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putting the pieces together: theory and practice

The use of data management planning among researchers in higher learning institutions: The case of the Nelson Mandela African Institution of Science and Technology in Tanzania

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Abstract

This study assessed the use of data management plans among researchers at a selected higher learning institution (HLI) in Tanzania. A pretested structured questionnaire was administered to registered postgraduate students. Many of the respondents reported that a data management plan (DMP) was required before writing a research project and when a research project was submitted. The results also demonstrated that many respondents did not use any online DMP template tools to formulate their DMP although most of them were aware of available DMP template tools such as OpenDMP. Many respondents stated that the requirement of using a DMP were selection of a DMP format, updating the DMP regularly, having a short and to-the-point DMP and a well-structured DMP specifying the kinds and formats of the data to be acquired, generated, produced, and preserved. Meeting funders' institutions, and publishers' requirements, and ensuring that data are accurate, complete, and reliable were among the DMP benefits in HLIs identified by the respondents. Several challenges were revealed including a lack of awareness, competence, and guidelines to assist researchers using a DMP for their research projects.

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Abstract Continued

The conclusion is that researchers need to develop and use DMP template tools to plan, organize, and work on their research projects in addition to ensuring that they meet funders' requirements. It is recommended that HLIs should provide extensive training programs for raising awareness about DMPs among the researchers and to make DMPs a mandatory requirement for finalizing research projects among researchers, and not only for funding purposes.

Introduction

A comprehensive data management plan (DMP) is among the tools for managing research activities throughout the research project, including the management of data which is a crucial component in most of research projects (Williams, Bagwell, and Zozus 2017). A DMP incorporates the essential actions, procedures, and tactics for managing the full data life cycle including identification, collection, preparation, organisation, classification, processing, analysis, storage, publication, curation, and reuse of data (Gupta and Müller-Birn 2018). In general, DMPs are also known as data handling protocols, research data security plans, data sharing plans, manuals of procedures, and manuals of operations (Williams, Bagwell, and Zozus 2017). In addition, a DMP is the most effective method of having researchers explain how they intend to create, store, use, maintain, and make available their research data (Smale et al. 2018).

A DMP is defined as a formal document that gives researchers a way to start managing their data before, during, and after their research projects (Holles and Schmidt 2018; Hudson-Vitale and Moulaison-Sandy 2019; Miksa et al. 2019; Smale et al. 2018). The document needs to be regularly updated and maintained during the duration of the research endeavour (Van Wyk and Van der Walt 2020). On the other hand, the Society for Clinical Data Management [SCDM] (2016) defined a DMP as a document that describes the data collection process up to its final archival form or disposal. In a nutshell, a DMP is a business task that develops and implements plans, policies, practices, acquires data, controls, protects, delivers, and enhances the value of data (Data Management Association of America [DAMA] 2008).

A DMP has a potential of assisting researchers to effectively manage their research data effectively. Its application enables researchers to raise their awareness and knowledge on how to manage their data in a way that will keep it high-quality, usable, and accessible before and after the project is finished (Hudson-Vitale and Moulaison-Sandy 2019; Miksa et al. 2019; Smale et al. 2018; Van Wyk and Van der Walt 2020; Williams, Bagwell, and Zozus 2017). A DMP offers researchers the chance to consider the practical requirements for a successful research study by outlining the fundamental details of how the researcher will gather data, how data will be shared and kept, as well as any potential limitations (Mushi, Piennar, and van Deventer 2020). The ultimate objective of DMPs and library research data services is to promote sound data stewardship procedures (Mannheimer 2018).

A DMP is equally important for HLI, funders, and publishers (Hudson-Vitale and Moulaison-Sandy 2019; Smale et al. 2018; Van Wyk and Van der Walt 2020). It is now widely acknowledged that it has machine-actionable richness with added value for all stakeholders, including researchers, funders, repository managers, research administrators, and librarians within higher education institutions (Miksa et al. 2019). However, in some circles it is frequently viewed as an administrative exercise rather than as a crucial component of research practice (Miksa et al. 2019). Many researchers in HLIs use DMPs for funding purposes more than as a guide to their research work (Dietrich et al. 2016; Mannheimer 2017; Williams, Bagwell, and Zozus 2017). Since a DMP is an inevitable requirement for researchers in HLIs, there is a need for these institutions to create awareness of and facilitate the use of this crucial tool for their researchers (Gajbe et al. 2021).

For example, at the University of Illinois, bids for funding from the National Science Foundation (NSF) were not considered favourably without a DMP (Mischo, Schlembach, and O'Donnell 2014; NSF 2019). Researchers from the University of Houston held a meeting with the National Institutes of Health (NIH) and NSF to know more about the need for them to create DMPs and to comprehend campus demands and guide the creation of future library research data services (Peters and Dryden 2011). And since 2014, the library at Montana State University provided research data services, including assistance with preparing DMPs for grants (Mannheimer 2018). However, DMP requirements may vary for each funding agency, for instance the Dutch Research Council (NWO) requires researchers to complete the DMP before the grant is disbursed, while Horizon 2020 requires a DMP after providing the funding (Lefebvre, Bakhtiari, and Spruit 2020).

Apart from the use of a DMP as a guide to research projects and funding opportunities for researchers in HLIs, a DMP has myriad benefits including to ensure research data quality, to increase the rate of data reuse, and institutional planning (Smale et al. 2018). For instance, institutions within Australia and internationally frequently promote the professional benefits of DMPs use and endorse DMPs as a best practice (Smale et al. 2018). Other interpretations of DMP and data management techniques place an emphasis on data archiving and preservation (DAMA 2008), and data sharing (Hudson-Vitale and Moulaison 2019; Williams, Bagwell, and Zozus 2019). Bishoff and Johnston (2015, 12) added that DMPs can be used for “sharing or disseminating the results of the research project through publication in peer-reviewed journals and conference presentation.” A Georgia Tech study discovered that when creating new DMPs, academics frequently can share and reuse language from existing DMPs (Parham and Doty 2012).

Despite the fact that DMPs are frequently promoted across the scholarly literature, funding body policies, and institutional communications as a good research tool for researchers to have (Smale et al. 2018), developing a DMP takes time and effort (Fadlelmola et al 2021; Gajbe et al. 2021), and it requires researchers to be aware of the DMP template tools they can use based on their research projects (Gajbe et al. 2021). There are word-based as well as online DMP template tools for researchers to use (Gajbe et al. 2021). Over time, online

DMP template tools such as DMPonline and DMPTools have been gaining popularity and most of them are freely available and user-friendly (Gajbe et al. 2021; Holles and Schmidt 2018). DMPtool serves as a tool to help the researcher prepare a funding DMP while the Purdue DCP serves as a tool to help the researcher or graduate student develop a project DMP (Holles and Schmidt 2018). The first online DMP template tool named DMPonline was developed by Digital Curation Center (DCC) and is still offering support to researchers, librarians and funders through various hybrid, face to face, and/or online training (Donnelly, Jones, and Pattenden 2010; Jones, Pryor, and Whyte 2013). Some researchers are also collaborating with librarians to develop acceptable data management plans (Chaput and Walsh 2023).

Understanding of DMP

The efficiency of a DMP as a tool for guiding research projects depends on the ability and awareness among researchers as the main users of DMPs in HLIs. Despite the increase in allocation of library, research office, and policy-unit resources towards the promotion of DMP, research identified low usage of DMPs as a research tool (Lefebvre, Bakhtiari, and Spruit 2020; Smale et al. 2018). Among the major obstacles of creating and using DMPs in HLIs is a lack of awareness and knowledge about the usefulness and best practices of using a DMP as a research tool among researchers (Brazma et al. 2021; Fadlelmola et al. 2021; Lefebvre, Bakhtiari, and Spruit 2020).

There is also a dearth of instruction on how to incorporate DMPs into research projects in most of HLIs (Brazma et al. 2021; Lefebvre, Bakhtiari and Spruit 2020; Williams, Bagwell, and Zozus 2017). It has also been noticed that the majority of DMPs are not reviewed or updated resulting in being less effective (Van Wyk and Van der Walt 2020). Additionally, maintaining a DMP requires a time commitment from researchers, which diverts time from research-related activities and, as a result, are often lower on a priority list with little incentive (Gajbe et al. 2021; Miksa et al. 2019). Public funding agencies such as the National Research Foundation (NRF) and National Science Foundation (NSF) face novel challenges related to the management of research outputs produced in HLIs (Lefebvre, Bakhtiari, and Spruit 2020). As a result, DMPs are among the funders' requirements for researchers (Dietrich et al. 2016; Mannheimer 2018; NSF 2015; Williams, Bagwell, and Zozus 2017). This study focused on assessing how a DMP was used by researchers in HLIs using the Nelson Mandela African Institution of Science and Technology (NM-AIST) as a case study. NM-AIST is among the public universities in Tanzania established in 2011 as one in a network of African Institutions of Science and Technology (AISTs) in Sub-Saharan Africa (SSA), as an research-intensive university (NM-AIST 2009). Specifically, this study sought to:

- Assess the need for a DMP among researchers in HLIs.
- Establish the time frame appropriate to formulate a DMP.
- Identify DMP template tools used by researchers.
- Establish the requirements for using a DMP.
- Determine the benefits and challenges for using DMP among researchers in HLIs.

Methods

The NM-AIST is a research-intensive university, thus doing research is among the critical areas for postgraduate students joining this university. Various research methodologies workshops are conducted regularly thus students are familiar with various research aspects. The establishment of the research data management (RDM) project at the NM-AIST was among the initiatives to equip students and researchers with more skills and knowledge on research activities. To ensure the establishment of RDM services, the institution in collaboration with Hasselt University in Belgium conducted a RDM training from 6 to 9 June 2022 that required the participation of all registered postgraduate students. A pretested structured questionnaire was administered from 13 to 30 June 2022 to all the 300 registered postgraduate students with a response rate of 34.67%. A response rate above 25% is considered above average and acceptable for analysis (Hiebl and Richter 2018). The permission from the institution and the consent of the respondents were sought before the data was collected. Cross-sectional studies relying on self-reporting are the commonest ways of researching research data management activities (Perrier et al. 2017). The analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software.

Findings

Demographic characteristics of respondents

Of 104 respondents who participated in this study, 55 (52.9 %) were male. A total of 50 (48.1%) respondents were aged between 21 to 30 years. Table 1 demonstrates the demographic information of the respondents.

Table 1: Demographic information of respondents (N=104)

Item(s)	Categories	Frequency	Percentage
Gender	Male	55	52.9
	Female	49	47.1
Age (in years)	21- 30	50	48.1
	31- 40	43	41.3
	41-50	11	10.6
Level of study	Master	64	62
	PhD	40	38

The need for a DMP among researchers in HLIs

Respondents were required to establish the need for using a DMP for their research projects. A total of 101 (99%) respondents agreed on the need for a DMP for their research work. Table 2 illustrates the need for using a DMP among respondents.

Table 2: The need for DMP among researchers

The need for DMP among researchers	Yes	Percentage
Yes	101	99
No	3	1
Total	104	100

The time frame appropriate to formulate a DMP

Respondents were required to indicate a time frame appropriate for them to formulate a DMP. A total of 45 (43.2%) respondents indicated that a DMP was supposed to be formulated before writing a research proposal, and 32 (30.7%) respondents needed it when a research proposal had been submitted. Table 3 illustrates the results.

Table 3: The time frame appropriate to require a DMP

Time frame	Frequency	Percentage
Before writing a research project	45	43.2
During writing a research project	27	26.1
When a research project is submitted	32	30.7
Total	104	100

DMP templates tools used by researchers

The DMP template tools that researchers used to create their DMPs for their research projects had to be selected. A total of 70 (67%) respondents chose “none,” which means they did not use any templates, and 20 (21%) of the respondents used Word® template tools with only 13 (13%) using online templates. Table 4 shows DMP template tools used by researchers to create their DMPs.

Table 4: DMP template tools among researchers

DMP template tools	Frequency	Percentage
Word® template tools	21	20
Online template tools	13	13
None	70	67
Total	104	100

Respondents were also required to select online available DMP template tools that can help them create their own DMPs for their research projects. Most of the respondents 51 (49.2%) selected OpenDMP, followed by 13 (12.5%) who selected DMPTool. Table 5 provides the various online available DMP template tools that the respondents selected.

Table 5: Online available DMP template tools

Online available DMP template tools	Frequency	Percentage
OpenDMP: dmponline.dcc.ac.uk	51	49.2
DataONE: www.dataone.org	9	8.5
ResData RDMP: www.resdata.unsw.edu.au	12	11.5
TUB-DMP: dmp.tu.berlin.de	6	5.8
DMPTool: dmptool.org	13	12.5
RDM Toolkit: rdntoolkit.jisc.ac.uk	8	7.7
ezDMP: www.ezdmp.org	5	4.8
Total	104	100

Requirements for using a DMP

It was necessary for researchers to list the prerequisites for employing a DMP. A total of 35 (33.7%) respondents were agreed that researchers must choose a DMP template format (paper or electronic) to work on and must occasionally update the DMP. Table 6 shows the results.

Table 6: Requirements when using a DMP

Requirements	Frequency	Percentage
Know your data	13	12.5
Know the environment	6	5.9
Choose a DMP format (paper or electronic)	35	33.7
Write your DMP	15	14.2
Always update the DMP	35	33.7
Total	104	100

Secondly, researchers had to select criteria to describe an extensive DMP. A total of 27 (26.5%) respondents selected a short and to the point DMP, and 20 (19.2%) respondents selected a clear, specific, and detailed DMP. Table 7 illustrates criteria to describe an extensive DMP.

Table 7: Criteria to describe an extensive DMP

Criteria to describe an extensive DMP	Frequency	Percentage
Clear, specified, and detailed	20	19.3
Short and to the point	27	26.5
Feasible	8	7.7
Justified	12	11.6
Standards and practices	7	6.8
Optimal use	4	2.9
Relevant	10	9.6
Adhere to requirements	14	13.7
Not verbose	2	1.9
Total	104	100

Lastly, a well-structured DMP requires several components before being submitted to a funder, institution, or a publisher. Therefore, a total of 31 (29.7%) respondents selected types of data to be collected, generated, or produced, and 25 (24%) respondents selected data formats and standards to be used for documenting and describing the data. Table 8 presents components of a well-structured DMP.

Table 8: Components of a well-structured DMP

Components	Frequency	Percentage
Types of data to be collected, generated or produced	31	29.7
Methodology or processes used	18	17.3
Data formats and standards	25	24.0
The availability of the data and how they can be accessed	9	8.7
The guidelines, procedures or policies	6	5.9
Intellectual property rights (IPR) and copyrights issues	10	9.6
Long-term preservation and archiving	5	4.8
Total	104	100

Benefits and challenges for using a DMP among researchers in HLIs

The development and using of a DMP for researchers in HLIs have numerous benefits. A total of 31 (29.7%) respondents selected the option, meeting funders' institutions and publishers' requirements and 25 (24%) respondents selected that a DMP ensures data are accurate, complete, and secure. Table 9 presents several DMP benefits selected by the respondents.

Table 9: DMP benefits for researchers

Benefits	Frequency	Percentage
Meet funders, institutions, and publishers' requirements	31	29.7
Prevent and/or reduce likelihood of mashups such as data loss	18	17.3
Ensure data are accurate, complete, reliable, and secure	25	24.0
Enhance critically review of a research project	9	8.7
Outline research data life cycle from collection to data storage	6	5.9
Comply with community standards e.g., FAIR principle	15	14.4
Total	104	100

On the other hand, researchers mentioned various challenges that prevented them from utilising DMPs during their research projects. A total of 28 (26.9%) reported a lack of awareness and competency. Table 10 presents various challenges that prohibited the application of DMP among the respondents.

Table 10: Challenges that prohibited the application of DMP among respondents

Challenges	Frequency	Percentage
Ignorance	13	12.8
Lack of time and fund	15	14.2
Lack of guidelines for DMP	20	19.2
Lack of awareness	28	26.9
Lack of competency	28	26.9
Total	104	100

Discussion

The study's findings showed that for researchers to work on their research projects, a DMP is mandatory, with nearly 100% of respondents indicating the need for a DMP for their research activities. Gajbe et al. (2021) added that a DMP is also useful for funders, researchers, librarians, users, data curators, etc., since it provides comprehensive metadata and documentation regarding the entire research data life cycle. Moreover, a DMP is a suitable template for managing sensitive research projects (Bowman and Maxwell 2018). The study discovered that the DMP is required before the commencement of the research project, which is also supported by Miksa et al. (2019), who reported that the DMP is typically a static document generated before the start of a project. Fadlilmola et al. (2021) also added that a DMP needs to be created before the start of a research project and it is used to describe how research data is gathered, generated, preserved, and shared throughout the project.

However, Horizon2020 (2020) suggested that researchers need a DMP at various stages of their projects, but this is still dependent on static text files. It is also reported that a DMP is important at several stages of a project, such as when a project proposal is being created, during the execution of the project, and after the project is over (Donnelly and Jones 2011). Donnelly and Jones (2011) and Gajbe et al. (2021) recommended that the first stage is crucial from the funder's point of view since it clarifies the requirements for money and aids the researchers in obtaining it, the second stage is critical in the researchers' perspective and helps them to handle their data throughout the ongoing research process, while the third stage is important from a general perspective. DMPs provide optimal data reuse, data sharing, and data curation when used collectively in three phases, making data findable, accessible, interoperable, and reusable (FAIR) through DMP preparation (Wilkinson et al. 2016).

Most of the respondents did not use online templates and only preferred the word template for DMP creation. DMPs can be created using word templates or with the aid of the available online tools (Gajbe et al. 2021). However, the use of manual templates can be difficult due to lack of training and awareness, but online support tools can aid DMP processes. OpenDMP and the DMPTool, were selected among the openly available online DMP template tools by researchers for creating their DMP for their research projects. Gajbe et al (2021) pointed out that available online DMP template tools reduce effort and time.

The findings also established requirements for using a DMP among researchers. According to this study a DMP template tool (either paper-based or electronic) is required, and a DMP must be occasionally updated. Williams, Bagwell, and Zozus (2017) seen that researchers must consider and begin working on a DMP template while doing their study. The current study also discovered that researchers preferred a short and to the point, as well as "a clear, specific, and detailed DMP," as among the requirements for a standard DMP. The same observation was made by Michener (2015). Smale et al. (2018) also pointed out the need to have a detailed DMP to attract more funders for the researchers. Additionally, Miksa et al. (2019) proposed ten criteria for machine-actionable DMPs (maDMPs) including: (i) integrate DMPs with the workflows of all stakeholders in the research data ecosystem, (ii) allow automated systems to act on behalf of stakeholders, (iii) make policies (also) for machines, not just for people, (iv) describe components for both for machines and humans, (v) use persistent identifiers (PIDs) and controlled vocabularies, (vi) follow a common data model for maDMPs, (vii) make maDMPs available for human and machine consumption, (viii) support data management evaluation and monitoring, (ix) make DMPs updatable, living, versioned documents, and (x), make maDMPs publicly available.

A well-structured DMP requires several components before being submitted to a funder, an institution, or a publisher. The study findings indicated the types of data that are needed to be gathered, generated, or produced as well as the formats for the data and the standards as among the components required for a well-structured DMP. However, HLIs, funders, and publishers may have different components to constitute a DMP based on their requirements, mission and vision, and position in the society in general. For example,

NSF (2019) and Smale et al. (2018) identified DMP components documented in the literature that include data protection, sample documentation, physical collection sharing, curricular resources, and other associated research and educational outputs.

The study identified several benefits of DMP for researchers, including ensuring that the data to be collected, analyzed, and stored are correct, complete, and reliable as well as meeting the needs of funders, institutions, and publications. Meeting funders' policies is supported by several authors (Dietrich et al. 2016; Hudson-Vitale and Moulaison-Sandy 2019; Lefebvre, Bakhtiari, and Spruit 2020; Mannheimer 2018; NSF 2015, 2019; Smale et al. 2018; Williams, Bagwell, and Zozus 2017). The foremost reasons for developing a DMP is that funders' agencies such as NSF, the National Institute of Health (NIH), and the National Endowment for the Humanities (NEH) require a DMP as part of applications for funding (Dietrich et al. 2016; Hudson-Vitale and Moulaison-Sandy 2019; Mannheimer 2018; NSF 2015, 2019; Williams, Bagwell, and Zozus 2017). The DMP requirement from funding organizations is a commitment to the premise that effective DMPs may ensure that released research data complies with community standards like the FAIR data principles (Wilkinson et al. 2016). On the other hand, the creation of DMPs supports the FAIR principle to ensure data are accurate, effective, well-managed, and ready for long-term preservation (Fadlelmola et al. 2021). The application of a DMP as stated under the Data Management Research Tool (DART) needs to be a rich source of information about researchers' data management knowledge, capabilities, practices, and needs (Parham et al. 2016). In general, using a DMP has numerous benefits, including making it easier to comply with funder mandates, promoting open research, increasing data FAIRness, safeguarding data subjects, and facilitating compliance with local data protection laws (Michener 2015).

The findings identified several challenges that prohibit the application of DMPs among researchers in HLIs, including a lack of awareness, competency, and guidelines. Hudson-Vitale and Moulaison-Sandy (2019) and Parham et al. (2016), stated that the concept of a DMP is new, and there is a lack of awareness about it among the academic environments. Similarly, Melero and Navarro-Molina (2020) concluded that the notion of a DMP is not well understood by researchers. Many postgraduate programs do not offer any training on data management; and as a result, scientists in funding institutions may not be aware of the DMP as a tool for data-related quality assurance and control (Williams, Bagwell, and Zozus 2017). On the other hand, Williams, Bagwell, and Zozus (2017) stated that there is no widely accepted list of themes that a DMP should cover, hence there is a lack of uniformity in DMP topics in HLIs. Holles and Schmidt (2018) argued that graduate students should be taught DMP in RDM courses, which should be co-taught by faculty members and librarians.

Recommendations

- HLIs should provide extensive training programmes for raising awareness about DMP among the researchers.
- HLIs make DMPs a mandatory requirement for finalising research projects among researchers not only for funding purposes.

- HLIs should identify and recommend the use of available online DMP template tools for their researchers.
- Researchers should focus on DMP standards for their research projects.
- DMPs should guide research projects throughout their life cycle.

Limitations

Notwithstanding that this research is a case study, it used structured questionnaires to collect data from postgraduate students, as a result, the study was unable to obtain opinions of stakeholders such as librarians, lecturers, research and innovation personnel, and others in HLIs regarding the use of DMPs for research projects. Therefore, the results are not truly representative of the data management planning landscape in HLIs in general. Secondly, the study relied on self-reporting and it will be necessary to carry out a study to examine behaviour changes among postgraduate students, for example, determining the creation of DMPs and their use throughout the whole research cycle.

Conclusion

Various components and a road map for a completed DMP were presented and discussed. The benefits of DMP for researchers as well as the challenges that prevent HLIs from implementing DMP for their researchers were discussed. A larger focus is placed on implementing DMPs for researchers in HLIs, not only to meet funders' institution and publishers' criteria, but also for researchers to effectively plan and carry out their research projects, as evidenced by the high percentage of respondents who acknowledged a need for DMPs. Before the research project begins, a DMP must be created, but it must also be reviewed and updated during the research progress. Researchers must make use of a variety of online available DMP template tools during their research projects.

Data Availability

Questionnaire file available under the article [Supplementary Files](#).

Appendix 1: Survey Questionnaire to Collect Data for Postgraduate Students at the Nelson Mandela African Institution of Science and Technology (NM-AIST)

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Competing Interests

The authors declare that they have no competing interests.

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