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Awareness and Use of Persistent Identifiers in Research Data Repositories by Academic Librarians in Zimbabwe

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ABSTRACT



The study investigates the awareness and use of persistent identifiers (PIDs) by academic librarians in Zimbabwe's research data repositories. PIDs are essential in ensuring the discoverability, accessibility, and citability of research data. However, little is known about the level of awareness and use of these tools among academic librarians in Zimbabwe. A sequential mixed methods approach was employed, beginning with a questionnaire administered to scholarly communication librarians who were purposively selected. Quantitative data from the questionnaires provided an overview of the current landscape regarding PIDs in Zimbabwean higher education institutions. This informed the design of a focus group discussion which allowed for a deeper exploration of the themes identified in the survey, facilitating an understanding of the challenges of using PIDs within universities. The findings indicated that although the librarians were aware of PIDs, no institution has an institutional research data repository in the country. Challenges that were faced in integrating PIDs include lack of expertise, unclear policies, and infrastructure costs. The study will be significant in informing policy development, capacity-building initiatives, and creating guidelines for integrating PIDs into research workflows.

KEYWORDS

CARE principles; digital object identifiers; FAIR principles; ORCID; research data management; research integrity; research reproducibility

Introduction

Research data management (RDM), the processes of organization, storage, preservation, and sharing of data gathered and utilized in any research work, has emerged as crucial in modern academic settings because data management is central to academic work. As research datasets become larger and more complex, researchers require assistance to archive data for reuse and quality assurance purposes, as is now required by a growing number of funders and publishers.¹ Given that more funders and publishers require open and accessible research data, institutions are actively setting up dedicated services and repositories to enable their researchers to meet these requirements.² A key feature of effective RDM is that research data remain accessible, discoverable, and reusable over time. At this point, persistent identifiers (PIDs) emerge as indispensable tools for removing barriers to accessibility, discoverability, and long-term reference of research data. PIDs offer stable and unique references for digital objects as a response to the many RDM challenges such as broken links, ambiguous citations, and difficult tracking of use and impact of datasets. Hence, PIDs facilitate checking and safeguarding research credibility, replication, and responsibility by providing stable and viable reference and accessible retrieval of their research outcomes in the future.³

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In many research fields, efforts to promote wider access and reuse of research data as well as the implementation of persistent identifiers are gaining pace. This has been necessitated by various reasons; for instance, research misconduct, research and reporting transparency and credit for the scientific ideas are also coming to the forefront of academic research debate. In addition, concerns over research misconduct and ethical practices, report reliability and responsibility are also emerging.⁴ Moreover, large-scale data which can be processed and reprocessed have opened up new ways for dissemination of knowledge and scientific development. Therefore, PIDs are essential among these data management practices for making research data reliably referenceable and accessible over the long term. As permanent, unique, and stable links to digital objects, PIDs enable researchers to share and cite their data confident that the objects can be accessed in the future. To reap the full benefits of these possibilities, however, there must be systematic development of research data management strategies that make use of these persistent identifiers and thus enable broader access and reuse of research data. This study interrogates how persistent identifiers can help to find effective and efficient ways to store, identify, discover, retrieve, and share research data. Additionally, it suggests the advantages that can be gained through adoption of the well-rounded data management scheme whereby persistent identifiers are incorporated in the context of research.

Background

Efforts to promote wider access and reuse of research data have gained momentum globally. Online data repositories such as Figshare, Dryad, Mendeley Data, Open Science Framework and Zenodo exemplify the integration of PIDs into research workflows. These platforms assign unique and persistent links to datasets, enhancing their discoverability and ensuring long-term accessibility.⁵ As examples, Figshare allows researchers to upload diverse research outputs,⁶ Mendeley Data offers robust dataset management features,⁷ and Zenodo emphasises long-term preservation with integrations into tools like GitHub.⁸ The benefits of PIDs are far-reaching as they enable researchers to cite and share digital assets confidently, improving reproducibility and fostering collaboration.⁹ Additionally, PIDs also ensure data permanence, allowing researchers to create rich metadata structures that facilitate interdisciplinary research and support advanced data discovery.¹⁰ On one hand, PIDs such as DOIs, ORCIDs, and Handles are fundamental in facilitating the FAIR (Findable, Accessible, Interoperable, and Reusable) principles.¹¹ DOIs provide unique and persistent links to datasets, ensuring data can be cited and accessed regardless of location or metadata changes.¹² On the other hand, ORCIDs enable unambiguous identification of researchers, promoting academic integrity and collaboration,¹³ and Handles, often used in institutional repositories, provide stable identifiers for archived objects.¹⁴ However, challenges remain, particularly in developing countries. Researchers and librarians often face barriers such as low awareness, limited infrastructure, and negative perceptions of PIDs as administrative burdens rather than enablers of openness.¹⁵ Limited information is available on PID implementation within Zimbabwe, underscoring the need for research to identify existing practices, challenges, and opportunities for improvement.

Scope of the study

The study focuses on persistent identifiers (PIDs) related to research data, specifically DOIs, Handles, and ORCIDs. Other identifiers such as ISSN, ISBN, and ScopusIDs were excluded. By examining PID practices in Zimbabwean higher education institutions, the study aims to provide insights into their adoption and implementation.

Objectives of the study

The study was guided by three research objectives which were:

- To identify institutions with research data repositories in Zimbabwe.
- To ascertain academic librarians' awareness of persistent identifiers.
- To identify the challenges faced when using persistent identifiers.

This study aims to investigate PID practices across academic research organizations in Zimbabwe. It will analyse which institutions assign PIDs and to what types of research objects. Factors such as PID schemes, metadata practices, and identifier resolution services will be examined. The results will provide the first comprehensive overview of PID support within the Zimbabwean research sector. The findings of this study can help higher education institutions and researchers benchmark their services to facilitate collaborative and open research. The findings also reveal opportunities to strengthen identifier infrastructure and align with community data standards. Furthermore, this research seeks to advance the persistent identification of research assets nationally, contributing to the actualization of FAIR principles by maximizing data findability and accessibility. Additionally, the study evaluates institutional PID implementation practices against FAIR data principles, offering a robust and generalizable framework for improving reproducible research. Interaction between the biological and digital spheres through PIDs facilitates efficient data sharing. In this context, Carroll et al.¹⁶ emphasize the importance of CARE principles: Collective benefit, Authority to control, Responsibility, and Ethics, which advocate for ensuring that research data are shared ethically and without prejudice.

Literature Review

This study adopts the Technology-Organization-Environment (TOE) framework by Tornatzky and Fleischer¹⁷ and the Diffusion of Innovations Theory by Rogers¹⁸ to guide its exploration of the awareness and use of persistent identifiers (PIDs) in research data repositories by scholarly communications librarians in Zimbabwe. These frameworks provide complementary lenses for examining the systemic, organizational, and individual factors influencing PID adoption. The TOE framework offers a robust structure for understanding the multidimensional aspects of technology adoption. Its focus on three domains – technology, organization, and environment – allows for a holistic examination of the factors influencing PID integration. The technology dimension evaluates PIDs' perceived benefits, complexity, and compatibility in enhancing research workflows.¹⁹ The organizational dimension considers internal factors such as resource availability, institutional policies, and organizational readiness, which are critical in determining the feasibility of adopting new technologies. Finally, the environmental dimension explores external influences, such as regulatory frameworks, funding, and technological trends, which shape institutions' adoption behaviours. By encompassing these domains, the TOE framework captures the interplay of internal and external factors influencing PID use, making it particularly relevant to higher education institutions.

The Diffusion of Innovations theory complements the TOE framework by focusing on how innovations spread within social systems. It identifies key attributes that affect the adoption rate, such as relative advantage, compatibility, complexity, trialability, and observability.²⁰ The Diffusion of Innovations theory aligns with the study's interest in understanding how academic librarians perceive and adopt PIDs and the factors that facilitate or hinder their integration into research workflows. This perspective also highlights the role of champions within institutions who can drive the adoption of PIDs by demonstrating their utility.

Together, these frameworks are justified for this study as they provide a comprehensive approach to examining macro-level institutional dynamics and micro-level innovation diffusion. Their application ensures a thorough understanding of the factors shaping PID adoption, thereby addressing the study's aim to inform policy and capacity-building initiatives for Zimbabwean universities. This review examines existing research on the role of PIDs in RDM, global adoption trends, challenges in implementation, and the theoretical frameworks that underpin technology adoption in higher education institutions. By identifying knowledge gaps, this section situates the study within the broader discourse on PIDs and RDM.

PIDs have become integral to effective RDM, enabling researchers to store, share, and reuse data while ensuring long-term accessibility and citability. Online data repositories such as Figshare, Mendeley Data, and Zenodo provide tools for data organization and preservation while assigning PIDs like DOIs to datasets.²¹ Studies have shown a growing awareness of PIDs among researchers globally. For instance, Plantin and Thomer²² and Quarati and Raffaghelli²³ highlight an increase in the use of repositories to share data with PIDs, demonstrating a shift towards openness and reproducibility in research. However, practices vary across disciplines and countries, with significant disparities in PID adoption at institutional levels.

According to De Castro et al.,²⁴ PIDs enhance reproducibility by ensuring permanent links to digital assets, while²⁵ emphasize their role in fostering interdisciplinary research through improved metadata structures. These features enable researchers to locate related datasets, collaborate effectively, and enhance the impact of their work. Despite their benefits, the adoption of PIDs faces significant challenges, particularly in developing countries. Mushi²⁶ notes that lack of awareness and technical expertise among researchers and librarians often hampers adoption. Negative perceptions of PIDs as administrative burdens rather than enablers of openness further complicate their implementation.²⁷ Infrastructure costs, limited governance, and inconsistent adoption across disciplines are additional barriers.²⁸ In regions like Zimbabwe, where research data repositories are often absent, the integration of PIDs is constrained by policy gaps and resource limitations. Studies also highlight a reliance on informal data-sharing networks, which undermines the potential benefits of PIDs.²⁹

De Castro et al.³⁰ confirm that most European countries, particularly Denmark, Finland, France, Germany, Netherlands and the United Kingdom have taken on board PIDs in their universities despite the lack of coordination among key stakeholders such as funders, policy makers and research institutions. Australia has taken a step further to ensure accelerated adoption of PIDs in a coordinated fashion by adopting a national PIDs strategy; this toolkit seeks to ensure enhanced research quality, efficiency, and impact through universal adoption of connected persistent identifiers.³¹ There are growing efforts towards PIDs adoption in Africa, for instance, the Training Centre in Communication (TCC-AFRICA) set up the Africa PID Alliance, an initiative that is driving PIDs adoption across Africa.³² This initiative, among similar others, have seen South Africa, Kenya and Burkina Faso taking the lead in adopting well organised research data management practices.³³ While global trends and challenges in PID adoption are well-documented, limited research exists on their implementation in developing countries, particularly in Zimbabwe. Mayernik and Maull³⁴ observe irregular literacy patterns around PIDs, but their findings are not specific to institutional practices in African contexts. Furthermore, there is scant literature on the role of librarians and other stakeholders in promoting PIDs in resource-constrained environments. This study aims to fill these gaps by examining PID practices in Zimbabwean academic institutions. Literature underscores the growing importance of PIDs in advancing research integrity and openness. However, significant disparities in awareness, adoption, and infrastructure persist, particularly in developing countries. By addressing these gaps, this study contributes to the understanding of PID practices in Zimbabwe, providing insights to support capacity building and policy development.

Methods and materials

The study employed a sequential mixed methods approach³⁵ where quantitative data were collected using a questionnaire, while qualitative data were collected using a focus group discussion. The questionnaire was administered to academic librarians who work in the scholarly communication sections and those who offer research support services at higher education institutions in Zimbabwe. A census was conducted among the respondents who were purposively selected as they constitute a population of librarians who deal with researchers and issues of persistent identifiers in the country's³⁶ university libraries. An online questionnaire was administered using Google Forms, and respondents were invited to participate using various communication channels such as WhatsApp, telephone calls, email, and word of mouth. A semi-standardised

online questionnaire with both open and closed-ended questions was used. Twenty-two responses were received from scholarly communications librarians who constituted the population for the study. The quantitative data from the questionnaires informed the design of the focus group discussion, which was conducted during the train-the-trainer workshop to create awareness and use of persistent identifiers in Zimbabwean universities. The focus group discussion was conducted in person at the workshop venue, and the group was composed of 22 scholarly communication librarians. It took ninety minutes and the moderator used probes to encourage elaboration and ensure that all the participants contributed. A guide was used to give direction to the discussion, where the librarians were asked to briefly introduce themselves and describe their current role in scholarly communication and research support at their institutions. The questions that were asked include: Does your institution have a data repository? How is research data currently being managed and shared at your institution? What platforms are being used for research data management at your institution? Which type of persistent identifiers are you familiar with? What is the purpose and importance of using persistent identifiers in research data management? What challenges have you encountered when implementing persistent identifiers at your institution? What barriers hinder the adoption of persistent identifiers in Zimbabwean university libraries? How do researchers at your institution respond to the idea of using persistent identifiers? What support would most help academic libraries in Zimbabwe to implement persistent identifiers? The focus group discussion allowed for a deeper exploration of the themes identified from the questionnaire responses,³⁷ facilitating an understanding of the challenges, benefits, and perceptions of PIDs within the academic library setting. Participants were allowed to explain further on the services that they were offering at their institutions and the moderator asked follow-up questions to stimulate the discussions. Quantitative data were analysed using the Statistical Package for the Social Sciences (SPSS) version 26.0. Qualitative data were analysed using content analysis guided by the research objectives. The results were then brought together and presented according to the objective of the study using text, tables, and figures.

Results

The census targeted library staff in academic institutions in Zimbabwe, receiving 22 responses. The findings revealed that 54.5% of academic institutions claimed to have a research data repository, while 45.5% did not. When requested to provide the uniform resource locators (URLs) for the data repositories, only five respondents provided them, and the rest either did not or just indicated that these were available locally on campus. Nevertheless, after verification for those who had provided URLs, it was ascertained that they were Institutional Repositories (IR's) and not data repositories. However, during a follow-up workshop, group discussions revealed that all respondents who initially claimed to have research data repositories were referring to institutional repositories. This misinterpretation indicates that none of the institutions in Zimbabwe possesses a dedicated research data repository.

Stages of Data Repository Development

The study sought to establish the current level of development of the data repositories within institutions. Eight (36.36%) of the respondents indicated that they have data repositories that were already accessible, although this was clarified in the focus group discussion that they were referring to institutional repositories, not data repositories. Some of the respondents revealed that they were at various stages of developing and planning to set up data repositories. The respondents indicated stages such as understanding the need for a data repository (1 respondent), defining goals and objectives of the data repository (1 respondent), development of policies and determination for the data repository (4 respondents), and the need for hardware, software, and other infrastructure (1 respondent).

Another respondent (4.55%) said that their institution was in the process of developing or coming up with governance structures, three respondents (13.63%) said that their institution was still planning on governance structures. Furthermore, four respondents (18.18%) said that they had no plans in the pipeline for the establishment of a data repository, and they answered this question as “Nil” or “None.”

Personal Data Repositories

The study sought to identify the repositories that the respondents used to archive their data. The results are shown in [Figure 1](#).

The respondents indicated that they use different data repositories to archive their personal research. Mendeley Data had the highest selection (12), with a combination of Mendeley Data and Zenodo being selected by one respondent (1), Figshare (1) and Google Drive (1) which is not a data repository. Seven of the respondents, (32%), indicated that they do not use any data archiving services, systems or repositories.

Persistent identifiers used

[Figure 2](#) illustrates the distribution of persistent identifiers used by the respondents either personally or at the institution, highlighting the adoption and usage rates of various digital identifiers.

As [Figure 2](#) illustrates, ORCID identifiers are the most common, having been used by 27.27% (6) of the respondents. DOIs issued by DataCite are indicated separately by 22.72% (5), standalone use of Handles was selected by two respondents or 9.09%. There were three cases of multiple usage of persistent identifiers with one respondent each. The first one indicated that they use Crossref,

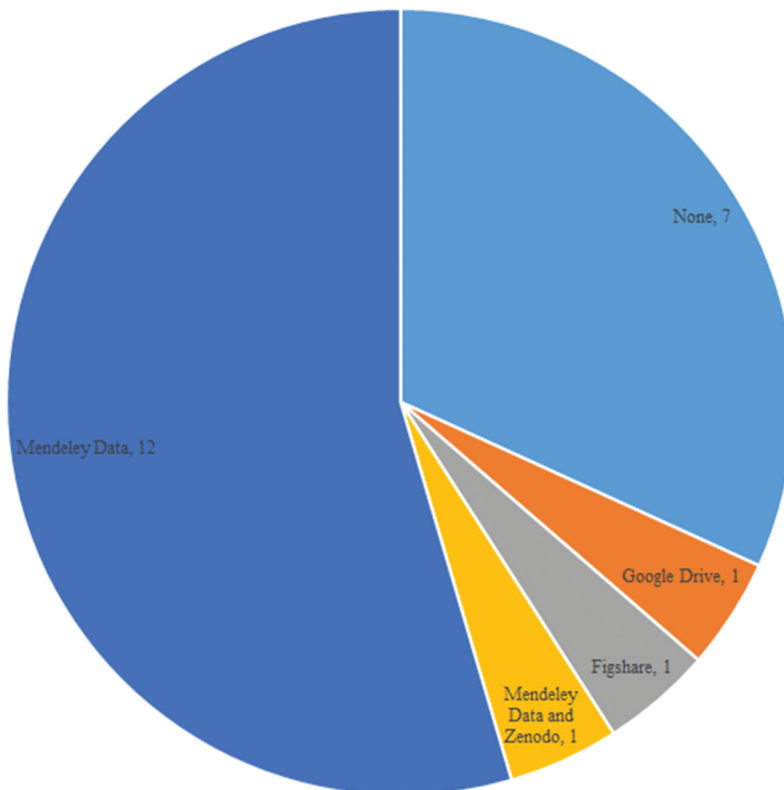


Figure 1. Personal data repositories used ($n=22$).

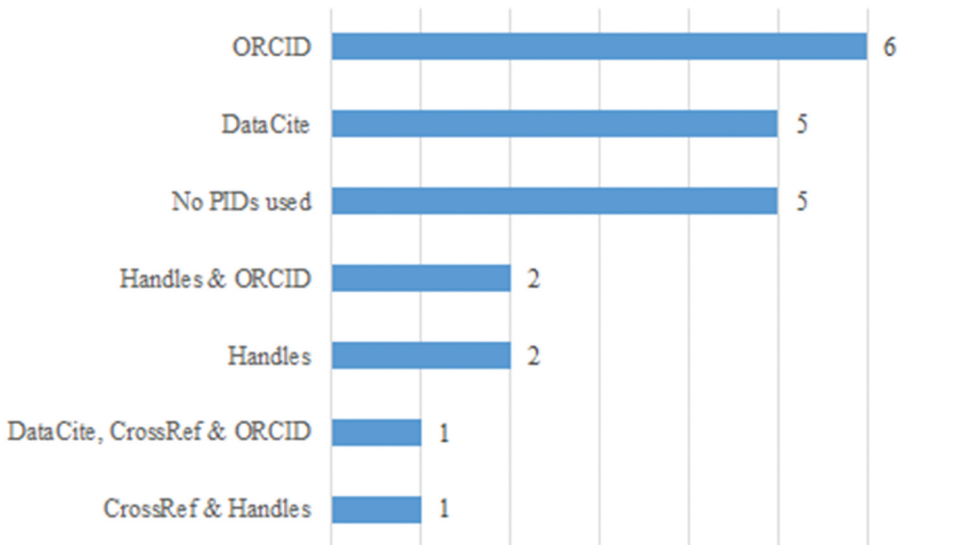


Figure 2. Persistent identifiers used ($n=22$).

DataCite and ORCID, the indicated that they use Crossref and Handles and the last one indicated use of ORCID and Handles. Surprisingly, as many as five respondents, (22.72%) responded that they do not use any persistent identifiers whether personally or at institutional level.

Reasons for Use of Persistent Identifiers by Institutions

The survey investigated the rationale of the use of PIDs at the institutional level, and from the survey responses, analysis of the usage and reasons for PIDs from respondents are depicted from the Table 1.

Table 1 shows the breakdown of the responses given relating to the use of PIDs. The most frequently cited reason was “Unique identification,” which was mentioned by 45.5% (10 respondents). Closely related to that was “Unique identification and long-lasting reference” mentioned by 40.9% (9 respondents) then 9.1% (2) of the respondents indicated that they use PIDs to share research data showing a small but significant percentage who prioritised the data sharing capabilities offered by PIDs. Finally, there was only one respondent who indicated long-lasting reference as the reason why they use PIDs. The findings reveal general variation in the objectives claimed by respondents, where overwhelming focus was on the twin advantage of identification and archival preservation in the long run.

Rating Aspects of PIDs

Respondents were also asked several questions concerning how they would rate different factors relating to the use of PIDs. From the ratings gathered, this research is able to deduce the perceived benefits of PIDs regarding the needs and perception of members of the academic community in Zimbabwe as shown in Figure 3.

Table 1. Reasons for use of persistent identifiers ($n=22$).

Reason	Frequency	Percentage
Long-Lasting Reference	1	4.55%
Sharing Research Data	2	9.09%
Unique Identification and Long-Lasting reference	9	40.90%
Unique Identification	10	45.55%



Figure 3. Rating of PIDs ($n=22$).

Respondents regarded the effectiveness of PIDs in facilitating research highly. This aspect of PIDs had a mean score value of 4.36 out of 5 and a standard deviation of 0.727. This points to a high level of agreement regarding the role of PIDs in the facilitation of research. The respondents also agreed that PIDs serve as unique and stable identifiers. This was reflected in the score of 4.23 with a standard deviation of 0.685. Likewise, the use of PIDs to create credibility of research output was also approved that has a mean of 4.27 and standard deviation of 0.631. This indicates that respondents have faith in PIDs as they enhance the credibility of the research outputs. The role of PIDs in promoting interdisciplinary research which got a mean score of 4.14 and a standard deviation of 0.560, which shows that the respondents perceive PIDs as helpful in promoting interdisciplinary cooperation. Finally, the extent to which participants implemented PIDs in their research work was rated at a mean score of 4.09, on average with a standard deviation of 0.610. This gave an overall positive view on the part of the researchers about the use of PIDs in improving the integration of research.

Challenges in the adoption of Persistent Identifiers by Institutions

The greatest concern that the participants indicated was lack of expertise which was indicated by 31.81% (7 respondents), followed by unclear institutional policies which was another major concern identified by 18.18% (4 respondents). Another key concern that emerged was infrastructure costs which was nominated independently by one respondent. However, this concern was reported more often when combined with other challenges. For instance, 13.64% (3 respondents) indicated costly infrastructure paired with a lack of adequate expertise while 9.09% (2 respondents) indicated that it was a challenge alongside uncertainty of the institutional policies. Additionally, another 9.09% cited infrastructure costs along with misconceptions or negative attitudes towards PIDs as challenges, and 13.64% (3 respondents), also pointed to the absence of clarity of institutional policies and the need for expert knowledge in the management of PIDs thereby identifying the policy-clarity and policy-expertise interaction. [Table 2](#) provides a clear overview of the frequency and relative percentages of each challenge, highlighting the most significant barriers to implementing persistent identifiers.

The distribution of challenges reveals several key insights. Lack of expertise and infrastructure stand out as the most prominent barriers, each representing a substantial portion of the overall challenges (68.14% and 40.91%, respectively). These findings suggest that institutions are primarily hindered by a lack of technical knowledge and the absence of appropriate systems to support persistent identifiers. Secondary challenges, such as unclear policies (31.82%) and misconceptions (18.18%), point to a need for institutional reform and cultural shifts around the use of PIDs. Finally, concerns

Table 2. Challenges when using or implementing persistent identifiers ($n=22$).

Challenge	Frequency	Percentage
Expertise	15	68.14%
Infrastructure	9	40.91
Unclear Institutional Policies	7	31.82
Misconceptions/Negative Perception towards PIDs	4	18.18
Costs	3	13.64
Data Persistence and Link Rot	1	4.55
Dependence on External Repositories	1	4.55

around costs, data persistence, and reliance on external repositories, while less frequently mentioned, indicate that financial, technical, and strategic barriers must also be addressed for the widespread adoption of persistent identifiers.

The results also indicate that challenges related to the implementation of persistent identifiers are numerous and varied across institutions. The most frequently reported combination of challenges was lack of expertise and lack of infrastructure. Out of the respondents, 18.18% identified this combination to be a major challenge. From the findings, 13.64% of the respondents indicated a combination of challenges that include inadequate policy governing the usage of PID in the institution and the common misconceptions about PIDs. Furthermore, 9.09% of respondents attributed practical issues as concerns, including infrastructural challenges and costs whereas 9.09% identified a combination of unclear institutional policies and infrastructure as the two major areas of concern. Secondary issues, including unclear policies (27.27%) and misconceptions (18.18%), are noted many times along with other primary concerns pointing towards the need for institutional changes and better understanding of the value of PIDs.

Strategies for addressing the challenges identified

There was a significant focus on the training and capacity development sub-theme when the respondents were asked to provide the strategies that could be taken to solve the persistent identifier challenges. In this regard, the most frequent keyword was “training” present in the statements of seven (31.82%) of the respondents. Training was proposed in different forms such as workshops, tutorials, and awareness programmes to inform stakeholders. The need for the development of local infrastructure like data repositories and PID management systems was also pointed out by respondents. One respondent suggested “establishing our own repository” as the best solution. Other strategies suggested were advocacy, policy formulation, research, and collaboration which were also acknowledged. Participants also suggested solutions which included acquiring dedicated resources and using free applications such as ORCID as foundations on which to build their PID implementations. Another respondent said that the design “should consider engaging researchers in Research Commons/Learning Commons training.” Collectively, the findings suggest that several complex interventions were beneficial, with training being an essential component complemented by infrastructure and guidance tools (Table 3).

Discussion

This study’s findings prove that PIDs adoption and utilisation in Zimbabwean academic institutions remain lagging. While these gaps present weak policy frameworks, lack of infrastructure, and low cultural integration, they highlight the need for a theoretically informed understanding and tackling of these challenges. The findings of this discussion are critically evaluated using the Technology-Organisation-Environment framework and Diffusion of Innovations theory, and possible pathways to support open science and reproducibility are suggested.

Table 3. Strategies being used to address the challenges.

Theme	Examples of Responses
Training and Education	<ul style="list-style-type: none"> ● "Offer training programmes and support to educate repository users" ● "Engaging researchers in training" ● "Request for training."
Workshops and Learning Opportunities	<ul style="list-style-type: none"> ● "Looking forward to learning more on managing persistent identifiers by attending the workshop" ● "Gaining relevant information through workshops"
Institutional Support	<ul style="list-style-type: none"> ● "Increasing funding for the appointment of expert IT personnel" ● "Adverts were placed for a Systems Librarian"
Policy Formulation and Advocacy	<ul style="list-style-type: none"> ● "Changes in institutional policies" ● "Policy formulation" ● "Advocacy"
Collaboration and Engagement	<ul style="list-style-type: none"> ● "Involving stakeholders including researchers" ● "Community engagement" ● "Seeking assistance from colleagues"
Infrastructure and Repository Creation	<ul style="list-style-type: none"> ● "Hosting our own data repository" ● "The institution is yet to establish a functional repository"
Monitoring and Evaluation	<ul style="list-style-type: none"> ● "Regularly monitor and evaluate the usage and impact of PIDs" ● "Continuously assessing the use and impact of PIDs to ensure improvement"
Resource Utilisation	<ul style="list-style-type: none"> ● "Use of free systems such as ORCID"

Usage and Awareness of Persistent Identifiers

Findings from this study highlight the gaps in the adoption and utilisation of PIDs in academic institutions in Zimbabwe. Whilst librarians and researchers in Zimbabwe have become aware of PIDs, non-existent repositories and reliance on general institutional repositories embody a misalignment between open science needs and technological capacity. As MacGregor et al.³⁸ point out, the assumption that institutional repositories are the same as data repositories adds yet another layer of complication to this problem. This misalignment limits the capacity of PIDs to promote research visibility and integrity by failing to afford proper alignment with international standards for infrastructure. This shows the missing link which is a wide gap between the awareness of PIDs by researchers and their recognition of the tools' potential benefits. The existence of this gap implies that the potential benefits of PIDs, including increased research visibility, credibility and collaboration potential, are not effectively promoted. The misalignment between awareness and adoption can be understood in the context of one of the main concepts of the DOI, attributes of the innovation under which the relative advantage, which simply questions how much better the innovation is in comparison to what it seeks to replace.³⁹ According to Macgregor et al.⁴⁰ researchers often fail to see the direct contribution PIDs can make toward advancing their professional careers, thereby impeding their adoption. The study shows that researchers and librarians did not have clear examples of how PIDs can improve research discoverability and integrity, so it is less likely that researchers will take the time and effort needed to adopt PIDs in their RDM practices.

Despite awareness, the study showed that PID adoption is poor in Zimbabwean academic institutions as revealed. For example, although ORCID was identified as the most known PID among Zimbabwean researchers and librarians, its adoption is very low. This could also reflect a gap between awareness and perceived value. Such findings show that challenges in perceived relative advantage and trialability are leading researchers to prefer consumer tools such as Mendeley Data and Google Drive over institutional repositories.⁴¹ For instance, Dappert et al.⁴² attribute it to indecisiveness about sustainable research data stewardship, as approximately one-third of the respondents lacked sufficient knowledge of research data stewardship. This mirrors Fecher et al.⁴³ and Wallis et al.⁴⁴ who observed reliance on informal, unsustainable data-sharing tools among researchers. Yet again, this is consistent with Macgregor et al.⁴⁵ who contend that awareness does not imply actual use. Further hindering adoption, as Cobey et al.⁴⁶ and Macgregor et al.⁴⁷ have noted, is perceived researcher difficulty with

registration and uncertainty about career benefits. The study also shows that gaps in institutional policies and technical integration are highlighted by the low institutionalisation of PIDs beyond awareness campaigns. According to Haak et al.⁴⁸ and Turki et al.⁴⁹ the role of PIDs in research visibility and discoverability must be optimised through clear policy frameworks and synchronised processes.

Challenges in the adoption of Persistent Identifiers by Institutions

Several structural, organisational, and environmental challenges have been identified to be hindering the adoption of PIDs within Zimbabwean institutions. The TOE framework's technological dimension brings out the lack of specialised research data infrastructure as a key impediment to the adoption of PID. Importantly, the absence of specific investments in infrastructure helps to perpetuate this technological deficiency. The focus should shift towards building robust, interoperable systems that adhere to international best practices. As Haak et al.⁵⁰ argue, technologies must be integrated with clear institutional policies and operational frameworks to be adopted sustainably.

The organisational dimension of the TOE framework demonstrates significant institutional readiness weaknesses. The absence of organisational commitment leading to advance open science practices indicates the absence of clear policies governing the use and integration of PIDs. Additionally, even fewer library staff and researchers are knowledgeable about or support PID adoption. According to Mayernik and Maull,⁵¹ the gaps between expertise are most pronounced in developing countries, where the lack of training facilities and insufficient professional development prevents the proper adoption of new tools. In Zimbabwe, the problem of this lack of expertise is compounded by poor training programmes that do not convey the practical relevance of PIDs. That feedback loop means that adoption does not scale without the right expertise, and without experts the adoption does not happen. However, benefits of these tools are unrealised without explicit policies that integrate PIDs into institutional workflows.

Besides the organisational cultures, it should be noted that external forces and opportunities play a significant role in influencing the adoption of PID schemes, as highlighted in the environmental dimension of the TOE framework.⁵² Building on this perspective, a significant missed opportunity in Zimbabwe is the lack of collaboration with international consortia or institutions that have successfully incorporated PIDs. As argued by Mushi,⁵³ the adoption of open science tools can be made easier through partnerships with established institutions that offer access to expertise, resources, and best practices. However, this dependence on external resources must be carefully managed to avoid overreliance on non-sustainable solutions. The overreliance on external archive facilities can expose vulnerabilities in data security and accessibility, warns the Digital Preservation Coalition.⁵⁴

The study indicates that PIDs are perceived as extremely complex to implement and use something which is further aggravated by the lack of technical support. This aligns with complexity, a core element of the Diffusion of Innovations theory, which refers to the perceived difficulty of understanding and using innovation. According to Zoellner and Porter,⁵⁵ if users perceive a technology, in this case PIDs in RDM, to be difficult, they will not adopt it. The Diffusion of Innovations theory construct is operationalised by Putteeraj et al.⁵⁶ who claimed that perceived complexity is a significant barrier to the adoption of new technologies, notably, when users do not have sufficient training or support systems. The complexity and restricted technical expertise within Zimbabwean institutions form a major obstacle to the wider adoption of PIDs. In addition to those challenges, the study also draws attention to structural, organisational, and environmental challenges hindering the adoption of PIDs in Zimbabwean academic institutions. Less often cited were cost, data durability, and reliance on external archive facilities, which present difficulties, particularly for financially constrained institutions.⁵⁷ PID implementation is constrained by budgetary limitations, and dependency on third-party resources creates vulnerabilities in terms of data control, security and sustainability.

What the findings point out is that challenges are rarely challenges in isolation, but they are connections between challenges. This brings forth manifold problems within institutions regarding

a lack of expertise, a lack of infrastructure, ambiguous guidelines, and misconceptions as to what PIDs are and what role they play in RDM and research in general. Finally, these overlapping barriers reflect the interdependence of technological capacity, organisational readiness, and pressure from the external environment as posited by the TOE framework. Moreover, the Diffusion of Innovations theory states that adoption is limited owing to a perception of complexity and uncertain advantages. To meet these challenges, both technological investment and the policy and institutional reforms that underpin them must be integrated into holistic strategies embedded in the cultures in which these programs exist.

Strategies for Increasing Adoption of Persistent Identifiers

The study also looked at how to tackle the problems that were raised. First, similar awareness campaigns need to be targeted to researchers to provide them with an understanding of the value of registration in ORCID within the context of scholarly communication as well as potential benefits for their professional achievements as suggested by Haak et al.⁵⁸ The study also identified that investment in purpose-built research data repositories aligned to global standards is a key requirement to support sustainable data stewardship and PID integration. However, as Haak et al.⁵⁹ point out, having infrastructure is a start and is not enough without additional investment. To do that, PIDs need to be incorporated into clear institutional policies which create the procedural and structural context in which they can thrive. Furthermore, institutions need to look at and address the expertise gap via targeted training programmes. According to Fecher et al.⁶⁰ weak training initiatives have been a part of the problem particularly as they have allowed misconceptions about PIDs which has hampered their adoption. Training needs to be effective and should not be limited just to awareness of how available PIDs are for researchers and librarians but should point out how PIDs can positively affect their work. Training should also give researchers and librarians practical, hands-on opportunities to work with PIDs and see how they can help. According to Fecher et al.⁶¹ demonstrative use cases are of great importance in overcoming skepticism and gaining trust in new technologies.

Notwithstanding investment and training, there is a need for a shift in organisational culture within academic and research institutions when it comes to RDM and PID adoption. Mayernik and Maull⁶² opine that to correct the misconception of PIDs being bureaucratic tools, there is a need for sustained advocacy and engagement, especially among the research community of academic institutions. This is in line with what Mayernik and Maull⁶³ found out, that traditional cultural resistance to new technologies is an often-repeated challenge in academic institutions, as these are frequently perceived by users as bureaucratic rather than enabling tools. Therefore, encouraging the use of PIDs can help to create a culture that values PIDs in supporting research integrity, visibility and reproducibility of open science. Another avenue for addressing infrastructural and expertise gaps is through international collaborations. This can be done through partnerships with regional or global consortia that will provide access to best practices, technical support, and resources.⁶⁴ Collaborations like this can speed the uptake of open science tools and lessen dependence on ephemeral external systems. Through the TOE framework and the Diffusion of Innovations theory insights, Zimbabwean academic institutions can develop strategies to tackle technological, organizational, and cultural barriers at the same time, henceforth putting Zimbabwean academic institutions in a position to utilise the full potential of PID.

Conclusion and recommendations

The study confirmed that none of the institutions that participated in the study has a research data repository in Zimbabwe. While there was awareness of PIDs and institutional research data repositories among respondents, the study suggests a dearth of dedicated research data infrastructure and low adoption of PIDs in the country. The study findings also suggest that there was a misunderstanding of the difference between a research data repository and an institutional

repository among the participants. The use of research data repositories and PIDs at a personal level is relatively high as confirmed by the use of Mendeley, Google Drive, and ORCID. In addition, the policy framework, financial resources, and requisite infrastructure to support the use of PIDs are still at the embryonic stage thereby deterring optimum uptake of open science in general and PIDs in particular. More importantly, respondents unanimously concurred that PIDs facilitate long-lasting access to research and researcher collaboration credibly.

Given the research findings, it is recommended that research institutions in Zimbabwe consider systematically integrating research data management practices for the creation of a progressive ecosystem. The following specific recommendations are proffered:

- Instituting policies at national and institutional levels to provide overarching direction on open science issues that include research data management and PIDs. Adopting the Australian model of a national PIDs strategy could provide Zimbabwe with a structured framework to leapfrog toward successful implementation. This approach would align with international best practices and strengthen the country's capacity to coordinate, fund, and sustain PIDs adoption at a national level.

- Raising awareness and offering training to researchers, ICT personnel, research officers, librarians, and policymakers on PIDs and their role in research data management. Zimbabwe could collaborate with TCC-Africa, whose initiatives across the continent have achieved significant progress in Kenya, Burkina Faso, and South Africa. Partnering with TCC would be particularly valuable in advancing capacity development.

- Availing necessary infrastructural, financial, and human resources to ensure that adoption of PIDs is seamless. Engaging the Research Council of Zimbabwe (RCZ) presents an effective strategy to secure centralized funding and establish the necessary infrastructure for the adoption of PIDs in the country. This approach is particularly fitting, as the RCZ is mandated by the Government of Zimbabwe to spearhead and coordinate national research initiatives.

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