book	4	0	4
book chapter	27	2	25
conference paper	557	41	516

a notable increase in journal articles, including early access articles, and a substantial rise in conference papers to 516. ChatGPT was definitively an inflection or tipping point for GenAI and AI usage (Twinomurinzi & Gumbo, 2023).

3.2 Annual Scientific Production

The publication trends between 2012–2022, Figure 2(a), indicates a slow and steady increase in publications peaking at 25 publications until November 2022, suggesting a nominal interest in GenAI. In contrast, the period December 2022–2024, in Figure 2(b) reveals an explosive growth from 4 publications in December 2022 to 1808 in 2023. The sharp reduction in 2024 reflects the 16 early access publications in the forthcoming 2024.

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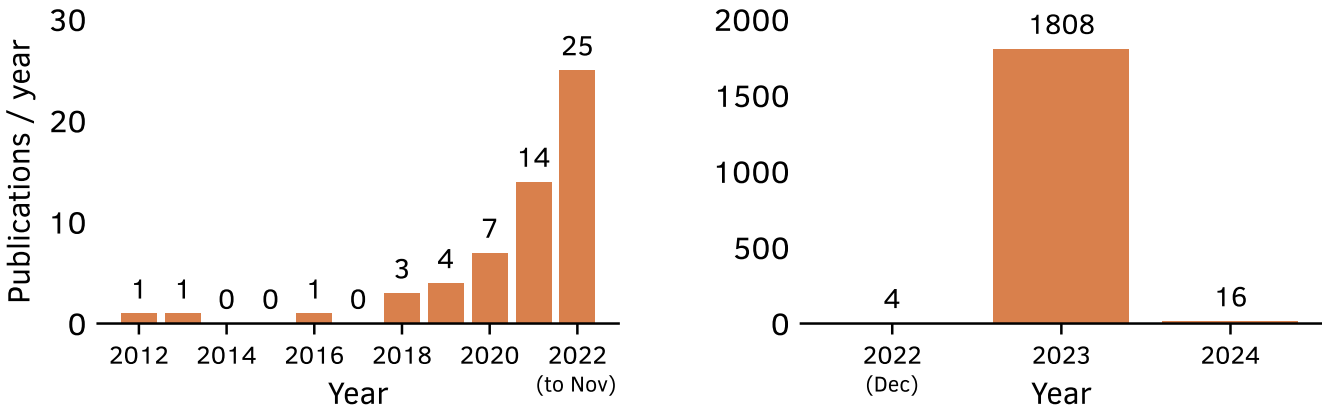

(a) 2012 to November 2022

(b) December 2022 to 2024

Figure 2: Annual scientific production of GenAI

3.3 Top 10 Country Specific Production

Between 2012–2022, the scholarly discourse on GenAI was predominantly led by the United States of America (USA), which contributed 137 publications, nearly twice the total output of the nine other leading countries in GenAI research combined, 75 publications (Table 2(a)). China followed with 20, marking a substantial gap from the top article producer, USA. The presence of the Netherlands (9), Germany (8), Greece (7), Ireland (7), and Switzerland (5) reveals Europe's contribution in the first period. Japan (8), Canada (6), and Argentina (5) represented Asia, North America, and South America, respectively, depicting a nearly global diversity in scholarly production. Notably, African countries were absent. In the subsequent period (2022–2024), the USA maintained its lead with 1877 occurrences (Table 2(b)). China also saw a substantial increase to 639, reinforcing its position as a global research producer. In Europe, Germany (348), the United Kingdom (UK) (315), and Italy (299) were in the lead. Australia (286) emerged in the top 10, suggesting its growing role. Asia's expanded role had India (252), South Korea (143), and Singapore (126). Canada (138), showed a slower growth rate compared to other leading countries. Both periods had no representation from Africa in the top 10.

3.4 Most relevant sources

Between 2012–2022 (Table 3(a)), the sources were centered around Computer Science, particularly in specialist AI conference series. Between 2022–2024 (Table 3(b)), there was a significant shift in the scholarly discourse on GenAI, with the medical and biomedical fields emerging as the new leaders. This transition marks an increased integration of GenAI technologies in healthcare, particularly in diagnostics, personalised medicine, and pandemic response, reflecting the sector's growing reliance on GenAI.

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Table 2: Country and continent specific production

(a) 2012–2022

#	Country	Continent	count	%
1	USA	North America	137	64.6%
2	China	Asia	20	9.4%
3	Netherlands	Europe	9	4.2%
4	Germany	Europe	8	3.8%
5	Japan	Asia	8	3.8%
6	Greece	Europe	7	3.3%
7	Ireland	Europe	7	3.3%
8	Canada	North America	6	2.8%
9	Argentina	South America	5	2.4%
10	Switzerland	Europe	5	2.4%
Total			212	

(b) 2022–2024

#	Country	Continent	count	%
1	USA	North America	1877	42.4%
2	China	Asia	639	14.4%
3	Germany	Europe	348	7.9%
4	UK	Europe	315	7.1%
5	Italy	Europe	299	6.8%
6	Australia	Australia	286	6.5%
7	India	Asia	252	5.7%
8	South Korea	Asia	143	3.2%
9	Canada	North America	138	3.1%
10	Singapore	Asia	126	2.8%
Total			4423	

3.5 Most relevant authors

From 2022–2024 (Table 4(b)), there was a notable shift in the leading scholars on GenAI. While all top 10 contributors in the period 2012–2022 (Table 4(b)) came from the USA, 2022–2024 saw a significant pivot towards Asia. China particularly emerged as the leading scholarly voice on GenAI. This shift indicates the rising influence of Asian researchers in GenAI.

https://doi.org/10.18489/sacj.v37i1.17890

Table 3: Most relevant sources

(a) 2012–2022

Source	count
CEUR Workshop Proceedings	8
Conference on Human Factors in Computing Systems – Proceedings	5
Lecture Notes in Computer Science[a]	5
ACM International Conference Proceeding Series	4
International Conference on Intelligent User Interfaces, Proceedings IUI	3
Proceedings of the 36th AAAI Conference on Artificial Intelligence, AAAI 2022	2
Proceedings of the National Academy of Sciences of the United States of America	2
2012 IEEE Congress on Evolutionary Computation, CEC 2012	1
2022 IEEE Congress on Evolutionary Computation, CEC 2022 – Conference Proceedings	1
35th AAAI Conference on Artificial Intelligence, AAAI 2021	1

[a] including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics

(b) 2022–2024

Source	count
Cureus Journal of Medical Science	56
CEUR Workshop Proceedings	55
Lecture Notes in Computer Science[a]	50
Proceedings of the Annual Meeting of the Association for Computational Linguistics	41
ACM International Conference Proceeding Series	32
Annals of Biomedical Engineering	19
Conference on Human Factors in Computing Systems – Proceedings	16
JMIR Medical Education	16
IEEE Access	13
Journal of Medical Internet Research	13

[a] including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics

3.6 Top Affiliations

Between 2012–2024, the affiliations of leading contributors also underwent a notable shift. Initially (Table 5(a)), the USA dominated, reflecting its strong research infrastructure. However, from 2022–2024 (Table 5(b)), a significant diversification occurred, with a broader international representation emerging. This period saw the rise of institutions from the United Arab Emirates (UAE), Singapore, Australia, Poland, and the UK, among others.

3.7 Country collaboration

There was hardly any international collaboration on GenAI during the first 11-year period (Figure 3(a)), with only one discernible partnership between the USA and Argentina. This con-

Table 4: Most relevant authors

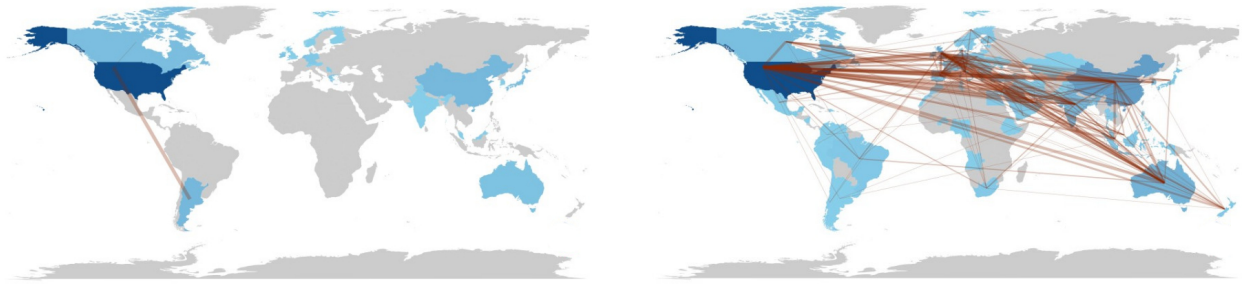
(a) 2012–2022

Author	Country	count
Houde S	USA	7
Muller M	USA	7
Agarwal M	USA	6
Talamadupula K	USA	6
Weisz Jd	USA	6
Breazeal C	USA	5
Martinez F	USA	5
Richards J	USA	5
Ali S	USA	4
Ross Si	USA	4
Total		55

(b) 2022–2024

Author	Country	count
Chen J	China	13
Kim J	Korea	11
Li H	USA	11
Li Y	China	11
Liu H	China	11
Liu J	China	10
Seth I	Australia	10
Wang X	China	9
Wang Y	China	8
Zhang Y	USA	8
Total		102

trasts sharply with the surge in global collaboration from 2022 onward (Figure 3(b)), spanning nearly every continent.



(a) 2012–2022 (b) 2022–2024

Figure 3: Country collaboration

Within the past year, GenAI has markedly enhanced global collaboration, establishing itself as a pivotal platform and catalyst across various disciplines. Its broad appeal, as seen in its application across diverse research fields in Section 3.10, shows GenAI's role in fostering transdisciplinary integration. The integration has enabled scholars from diverse fields to pool their expertise and perspectives, thereby enriching the collaborative efforts.

GenAI platforms such as ChatGPT, Google's Bard, and Microsoft's Copilot have been designed with user-friendliness in mind, reducing the need for specialist technical expertise that was once necessary for engaging with advanced AI tools as seen in the period 2012–2022. This approachability has significantly contributed to their widespread adoption, allowing a broader range of users from various backgrounds to utilise these platforms effectively. By lowering the

Table 5: Top affiliations

(a) 2012–2022

Affiliation	Country	count
Facebook AI Research	USA	6
Hefei University of Technology	China	6
Massachusetts Institute of Technology	USA	6
IBM Research AI	USA	5
Swiss Federal Institute of Technology (ETH Zurich)	Switzerland	5
University of Tsukuba	Japan	5
Universiti Malaysia Sabah	Malaysia	4
University of Illinois	USA	4
Kansas State University	USA	3
Shanghai Jiao Tong University	China	3
Total		47

(b) 2022–2024

Affiliation	Country	count
New York University, Abu Dhabi	UAE	41
University of Southern California	USA	36
National University of Singapore	Singapore	33
Icahn School of Medicine at Mount Sinai	USA	32
Monash University	Australia	30
University of California	USA	29
University of North Texas	USA	29
Wrocław University of Science and Technology	Poland	24
Mayo Clinic	USA	23
University of Cambridge	UK	23
Total		300

barrier to entry, these GenAI platforms have democratised access to advanced AI capabilities, facilitating a more inclusive environment for users worldwide including those from marginalised communities who often face barriers due to the digital divide. GenAI therefore offers opportunities for greater participation and representation in AI-driven advancements.

Their accessibility also ensures that individuals across different technical proficiencies can participate, further promoting an inclusive environment conducive to collaboration. This ease of access is a key factor driving GenAI's popularity as a collaborative tool.

Moreover, the rise of GenAI mirrors a broader shift in the research and academic culture towards openness and collective problem-solving. This paradigm shift acknowledges the complexity of contemporary challenges, which often demand efforts from more than one discipline, a process seamlessly facilitated by GenAI. The network effects triggered by GenAI's rapidly expanding user base further increase its value. As more scholars, individuals and institutions

engage with GenAI platforms, the resultant growth not only enhances GenAI's usefulness but also fosters a virtuous cycle of increased scholarly adoption and collaboration.

3.8 Top 10 cited documents

The top ten papers from both periods (Tables 6 and 7) illustrate a shift from the ethical concerns and technical proficiency in the use of GenAI to a large scale usage of GenAI particularly in the medical and education fields.

Table 6: Top 10 cited documents 2012–2022

Source	Publication	TC	Summary
Rives et al. (2021)	Proceedings of the National Academy of Sciences of the United States of America	504	This paper investigated the use of unsupervised learning in AI to train a deep contextual LLM, leading to breakthroughs in biological data interpretation. The study demonstrated how the model's representations hold key biological insights from sequence data, offering a predictive edge in mutational effects and protein structure.
Gupta et al. (2017)	Molecular Informatics	285	This research presented a novel chemogenomic approach using generative recurrent neural networks (RNNs) for drug design, bypassing the need for extensive compound libraries. It highlighted the method's precision and adaptability, particularly in low-data scenarios for drug discovery.
Mirsky and Lee (2021)	ACM Computing Surveys	138	This article explored the ethical concerns of deepfake technology. It detailed the creation and detection of deepfakes, the progression of the technology, and the need for further research to bolster defence mechanisms against its misuse.
Williams et al. (2019)	Conference on Human Factors in Computing Systems – Proceedings	79	This study developed Popbots, an AI educational platform for preschoolers. It found that early AI education could significantly shape children's understanding of AI, with varied perceptions based on their age and learning performance.
Weisz et al. (2021)	International Conference on Intelligent User Interfaces, Proceedings IUI	33	This paper examined the application of unsupervised neural machine translation for code generation. It assessed software engineers' tolerance for imperfections in AI-generated code and discussed the potential for generative AI in software modernisation.
Sun et al. (2022)	International Conference on Intelligent User Interfaces, Proceedings IUI	24	This research interrogated explainable AI for generative models in software engineering. It proposed new explainable AI features and highlighted the importance of human-centered design in the technical development of explainable AI.
Zhang et al. (2022)	Conference on Human Factors in Computing Systems – Proceedings	24	This study designed StoryBuddy, an AI system for interactive storytelling. The system aims to balance the need for parent involvement with the goal of enhancing parent-child bonding while also accommodating parents' busy schedules.
Suh et al. (2021)	Conference on Human Factors in Computing Systems – Proceedings	23	This paper observed the role of AI in human collaboration during creative tasks. The key findings suggest AI can significantly influence social dynamics and creativity, offering insights for the future integration of AI in co-creative processes.
Wu et al. (2020)	Computers in Human Behaviour	20	This survey investigated perceptions of AI-generated content across different cultures. It found contrasting views between American and Chinese subjects regarding AI's role in artistic creation, enriching the dialogue on the impact of AI in the arts.

[Continued …]

Table 6: […continued]

Source	Publication	TC	Summary
Ali et al. (2021)	Conference on Human Factors in Computing Systems – Proceedings	17	This study proposed a learning trajectory for middle schoolers about GenAI. It emphasised the importance of educating the young on ethical aspects of AI, based on findings from interactive workshops.

Table 7: Top 10 cited documents 2022–2024

Source	Publication	TC	Summary
Y. K. Dwivedi et al. (2023)	International Journal of Information Management	226	This study scrutinised the integration of GenAI in streamlining information management processes, illustrating its pivotal role in enhancing data interpretation and decision-making within organisations.
Gilson et al. (2023)	JMIR Medical Education	205	The research investigated the deployment of GenAI in medical education, revealing innovative teaching tools that leverage AI to create dynamic learning materials and simulations, significantly impacting educational outcomes.
Rudolph et al. (2023)	Journal of Applied Learning & Teaching	123	The study highlighted the use of GenAI in crafting customised learning experiences, focusing on the practical application of AI-generated content to enhance teaching methodologies.
Tlili et al. (2023)	Smart Learning Environments	112	This article presented the application of generative AI in smart learning environments, demonstrating how it can tailor educational content to individual learner profiles, thereby revolutionising traditional educational paradigms.
Ayers et al. (2023)	JAMA Internal Medicine	109	The study explored GenAI's role in internal medicine, particularly in developing predictive models for patient care, which has led to more precise and personalised treatment plans.
Pavlik (2023)	Journal of Mass Communication Education	108	This paper examined the impact of GenAI on mass communication education, emphasising how AI tools can generate diverse media content, thereby enriching the learning experience for students.
Cotton et al. (2023)	Innovations in Education and Teaching International	103	The research focused on the GenAI's contribution to educational innovation, particularly its capability to produce diverse and inclusive educational materials that resonate with a global student body.
Cascella et al. (2023)	Journal of Medical Systems	101	This study investigated the incorporation of GenAI in medical systems, noting its potential to revolutionise patient diagnostics and treatment pathways through advanced AI-generated models.
Salvagno et al. (2023)	Critical Care	98	The paper highlighted how GenAI is being utilised to create simulation models for critical care training, offering realistic scenarios that are instrumental in preparing healthcare professionals for emergency situations.
Alkaissi and McFarlane (2023)	Cureus Journal of Medical Science	87	This study outlined the use of GenAI in medical science education, underlining its role in generating complex biological models that aid in both teaching and research.

3.9 GenAI Usage and Opportunities

A thematic analysis using an open coding approach was conducted for the usage and opportunities, as well as the concerns, between the two periods (Braun & Clarke, 2006). Initially, all the abstracts in the period 2012–2024 were manually analysed to derive codes, and from the codes, overarching themes, and then finally constructing a narrative to describe the themes that emerged. Atlas.ti was used for this process. ChatGPT was then used to compare its thematic analysis with the manual analysis which proved sufficiently similar and revealed a few more codes. ChatGPT GPT-4 version was particularly useful for the second period 2022–2024 with 1828 abstracts.

Before the emergence of ChatGPT (Table 8), GenAI was prominently engaged in the arts and design sector due to its creative capabilities. In education, GenAI was leveraged to enrich learning experiences, frequently through robotic intermediaries. GenAI had already begun integrating into a few other disciplines, illustrating its potential even before ChatGPT.

Table 8: Usage of GenAI prior to ChatGPT (2012–2022)

Discipline	Code (number)	Brief integrative narrative
Computer Science (30)	Algorithm (2) Computing (5) Software (10) System (12) Simulation (1)	GenAI was used in system development, software engineering, and algorithm design. It also played a role in simulation and computing, reflecting its foundational impact on technological advancements. An example includes the novel use of a modified Pareto Differential Evolution (PDE) algorithm for bi-objective optimisation of the weights in an Artificial Neural Network (ANN) controller. This marked a significant development in the field, which previously focused only on single-objective optimisation.
Art and Design (42)	Design (19) Art (9) Creative (10) Aesthetic (1) Visual (3)	GenAI played a pivotal role in the art and design sector, particularly in creative projects involving real-time strategy games. This indicated GenAI's emerging role in enhancing creativity and aesthetic judgment. Examples included creating simulations and collaboration in the creation of classical Japanese poetry.
Environmental Science (2)	Environment (1) Sustainable (1)	While less prominent, GenAI used top-down strategy mechanisms like steering development processes and addressing misinformation. For instance, the use of interactive learning environments and digital literacy programs to combat deepfakes and social media misinformation demonstrated how to refine ideas and ensure alignment with desired outcomes.
Healthcare (4)	Drug (4)	GenAI models provided innovative approaches to chemogenomics and de novo drug design. They enabled researchers to focus on specific regions of the chemical space, as demonstrated by exploring the chemical space and generating new molecules. This assisted in the discovery of new drugs. GenAI was also used to maximise the use of limited data in making new drug discoveries.
Education (32)	Learning (25) Education (6) Teaching (1)	GenAI also played a role in education, especially in enhancing learning experiences. One notable example involved fine-tuning Recurrent Neural Network (RNN) predictions for specific molecular targets using transfer learning. Additionally, the introduction of the NAO humanoid robot in elementary schools offered a unique perspective on learning. Here, students engaged in collaborative discussions, questioning, and reflective writing activities centered around the robot.

[Continued …]

Table 8: […continued]

Discipline	Code (number)	Brief integrative narrative
Robotics (2)	Robot (1) Humanoid (1)	In robotics, GenAI contributed to the development of sociable robots, which are increasingly being used as interfaces for various services. Notably, children born after 2010, the "AI Generation" became familiar with social robotic interfaces, influencing their mental development. Some children percieved the social robots as more intelligent and/or less intelligent than humans, and others simply viewed them as toys.

Post-ChatGPT (Table 9), there has been a substantial surge in the usage and integration of GenAI, marking a new era of technological adoption. The scholarly discourse has evolved past the previous ethical concerns surrounding GenAI, embracing its integration across various disciplines. Education has particularly been at the forefront of using GenAI, significantly enhancing the learning experiences. Similarly, healthcare has expanded its use of GenAI, enriching medical science curricula and improving patient outcomes. GenAI has also facilitated the development of autonomous robots equipped with communicative capabilities.

Table 9: Usage of GenAI post ChatGPT (2022–2024)

Discipline	Code (number)	Brief integrative narrative
Education (1208)	Learning (543) Education (495) Teaching (170)	GenAI has revolutionised education, significantly enhancing learning and teaching methodologies. Notably, the integration of LLMs into educational systems. These LLMs are being used to develop personalised study plans, innovative teaching methods, and more interactive learning materials. For instance, ensemble neural models have been proposed to generate probabilities from different pre-trained LLMs thereby offering more tailored and effective educational experiences.
Computer Science (83)	Algorithm (44) Computing (39)	LLMs have significantly advanced NLP, setting new performance standards, with ChatGPT having the most profound impact on GenAI. These LLMs are now fine-tuned using advanced ML techniques capable of generating fully autonomous NLP conversations, demonstrating the rapid progress and growing capabilities in AI and computing.
Psychology (108)	Behavioral (20) Cognitive (55) Mental (33)	GenAI is now being used in psychology to understand behavioral and cognitive dynamics, to analyse and predict human behavior and mental processes, thereby offering deeper insights into the human psyche. For example, studies on chatbot acceptance show how instrumental and non-instrumental gratifications, along with social norms, significantly influence user interactions with AI, revealing the intricate relationship between technology and human psychology.
Communication (685)	Information (460) Media (114) Communication (111)	While GenAI-generated content enhances information dissemination, it also poses risks of misinformation and factual inaccuracies. A critical examination of these issues, including algorithmic bias, privacy concerns, and the impact of GenAI on media and communication, reveals the need for ethical considerations and responsible use of technology in communication.

[Continued …]

Table 9: […continued]

Discipline	Code (number)	Brief integrative narrative
Healthcare (694)	Medical (284) Clinical (238) Health (172)	GenAI has also led to transformative changes in healthcare. LLMs have revolutionised medical curriculum development, teaching methodologies, and student assessments. These models hold promise for creating more effective and personalised medical training and patient care strategies. Their application in clinical settings is also expanding, with the potential to significantly improve patient outcomes and healthcare services.
Robotics (38)	Autonomous (25) Robotics (12) Humanoid (1)	In robotics, GenAI is enhancing the development of autonomous systems and humanoid robots. Technologies like ChatGPT are demonstrating the ability to autonomously generate natural language, which is vital for human-robot interaction. The ongoing research in this field is focused on optimising these interactions to be more ethical and to minimise harm, reflecting the growing sophistication and ethical considerations in the use of GenAI in robotics.

3.10 GenAI Challenges and Concerns

Prior to ChatGPT (table 10), the concerns about GenAI included inaccuracies and ethical issues stemming from biased training data. These inaccuracies, ethical concerns and societal impacts remain the dominant challenge with GenAI post-ChatGPT (Table 11) despite the widespread usage. This shows that scholars in the GenAI community recognised these challenges early on and raised the alarm.

Table 10: Challenges with GenAI pre-ChatGPT (2012–2022)

Discipline	Code (number)	Brief integrative narrative
Technical Challenges (10)	Performance (5) Errors (3) Accuracy (1) Scalability (1)	The most noted challenge was with the performance of GenAI models, particularly in ensuring their efficient and effective operation. There were other challenges related to errors from inaccuracies and mistakes in GenAI-generated outputs. These concerns about accuracy further pointed to the challenges in maintaining precision in the outputs. Scalability problems reflected the difficulties in expanding GenAI systems to handle larger or more complex tasks without a loss in performance or efficiency.
Ethical Concerns (3)	Bias (2) Privacy (1)	Bias was identified twice, highlighting the problem of GenAI systems potentially perpetuating or even amplifying existing societal biases. Privacy concerns were also noted, reflecting the complexities involved in responsibly handling personal data within GenAI systems.
Societal impact (2)	Society (2)	The two instances pointed to broader implications for society around the impact of GenAI on social dynamics and human interactions, raising questions about the long-term effects of increasingly relying on GenAI systems in various aspects of life. This is particularly relevant where decision-making, both at individual and organisational levels, becomes heavily dependent on GenAI recommendations. This dependency might reduce human engagement in critical thinking and problem-solving, potentially leading to an erosion of these skills. Another concern relates to shifts in labour markets, and the moral implication in areas such as law enforcement or healthcare.

Table 11: Challenges with GenAI post-ChatGPT (2022–2024)

Discipline	Code (number)	Brief integrative narrative
Technical challenges (791)	Performance (384) Accuracy (329) Complexity (39) Error (33) Scalability (6)	There is still a significant challenge with the performance of GenAI systems. For example, one abstract described the ongoing efforts to improve real-time processing capabilities in autonomous vehicles. The accuracy of predictions remains a crucial focus with research going into refining LLMs to better understand and generate human-like text. The issues of complexity and scalability further highlighted the ongoing work to simplify GenAI models for broader applications, particularly in fields such as healthcare, where complex data requires simplified yet effective analysis.
Ethical concerns (186)	Privacy (88) Bias (71) Consent (14) Moral (13)	There is a growing emphasis on privacy, especially in contexts where GenAI is used for personal data analysis, urging for enhanced data protection measures. Bias continues to be a critical ethical challenge, with some studies indicating that GenAI-driven hiring tools perpetuate gender bias. The need for informed consent and ethical considerations,such as the use of facial recognition technology when used in public spaces, is important.
Societal impact (169)	Society (147) Employment (9) Human Interaction (8) Dependency (4) Social Impact (1)	The major concern is the way GenAI is transforming society particularly traditional education systems, promoting personalised learning while raising questions about reduced human interaction. There are envisaged and real employment changes especially with job displacement, changed human interaction as a result of changes in social behaviour, and feared societal dependency on GenAI due to the increased AI integration.
Legal issues (163)	Legal (76) Law (37) Regulation (34) Compliance (16)	There is a need for new regulations in applications that use GenAI such as drone technology when it is used in surveillance. The implications have effects on compliance with the law and the associated regulations.
Data issues (36)	Data Privacy (20) Data Security (12) Data Quality (3) Data Availability (1)	Data privacy and security are highlighted for examples of research to secure GenAI systems against data breaches. Data quality and availability were illustrated by studies on the impact of poor data quality on GenAI decision-making in critical sectors like finance.

3.11 Sentiments before and after ChatGPT

From 2012–2022 (Table 12), the sentiment towards GenAI was predominantly positive, reflecting optimism in sectors like healthcare, where GenAI's accuracy in disease identification promised to revolutionise diagnostics. However, concerns about privacy and ethical implications of GenAI in surveillance were noted, emphasising the need for thoughtful regulation. Years 2022–2024 witnessed a huge surge in positive sentiment towards GenAI, particularly for its applications in various fields, signaling its potential to address pressing global challenges. Yet, the rising optimism has not been without reservations, particularly around the impact of GenAI on job automation, highlighting the need for a balanced approach in embracing GenAI advancements.

Table 12: Sentiments before and after ChatGPT

Period	Sentiment	#	Brief narrative
2012 – 2022	Positive	46	The positive sentiment predominantly leans towards optimism and enthusiasm. An example is the breakthrough in AI-driven healthcare solutions where GenAI algorithms successfully identified diseases with greater accuracy than traditional methods. Such advancements demonstrate the potential of GenAI to revolutionise medical diagnostics and treatment, eliciting a sense of hope and excitement for the future of healthcare.
	Neutral	0	
	Negative	10	There were concerns and apprehensions about the impact of GenAI for example around the ethical implications of GenAI in surveillance, where fears about privacy invasion and misuse of GenAI for intrusive monitoring were highlighted. These concerns highlighted the need for careful consideration and regulation in the deployment of AI technologies to protect individual rights and freedoms.
2022 – 2024	Positive	1589	There is now an overwhelming positivity especially around the groundbreaking GenAI applications. For example, in environmental science, GenAI models actively predict climate change patterns, offering vital insights for mitigating environmental risks. These examples foster a sense of hope and anticipation for the potential of GenAI to address some of the world's most pressing challenges.
	Neutral	12	While limited the neutral sentiments indicate areas where the impact of GenAI is still uncertain or where its implications are yet to be fully understood. For example the use of GenAI in artistic endeavors, where there is a mix of curiosity and skepticism about the role of GenAI in creative processes.
	Negative	227	There are nonetheless still major concerns and reservations about GenAI and AI. A notable example was over GenAI in job automation, where there is apprehension about potential job losses and the displacement of human labour. These concerns highlight the complexities and ethical dilemmas that GenAI introduces, prompting a call for more stringent regulations and ethical guidelines.

4 DISCUSSION OF FINDINGS

In order to offer a balanced discussion of the key findings, we adopted a post-digital lens mainly because it allows for a critical examination of the seamless integration of digital technologies into daily life, highlighting the intertwined nature of digital and non-digital realms and the cultural, social, and economic implications of this ubiquity (Cramer, 2015).

4.1 More Rapid Technological Evolutions and their Impacts

The rapid integration of ChatGPT and similar GenAI technologies marks a significant evolution in AI capabilities. This evolution is characterised by the sophisticated development of transformer architectures, pre-training processes, and fine-tuning methodologies. These technical advancements have revolutionised sectors like healthcare, education, and software engineering, demonstrating the potential for significant innovations and efficiency enhancements (Y. K. Dwivedi et al., 2023). This technological leap signifies a transformative change in how problem-solving, knowledge creation, and service delivery are approached across different sectors. The leap introduces a new era of enhanced productivity and innovation, where

GenAI's capabilities can be harnessed to tackle complex challenges more effectively. For example, a 2024 McKinsey survey shows that GenAI adoption has more than doubled in the previous five years, and there is an increase in GenAI investment (McKinsey & Company, 2024). For practitioners and policymakers, this new era points to the urgency of adapting to rapidly changing technologies. For educators and healthcare professionals, GenAI offers tools for unprecedented advancements in personalised education and patient care. Ultimately, GenAI impacts society at large, promising to elevate the quality of life through improved services and innovations.

4.2 Transdisciplinary Integration

The post-ChatGPT era has facilitated greater disciplinary collaboration regardless of region, enabling the integration of GenAI into diverse fields. This unprecedented collaboration is driven by the data-rich insights that GenAI platforms provide, which offer a deeper, evidence-based understanding of complex phenomena across domains. These data-driven capabilities empower researchers to not only test existing theories but also extend them into areas previously unexplored, thereby facilitating unique innovations and the creation of new theories and frameworks (Klein-Avraham et al., 2024). For example, researchers in Information Systems (IS) and Computer Science can use GenAI to provide unique opportunities to refine and adapt their core theories to address challenges in other domains, such as healthcare, education, and the arts (Twinomurinzi et al., 2022). This dynamic interaction allows for the tailoring of theoretical constructs to suit the specific needs and contexts of other disciplines (Y. K. Dwivedi et al., 2023).

Moreover, the insights generated through GenAI encourage the emergence of entirely new disciplines that reflect the convergence of traditional fields. For example, the integration of computational methodologies with social sciences or the arts leads to the development of hybrid fields such as computational sociology or AI-driven creative design (Davidson, 2024; Tan & Luhrs, 2024). This transdisciplinary potential not only bridges existing gaps between disciplines but also creates a fertile ground for the development of more holistic approaches to solving complex, global challenges.

4.3 Ethics Reflections

The rapid integration of GenAI has brought ethical considerations to the forefront, particularly concerning privacy, bias, and the equitable distribution of its benefits. These dilemmas challenge existing social and technical frameworks, necessitating careful navigation to ensure fairness and accountability (Xivuri & Twinomurinzi, 2022). For regulators and ethicists, this signals an urgent need to develop guidelines that promote the responsible and transparent use of GenAI (Cherner et al., 2024). For the general public, GenAI represents a dual-edged sword: it offers significant advancements while also posing risks to privacy, equity, and access to opportunity. Balancing these concerns is critical to ensuring that GenAI's transformative

potential benefits society as a whole and does not increase the digital divide.

4.4 Legal Implications and Societal Adjustments

The integration of GenAI into everyday life presents new and intricate legal, societal, and regulatory complexities. GenAI technologies challenge the boundaries of existing societal norms and legal frameworks, exposing significant gaps in their ability to address the rapidly evolving nature of emerging technologies. This means that legal experts and policymakers need to learn to innovate within legal structures to safeguard individual and collective rights without limiting technological progress.

The transformative potential of GenAI extends to the creation of entirely new disciplines and the jobs required within them. As these emerging fields take shape, educational institutions will need to rise to the challenge of designing entirely new curricula that equip learners with the skills necessary for the future world of work. This includes new programmes that merge technical expertise with ethical, social, and creative insights, ensuring future-fit skills.

For society, embracing a new world of work means rethinking traditional employment structures and adopting more flexible, adaptive approaches to workforce development. Policymakers should consider more experimental and dynamic methods in crafting policies that anticipate and respond to the fluid realities of a GenAI- and AI-driven economy. This could include policies that support continuous learning, universal access to reskilling opportunities, and equitable participation in the benefits of GenAI. The same applies to the legal domain which needs to become more reflexive and adaptive, developing mechanisms that not only regulate GenAI but also encourage its responsible and equitable deployment without stifling innovation.

The deeper societal issue is what it means to be human in an era shaped by these technologies that supercede human intelligence in many ways, and the role of human values such as creativity, spirituality, empathy, and connection.

4.5 Limitations

The study is limited in its usage of only two academic databases without taking into account the vast non-academic literature, nor other GenAI platforms that have emerged since ChatGPT. The limited scope is partially a result of the tools available to conduct bibliometric analyses.

5 CONCLUSIONS

The study investigated the scholarly discourse on GenAI since before ChatGPT and after ChatGPT using a bibliometric review and thematic analysis. We sought to interrogate how prevalent patterns of GenAI usage have manifested in scholarly discourse and the primary drivers behind the adoption of these technologies. The reality of the transition from one million “early

adopters" in five days to an "early majority" of 100 million users within two months indicates that ChatGPT ushered an inflection point in society (Altman, 2022).

The key factor that drives the scholarly discourse of GenAI is transdisciplinary collaboration across regions, disciplines and sectors. Transdisciplinarity is about building bridges between disciplines that have different notions of reality, which bridges themselves become a reality of their own with a new set of language to make sense of the bridge (Klein, 2004). GenAI has managed to navigate the challenges of transdisciplinarity by addressing key limitations inherent in traditional, reductionist approaches. The traditional approaches often prioritise rational logic over relational or qualitative understanding, overlooking the relatedness of disciplines and the role of intuition in knowledge creation (Max-Neef, 2005). In contrast, GenAI fosters a more integrated perspective, bridging the gaps caused by the uni-disciplinary focus prevalent in most educational institutions, particularly at the undergraduate level, and the compartmentalisation of funding into narrowly defined tasks and sub-disciplines (Max-Neef, 2005). While current universities guard disciplinary silos and primarily engage in interdisciplinary collaboration, GenAI opens ways for truly transdisciplinary innovation.

While GenAI has democratised access to advanced AI capabilities, the digital divide continues to pose a significant challenge. Certain demographics and regions, especially in Africa, have unequal access to technology, infrastructure, and digital literacy. These disparities risk exacerbating existing inequalities, leaving marginalised communities further behind.

The rapid adoption of GenAI has also brought ethical dilemmas to the forefront, particularly around issues such as privacy, bias, and equitable access. Ethical lapses in GenAI development and deployment could deepen societal mistrust and perpetuate existing inequalities. A proactive approach is needed to embed ethical considerations into the design, training, and deployment of GenAI models. This includes promoting transparency, accountability, and inclusivity at every stage of development.

The absence of robust legal and regulatory frameworks for GenAI presents significant risks. Without clear guidelines, the deployment of GenAI could lead to misuse, data breaches, and violations of individual rights. Legal experts and policymakers must act swiftly to develop adaptive and reflexive regulations that safeguard privacy, ensure accountability, and promote equitable use. Such frameworks should encourage innovation while protecting societal interests, ensuring that GenAI evolves in a manner that benefits all.

This paper makes a contribution to knowledge and offers some implications for academia, researchers, practice and policy. In IS, GenAI provides a basis for extending existing IS theories using data-driven insights. GenAI allows for the creation of hybrid theoretical frameworks that incorporate both technical efficiency and social implications. In Computer Science, GenAI demands a rethinking of traditional frameworks to include human feedback, contextual accuracy, and ethical AI design. The advancements in transformer models and reasoning capabilities prompt theoretical explorations into designing adaptive systems that balance technical innovation with accountability.

Educators face the challenge of preparing learners for a world reshaped by GenAI. This requires the design of new curricula that integrate technical, ethical, and creative dimensions of

GenAI, equipping students with the skills to navigate hybrid roles across emerging fields and disciplines. Educational institutions must prioritise disciplinary collaboration, offering programmes that blend technical expertise with insights from the humanities and social sciences. Additionally, there is a pressing need to foster lifelong learning by embedding AI literacy and digital skills training across all levels of education. Such efforts will ensure that students are not only proficient in GenAI and AI technologies but also prepared to address their societal implications.

Practitioners will similarly need to adapt to the evolving demands of a GenAI-driven world by embracing continuous learning and innovation. Workforce development initiatives should focus on reskilling and upskilling to align with the hybrid roles created by GenAI.

Policymakers will be required to navigate the complexities of integrating GenAI into society by developing adaptive and reflexive regulatory frameworks. These regulations should address critical issues such as privacy, bias, accountability, and equitable use, while encouraging an environment that supports innovation and humanity. Closing the digital divide is another pressing priority, requiring investments in infrastructure, digital literacy, and development policies. Policymakers should also adopt experimental approaches, such as sandbox regulations, to allow for dynamic and iterative responses to the challenges posed by GenAI.

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