Integrated National Research Portal (INRP): An Interoperable Web Application That Aggregates Research Publications

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A report submitted to the Department of Library and Information Science, The University of Zambia, in partial fulfillment of the requirements of the degree of Bachelor of Information and Communication Technologies with Education

THE UNIVERSITY OF ZAMBIA

LUSAKA

2022

Abstract

In recent years, research institutions have built systems (institutional repositories or research portals) that upload and store the different publications produced by researchers. These different institutional repositories help their respective institutions to keep the scholarly works in a central place. Institutions are using their repositories to host, manage, showcase, and distribute their research output. These different institutional repositories however, are stand alone portals which makes it tedious and time consuming for researchers to find information easily as they are made to move from one portal to another in search of information related to their research. The purpose of this study was to investigate the feasibility of building an Integrated National Research Portal(INRP) and thereafter build the system. The study employed an incremental development and integration and configuration model of system development to develop the different components of the system as part of the system was developed through configuration and customisation of open source platforms that includes searchkit and elasticloud. A survey research design was used to collect quantitative data on how the research publications must be structured and displayed on the INRP and what metadata of the research publication must be displayed. The target population was fourth year undergraduate students and postgraduates from the 13 different schools at the University of Zambia and a total of 30 students responded. The target area was the University of Zambia and data collection tools for the survey included structured questionnaires and observation methods. Data collected from the survey was analyzed using content analysis. The finding of the study on how the system must display the information revealed that (93.3%) out of 30 participants were undergraduates and (6.7%) were postgraduate students. The study established that the integrated national research portal was more effective for educational research than the stand alone portals. After the implementation of the INRP, an experiment was conducted to ascertain and measure the effectiveness of the system at making access to research publications fast and easy. A total of 30 students participated in this experiment who included both undergraduate and postgraduate students. Purposive sampling was adopted in the selection of the 30 participants. The majority of the respondents agreed that the Integrated National research Portal is more efficient and easy to use to search for information on publications. Therefore the study recommended that the integrated research portal is a very effective platform for searching for research publications as it makes research publications easily and quickly accessible and discoverable to the public.

Acknowledgement

First and foremost, our humble gratitude goes to the Almighty God, for his mercy, grace and inspiration. We also express our sincere gratitude and thanks to our supervisor Dr Lighton Phiri, for his great and constant support, encouragement, tireless effort and his patience throughout the development of our final year project. His continuous availability for consultation and guidance is immensely valuable. This research project would have been a failure without the support and encouragement from him.

Special thanks also goes to individual team members for their effort, contribution and undying spirit. Lastly we would like to thank everyone who helped us during our project in one way or the other as the list is endless.

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List of Abbreviations

Abbreviation	Description
JSON	Javascript Object Notation
MARC	Machine Readable Catalog
XML	Extensible Mark-up Language
INRP	Integrated National Research Portal
OAI-PMH	Open Archives Initiative Protocol for Metadata Harvesting
UNZA	The University of Zambia
API	Application Programming Interface
URL	Uniform Resource Locator
UI	User Interface
UX	User Experience
GUI	Graphical User Interface
SQL	Structured Query Language

1. Introduction

1.1 Overview

This chapter presents the introduction of the study on the implementation of an Integrated National Research Project. The first part covers the project description explaining the integration of the integrated National Research Portal. The chapter also presents the statements of the problem, Aims of the study, Broad objectives, specific objectives and research questions.

1.2 Project Description

This project was about customizing and configuring an integration national research portal that would be used to facilitate access to research publications generated by research institutes in The Republic of Zambia. In other words, this project was about building by customization and configuration, a web application or portal that would act as a central point of access to research publications generated by research institutes and published on their respective portals in zambia. This was in order to increase research publication's discoverability which was not easy to discover or easily visible to the public at that time due to the absence of a unified research portal that acts as a central point of access to research publications available on many different research portals in the country. The Implementation of this project involved a systematic evaluation of all potential open source platforms or tools that were customized and configured to build the national research portal, the adoption of an appropriate tool or platform, application system customisation and configuration and finally, the systematic evaluation of the features, usability and usefulness of the customized and configured platform.

1.3 Problem Statement

It was obvious to say that the volume of research publications made publicly available and the number of independent research portals together with their respective research institutes had or was dramatically increasing in Zambia. Figure 1 to Figure 2 shows the user interfaces of some examples of the independent research portals in zambia. The increase in number of research portals or research institutes that generated research publication had compromised research publication's discoverability as researchers didn't know much about the research institutes or their respective portal and if they did, then they were made to move from one research portal to another in search of information in order to have a comprehensive understanding of their topic of research. The state of affairs in relation to how research publications were accessed by researchers was tedious, time consuming or slow and ineffective. A potential solution to the problem was to use a scalable and robust web application that provided centralized access to research publications on different research portals across the Nation.

Figure 1: Interface for Malaria Institute at Macha

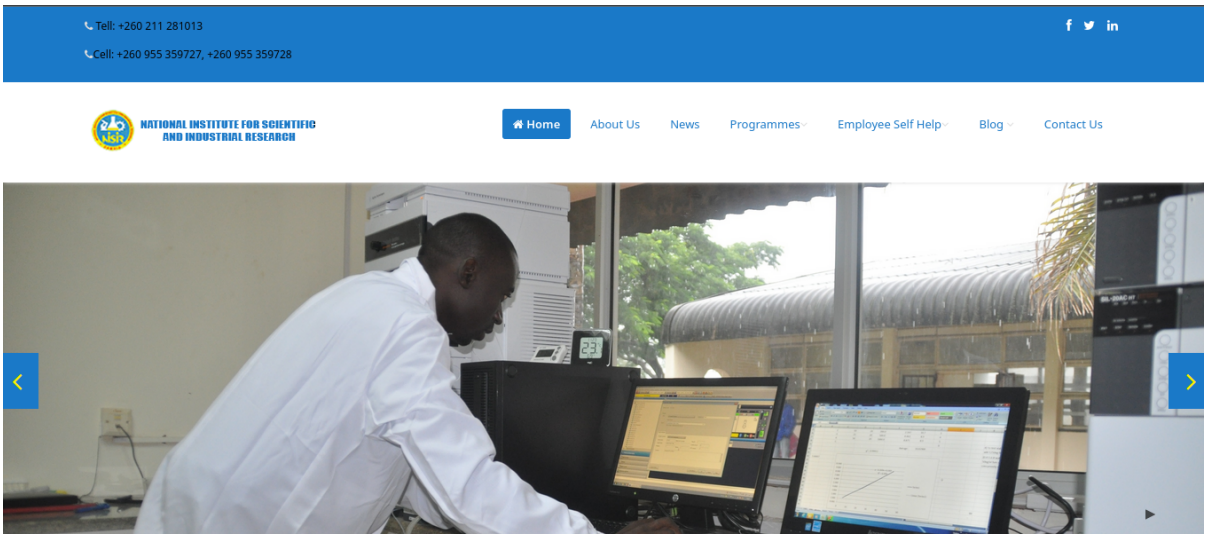

Figure 2: Interface for National Institute for Scientific and Industrial Research (NISIR)

1.4 Aims

The aim of this project was to improve research publication's discoverability by implementing a scalable, robust and user-friendly Integrated national research portal that facilitated centralized access to research publications from different research portals.

1.5 Broad Objectives

Was to integrate independent research portals and ensure centralized access to research publications.

1.6 Specific Objectives

The following were our research objectives:

- To determine the feasibility of implementing an integrated national research portal.
- To determine how effective the Integrated national research portal will be by accelerating access to research publications.
- To determine how research publications from various research institute portals will be integrated within one central portal.

1.7 Research Questions

This project attempted to answer each of the following questions:

I. With the implementation of an integrated national research portal, how effective and efficient would access to research publication be?
II. How would the implementation of an integrated national research portal have been feasible?
III. How would the integrated national research portal integrate research publications from various research institutes to one central portal?

2. Related Work

2.1 Overview

The chapter reviews the literature related to the usefulness of the INRP and other related literature on the topic of the study. A literature review is important because it brings clarity and focus on the research problem, as it helps the researcher to understand the subject area better, thus helping to conceptualize the research problem clearly and precisely. It also helps to understand the relationship between the research problem and the body of knowledge in the area. The literature review helps the researcher to use procedures and methods that are similar to the ones being proposed which have proved to have worked for them and the problems they faced. The source of information in the literature review includes journal articles, reports from educational organizations, books and recommended readings from the supervisor among others.

2.2. Interoperability

The functionality of different programs and systems to share data and information and files was made possible by the use of interoperability[17]. Interoperability is a term used to describe the exchange of data among information systems which is built upon the agreement on standards and protocols. There were a number of standards and protocols that would have been used in the integration of various portals. Below are examples of some of the protocols and standards of interoperability.

2.2.1. OAI-PMH

Open Archives Initiative Protocol for Metadata Harvesting is a protocol for harvesting metadata. Data harvesting is a process of extracting valuable data from a given source, a technique that search engines use to look for catalog and index content from various websites to make it searchable in a single location[21]. Dspace and Arc source tools are some of the tools used or implemented by OAI-PMH. All the tools support OAI-PMH v.2.0 and a few include v1.1 and v1.0 versions.

2.2.2 XML

The Ontorio council of university libraries, represents the libraries of 21 universities with a population of 480 thousand. The council developed an integrated Scholarly portal that gives access to collections of E-journals, E-books, social science and Geo- special data. The scholarly Portal also supports the online interlibrary Extensive markup language' (XML). XML is one of the tools the integrated scholarly portal used for hierarchical or analytical information to link between bibliographic records and digital resources[12]. XML is a markup language and a file format for storing and transmitting. It defines a set of rules for encoding documents in a format that is both human and machine readable.

2.2.3 SWORD

Sword is a software protocol that enables clients and servers to communicate around complex digital objects.Many universities and research institutions in the world have implemented institutional repositories for archiving, management of digital collections, maintenance of digital materials and electronic publications such as e-journals and e- books. The repository is the shared library storage facility whose operations are supported by the system and integrated policy.Centralised repository includes, electronic documents, digital archive and database of web content, this is enabled by Sword[8].

2.3. Feasibility

The Implementation of the Integrated National Research Portal was possible as was seen from the already existing or implemented portals that integrated research publications and usage of the research portals that integrated research publication from different research portals which had grown rapidly and had satisfied the requirements and met the research needs of students and researchers. Examples of such portals are the Scholarly Portal developed by Ontario Council of University Libraries (OCUL), the Water Quality Portal (WQP) developed by the U.S. Environmental Protection Agency, the U.S. Geological Survey, the National Water Quality Monitoring Council[21] and the Monash Psychology Research Portal (MPRP) developed by the Monash University of Australia.

2.3.1 Water Quality Portal

One of the feasibly implemented integrated research portals is the Water Quality Portal (WQP). It is a web based single point of access that integrates national-scale water quality data in the U.S developed by U.S. Environmental Protection Agency, the U.S. Geological Survey and the National Water Quality Monitoring Council[16]. The Water Quality Portal aggregates standardized data and serves more than 297, 000, 000 water quality data via a web interface and data services. The Water Quality Data Portal was implemented and designed to provide easy access to data stored in three large water quality databases (WQX, NWIS, STEWARDS) through a web-based form interface as well as standalone web services. Both the form interface and the web services use the same input parameters (filters) and produce the same output formats. The web service enables programmatic access to WQP data and metadata without manually interacting with the form interface. The water quality portal web services can be used to quickly and easily access the metadata available on the water quality portal[16].

The water quality portal (WQP) is a cooperative service sponsored by the United States Geological Survey (USGS), the Environment Protection Agency (EPA), and the National Water Quality Monitoring (NWQMC). The WQP integrates publicly available water quality data from the USGS National Water Information system (MWIS) , the EPA Water Quality Exchange (WQX) Data Warehouse, and the USDA ARS Sustaining The Earth's Watersheds- Agricultural Research Database System(STEWARDS). The EPA water quality data originates from the Water Quality

Exchange, the EPA's repository of water quality monitoring data collected by water resource management groups across the country. Organizations including states, tribes, watershed groups and universities, submit data to the WQX in order to make their data publicly accessible [11].

The USGS water quality data originate from the NWIS database. The database contains current and historical water data from more than 1.5 millions sites across the nation. It is used by state and local governments, public and private utilities, private citizens and other federal agencies involved in managing water resources

Water quality monitoring is a crucial aspect of protecting water resources. Under the clean water act, state, tribal and federal agencies monitor lakes, streams, rivers and other types of water bodies to determine water quality conditions. The data generated from these monitoring activities help water resource managers know where water pollution problems exist, where to focus pollution control energies and where progress has been made. The water quality exchange is the mechanism for data partners to submit water monitoring data to EPA. The water quality portal is the mechanism for anyone, including the public to retrieve water monitoring data EPA [11].

The WQP is also implemented with APIs (Application Programming Interface), the APIs together with web services are tools that enable communication between WQP and networked devices or pieces of software using standardized methods [24]. API also allows data from one system to be easily used by a second system without requiring the second system to locally store the data, which is especially beneficial when we are dealing with *big* data sets. In the same way the Integrated National Research Portal will make use of APIs which will allow it to integrate data or information from the local research institutes portals without itself locally storing the data [18]. A web service is a *type* of API that allows one computer to communicate data to another computer in a standardized way. The WQP web services are implemented using the 'https' protocol and by using REST, which provides a flexible and scalable approach for constructing standardized URL (Unique Resource Locator) statements.

The WQP and the INRP is said to be a single point of access or centralized platform for access to numerous sources or portals through a web interface. Both portals have National-scale coverage for data aggregation. However the INRP will make available research publications from various research institutes in Zambia while the WQP gives access to the information or results of the water quality of a specific area of interest by the researcher in a downloadable document.

2.3.2 Monash Psychology Portal

Another, yet exciting, research portal is Monash's Psychology Research Portal. An online platform that helps guide users through each step of their online research project, from identifying a research question, setting up the methodology, collecting and analyzing data online, and finally writing up their thesis. The research portal assists honors and post graduates psychology research students as well as research supervisors to conduct projects online [2]. The research portal itself can be seen as a memory system, information and theory presented is stored in long term memory and is available to support the entire research journey from start to finish. Inside the portal there are various tools and applications, many of which are housed in the virtual laboratory (vLab), that can be used to conduct research much like a working memory platform. New information can be added by using these tools to collect, analyze and store your research data as adding to your long-term memory bank [2].

The vLab is a practical online laboratory fitted with the tools needed for most end-to-end research workflows. It is the gateway to conducting research online. The tools and applications built on vLab are maintained by the users faculty and enables them to run full desktop applications such as qualtrics, inquisit, SPSS, NVivo, MatLab, R, Amos, LabArchives, core MsOffice application and many more, anyway and anytime from any internet connected devices. Monash School of Psychology Sciences launched vLab in January 2017 and a year later, in response to users feedback launched the vLab-Max, an updated version that uses the advanced MoVE (Monash Virtual Environment) platform, bringing performance and usability improvements. The vLab allows users to select and/or create psychological measurement tools, and to acquire human research data by conducting and contributing to the development of online experiments, surveys and databases.

2.3.3 Ontario Council Of University Libraries

The Ontario Council of University Libraries' Scholarly Portal was founded in 2002, in order to provide a shared technology infrastructure and shared collections for all 21 university libraries in the province[20]. Through the Ontario's University students, faculty and researchers have access to an extensive collection of e-journals, e-books, social science and geospatial data. The Scholarly Portal also supports an online interlibrary loan platform for Ontario's university, a virtual chat reference service and other tools designed to aid and enhance academic research on Ontario.

The Scholarly Portal contains Journals, Geoportal, Dataverse, Odesi services and features. Some of the features include, Accessible Content ePortal or ACE, Ask A Librarian, Books, Dataverse, Geoportal, Journals, Ontario Library Research cloud (OLRC), Ontario Data Documentation, Extraction, service and infrastructure (ODESI), Permafrost, Publishing and RACER (Rapid access to collections by electronic requesting)[20].

2.3.3.1 Eportal

The Accessible Content ePortal is a growing repository of accessible format texts available to users with print disabilities at participating institutions in Ontario. Users with print disabilities are given access to browse, search and download texts from the secure repository through their home institutions. Users can also request additional texts to be added to the repository through their accessibility offices [20].

Ask A Librarian, a bilingual virtual reference service that connects students, faculty and researchers from participating libraries with real-time library and research assistance through chat. It is available 67 hours per week during the academic year. It provides online, on-demand assistance from librarians allowing users to get immediate help no matter where they are. Chat support is available in both English and French during all service hours.The ePortal also has the following[20];

Dataverse , a research alerts management and sharing platform that allows for secure deposit, flexible sharing and operation and visualization of research data collected by individuals and organizations associated with subscribing to a Canadian university[14].

Geopartial, an award winning geospatial data discovery tool, allows Ontario's university students and resources of all disciplines to enrich their teaching and research with a single point of access and retrieval to a curated collection of maps and geospatial datasets.

Journals, a digital repository of over 53 million scholarly articles drawn from journals in every academic discipline. In 2013 journals was certified by the content for research Libraries (CRL) as a Trustworthy Digital Repository.

Ontario’s Library Research Cloud (OLRC), a collaboration of Ontoro’s universityLibraries to build a high capacity, geographically distributed storage and complete network using proven and scalable open source cloud technologies.
Ontario’s Data Documentation, Extraction, Service and Infrastructure (ODESI), a web based data exploration, and analysis tool. A unique partnership between university librarians, business and government, ODESI greatly improves access to statistical social survey and polling data for researchers, teachers and students[1] .

Permafrost, a hosted digital preservation service that provides a suite of tools, training and resources to enable OCUL members to begin actively processing digital objects for long term preservation and access. It is operated by Scholars Portal on a cost-recovery basis. Permafrost puts the importance of training and support front and center.

2.3.4 Open Source Software

There are a number of Free and open software platforms that are used for integration and configuration of research portals. Some good examples are Invenio, Fedora, Apache Jetspeed, UPortal and Project Blacklight. These platforms facilitate implementation of research repositories. Existing repositories that have been built using Invenio platforms to be specific are Zenodo, CDS videos and CERN Open Data[10] .

2.3.4.1 Project Blacklight

Blacklight is an open source Ruby on Rails engine for creating search on top of Apache solr indices. Ruby on Rails, is a server-side web application framework written in Ruby under the MTI Licence. Blacklight is used by libraries to create discovery layers or institutional repositories [6]. Blacklight includes faceted browsing, relevance-based searching, bookmarking documents, permanent URLs for documents[19]. It is simple to customize Blacklight by writing Ruby code that overrides default Blacklight code. It includes several plugins including an extension for geospatial data[25], digital exhibit creation tool and various search and user face features. The early implementers are University of Virginia, Stanford university, North Carolina state university, WGBH Open Vault, and University of Wisconsin-Madison.

2.3.4.2 Apache Jetspeed

Apache Jetspeed is another open source implementation of an enterprise information portal using Java and XML. JetSpeed offers services to facilitate web portal construction, enabling personalisation and aggregation of information from different sources. It has been evaluated as one of the best open source software by the development gateway foundation[26].

2.3.4.3 Uportal

Furthermore Uportal is another open source software platform used for configuring and customizing a web portal. It is managed by Aperco and operates under the Apache license and is one of the leading open source, built on open standards based technologies such as java and XML and enables easy, standard based integration with authentication and security infrastructure. It supports single sign-on secure access, web based content and user customization. It conforms with web content accessibility guidelines version 2.0 level AA and uses gradel for its project configuration and build systems[27].

2.3.4.4 SearchKit

Searchkit is a suite of User Interface (UI) components built in react. The aim of searchkit is to rapidly create beautiful search applications using declarative components. It is a powerful and streamlined C language framework for indexing and searching text in most human languages. It provides fast information retrieval in System Preferences, Address Book, Help Viewer, and Xcode. Apple’s Spotlight technology is built on top of Search Kit to provide content searching in Finder, Mail, and the Spotlight menu. Search Kit is appropriate when you want your application to have full control over indexing and searching, and when your focus is file content. Search Kit supports

phrase searches, prefix/suffix/substring searches, Boolean searches, summarization, and relevance ranking. Search Kit uses Spotlight's metadata importers when indexing documents and takes advantage of any additional importers available on a system. Search kit uses another open source platform for search and indexing but without being an ElasticSearch expert one can still work with searchkit. The platforms that have implemented using searchkit are Searchkit-HMS core Huawei and Apple's Spotlight technology.

2.3.4.5 Invenio

Invenio is an open source project that was initially developed by CERN. The Invenio brand today covers a suite of currently three main products developed by the Invenio community:

- InvenioRDM - a repository/document management platform
- InvenioILS - an integrated library system
- Invenio Framework - a code library to build large-scale information systems such as InvenioRDM and InvenioILS

In addition to the three main products, a larger number of smaller generic code libraries are also being maintained for the benefit of the open source community independently of Invenio.

2.4 Effectiveness and Efficiency

The Integrated National Research portal provides a simple way to broadly search for scholarly literature. From one place, you can search across many disciplines and sources in Zambia: articles, theses, books and abstracts from research institute's portals such as the UNZA repository. The introduction of this system might bring about immense change in the world of research in Zambia and improve the quality of research as it provides an effective way to find information online. Hypothesis is supported by the case study conducted by Hruby, McKiernan, Bakken and Weng to ascertain how efficient and effective a national research portal would be in 2013[9].

Hruby, McKiernan, Bakken and Weng focused their study on a system called Centralized Research Data Repository (CRDR) in the urology department at Columbia university. The system acts as a centralized research data repository for research data stored on three different portals in the urology department at Columbia University. They performed a retrospective analysis of the CRDR's impact on research by comparing the research capacity of the department of urology during a pre-CRDR period and a post-CRDR period. Their measurements included, User satisfaction and adoption of the system, Workflow efficiency, Publication quantity and Publication quality.

There was no campaign to require using the CRDR, but it gained great acceptance within the department. A descriptive statistical analysis was performed on PubMed and the research request logs. The findings were that, five out of eight (62.5%) clinician researchers and all four basic science researchers in the department used the CDRC[13]. The CRDR transformed the research workflow and enabled a new efficient research model. During the pre and post test periods, the department's annual retrospective study publication rate was 11.5 and 25.6, respectively; the average publication impact score was 1.7 and 3.1, respectively. The findings suggested that implementing the CRDR appeared to increase data access, user capacity, research productivity and quality, and enabled a new efficient research model, thus, achieving maximum productivity with minimum wasted effort. The most rewarding outcome from the CRDR implementation was the emergence of a new research model (i.e. using one platform to access multiple research data on different platforms) that transformed the research workflow and improved research efficiency and quality on multiple levels. Furthermore, the CRDR transformed research methodology within the department. The implementation of the CRDR correlated with an improvement in both the quality and quantity of departmental publications on retrospective studies. We believe that the improvement resulted collectively from the quality research data in the CRDR due to its integration with the other system, the new, efficient research workflow model enabled by the CRDR, and the expanded access to comprehensive research data for researchers

It should be noted that the CRDR system acts as a single point of storage where access to research data stored on other research portals is made available, in contrast to the INRP system which is a single point of access to research data stored on other research portals. However, both systems provide a centralized platform for accessing research data from different research portals. Therefore, the experience of the CRDR can be generalized to that of the INRP or other centralized portals. Furthermore, although CRDR is limited to only one department, its experience can also be generalized to other departments, institutions or groups of institutions [4]. Figure X shows the distribution of the department's research productivity by publication type between 2005 and 2011. The figure shows the department's research productivity contrasting the contribution of the new model to that of the old. From 2009 to 2011, the new model had a steady rise in research productivity. In 2011, research productivity in the new model had overtaken those in the old model.

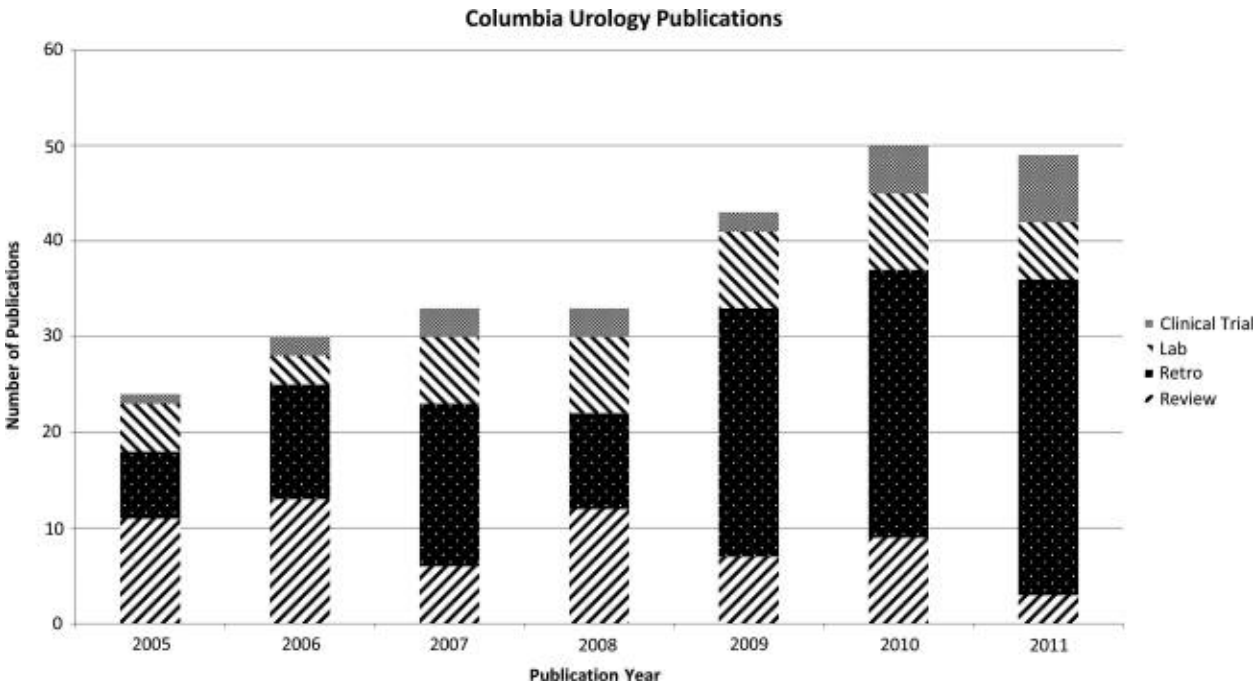

Figure 3. Columbia urology publication January 2005–December 201

2.5 Discoverability

Research works are done every year by different researchers and scholars that are posted on different portals. These research works are not easy to discover for the fact that they are hosted on different platforms hence the need for an integrated portal[15]. Denmark implemented a national research portal called National Open Research Analytics (NORA) which was financed by the Danish Agency for Higher Education and Science [14].

NORA, National Open Research Analytics, is a national initiative to enable robust and open insights and analytics of Danish research. NORA is focused on national level insights, and thus NORA supplements rather than replaces existing institutional systems, offering deep and detailed insights at various levels inside the institution, and existing global databases and research intelligence systems, offering insights and advanced analytics at the global level.

It was opened for public testing of four parallel prototype databases in February 2022, all of which display Danish research output from 2011 and forward based on different sources. The vision NORA was to Work with the best sources of data and expertise at the global level, the national level as well as the local/institutional level in the following[10];

- Import data sets and organize them in a national infrastructure, where:
    - The integrity of each data set and its curatorial universe is preserved

    - The data sets are linked and aligned to loosely couple records and search indices from sources at all levels – and from all data contributors at each level
    - Key terms of the data sets are enriched with their corresponding NORA standard terms in order to enable consistent national level search and analytics across the entire data aggregation
- Build a national portal offering overviews, insights, and analytics of Danish research[10]:
    - Search facilities – simple (for the standard user) as well as advanced (for the expert user)
    - Predefined reports with in-depth analyses of topics of national interest
    - Interactive dashboards with highly customisable analyses and visualisations
    - Links from the analytical modules to the search facility in order to support further scrutiny of the underlying data.

The diagram below figure 4. shows the sources of resources for NORA:

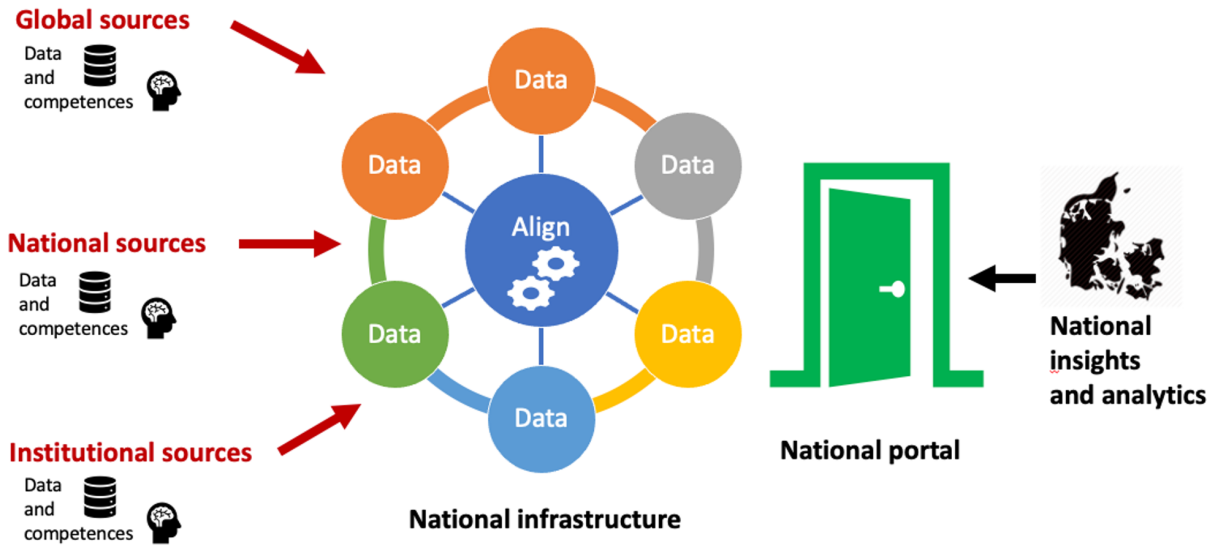

Figure 4. Sources of resources for NORA

Global Sources: At the global level, there is a large, and growing, number of interesting datasets and related competence clusters:

- Many are community-driven and linked to the infrastructures issuing persistent identifiers (PIDs) to networked objects and actors. Examples are Crossref (publications) and the associated initiatives for open citations (I4OC) and open abstracts (I4OA), as well as DataCite (datasets), ORCID (researchers), and ROR (organizations).

- Amongst the other important community-driven initiatives are Wikidata, arXiv and the many other preprint sharing platforms it has inspired, and comprehensive disciplinary platforms such as PubMed.
- Another important group of initiatives are Open Access facilitating infrastructures such as Unpaywall, DOAJ, and Sherpa/Romeo.
- Amongst the market-based commercial enterprises, Clarivate, Elsevier and Digital Science stand out with very comprehensive offerings.
- Finally, a new type of comprehensive offering has become available in the form of The Lens, a flagship project of the 'independent non-profit social enterprise' Cambia, bringing innovation also to the business/cost recovery model.

National sources: At the national level, several data sets are of interest and importance[9]:

- From the Ministry of Higher Education and Science, the data behind the national research indicator, the Danish Open Access Indicator.
- From the Ministry and its associated public research funders, data on Danish research grants.
- From Universities Denmark, statistical data on many university aspects.
- From Statistics Denmark, a wide array of statistical data that could be used to put research in the context of Danish society at large

Institutional sources: At the institutional level, several data sets could be of interest and importance. Currently only one group of systems seem to have adopted national standardization.

- The data of the institutional research databases (CRIS, RIMS) are thus of special interest and importance

This has made research work easy to discover. In a similar way, INRP will make publicly funded research easy to discover since it will integrate all decentralized portals. A number of research portals have been implemented in Zambia and the main gap is that they are not centralized, it is for this fact that makes the implementation of INRP significant.

3. Methodology

3.1 Introduction

Chapter three outlines the research methods and procedures that were used in this study. It describes the approaches that were used in answering the research questions, research design, study area, target population, sample size, sampling techniques, reliability, validity, and the procedures and processes for pilot study. Further, the chapter explains the data collection instruments, data collections procedures, and methods of data analysis.

3.2 Research Design

Research design refers to the overall strategy that you choose to integrate the different components of the study in a coherent and logical way thereby ensuring that the research question will effectively be addressed; it constitutes the blueprint for the collection, measurement and analysis of data. In this research project, we adopted a mixed method as a method of data collection which is the combination and integration of qualitative and quantitative methods in the same study for the broad purpose of breadth and depth in understanding and corroboration [5]. The use of mixed methods research in impact evaluation has shown that this methodology provides a broader spectrum of ways to better understand complex research problems in different contexts than could be done through either approaches alone as was the case with our research project.[5] mainly is used for both large and small populations, and the quantitative method produces a detailed description of participants' feelings, opinions and experiences; and interprets the meaning of their actions .

To justify the feasibility of implementing an integrated research portal a study was conducted and different existing softwares were looked at and it was found out that indeed it is feasible to build a research portal. This study made use of the qualitative research design because different documents were read and the platforms were observed on how they are able to perform their different functions. The already existing software included the water quality portal, the Monash psychology portal, and many others.

On the other hand, quantitative methods of data collection and analysis helped to make generalization of the data collected on one study area(University of Zambia) possible to other study areas, interaction made with one research institute was generalized to other research institutes. Similarly, the interpretation of research finding need not to be seen as a mere coincidence while qualitative research methods such as observations and interviews helped to collect more detailed data. Lastly, the quantitative research method was mostly used for research objectives that required us to explore, discover and construct [4].

- To determine the feasibility of implementing an integrated national research portal.
- To determine how effective the Integrated national research portal will be by accelerating access to research publications.
- To determine how research publications from various research institute portals will be integrated within one central portal.

3.3 Feasibility

A study was conducted as part of measuring how feasible the implementation of the INRP would be. The study aimed at finding out how the Information or publications would be structured and displayed to the user, the metadata about a document that should be displayed and any other vital feature that the users wanted included to the system that was not in the initial development plan. A survey was conducted for this study using online Questionnaires, (APPENDIX section shows a copy of the online questionnaire). The questionnaire was distributed to both the undergraduate and postgraduate students at UNZA.

3.3.1 Target Population

The study was carried out at the University Of Zambia in all the schools. These included the school of Agriculture, Education, Engineering, Graduate school of business, Health Sciences, Humanity and Social Sciences, Law, Medicine, Mines, Natural Sciences, public Health and Veterinary Medicine. The University of Zambia was chosen as it is one of the research institutes in Zambia that aspires to meet the needs of Zambia through excellence in teaching, research and service in order to foster sustainable development and it was cost effective to the research team as they were within the the University of Zambia for the most part of the research which made it possible for us to carry out the research. Thus, to determine the structure of the integrated research portal, a study was conducted on all the schools. While, the target population comprised postgraduate and undergraduate students in the thirteen schools of the university of Zambia.

The sample size included all the schools at the university of zambia. The schools being, the school of Agricultural science, Education, Engineering, Law, Humanity and Social Sciences, Graduate School of Business, Health sciences, Medicine, mines, Nature Science, Nursing Sciences, Public Health and Veterinary Medicine. The research was conducted on all schools because all schools at the University of Zambia do conduct research and are the potential users of the system.
Furthermore, we used online questionnaires that were created using the google forms to elicit information from the target population. For interviews, we used physical meetings.

3.3.2 Sampling technique

The research used cluster and purposive sampling techniques which helped us come up with the participants to elicit the specific requirements of our system. Purposive technique involves the researchers to judge, select and make subjective decisions. The target population for example was chosen because the researchers are near the premises of UNZA, thus less costly for the researchers.

3.3 3 Procedure

Our research followed a traditional approach for research development where we identified and developed our topic, reading different literature, which is document analysis on how to build an integrated national research portal. After finding reading resources, they were evaluated and applicable resources were applied and cited. Each stage of the research process was tied together with document analysis.

3.3.4 Data Analysis

Data analysis is defined as a process of cleaning, transforming, and modeling data to discover useful information for business decision-making. Narrative Analysis was used to analyze qualitative data or research and inferential Analysis was used for quantitative data or method of research

3.4 Effectiveness and Efficiency

On effectiveness and efficiency, a case study was conducted to ascertain the effectiveness of the integrated National research portal.. This experiment was conducted on a group of 30 UNZA students. The 30 students were asked to carry out research using both the INRP and the conventional way(searching from different sites) using a predefined search query or phrase. The experiment was done in three parts or sessions, each session consisting of 10 students. These students were each assigned a unique number from 1 to 10. Those who had an even number as a unique number assigned to them were asked to begin their search using the INRP and thereafter the conventional way. While the students with prime numbers as their unique assigned numbers were required to start the search using the conventional way and end with the INRP. All the participants were asked to use the stopwatchers on their phone to keep track of how long they took to successfully carry out their research using either the INRP and the conventional way. During the use of the systems to carry out the search, the participants were asked to keep the different aspects that would help eventually measure effectiveness into consideration such as how fast one way of searching for data is between the INRP and the conventional way, how easy it was to find useful information using either ways and the number of useful records found using either ways. After the participants successfully completed their search, they were all asked some questions based on their experience with using the two ways of searching for information (INRP and Conventional way).

3.4.1 Target Population

The target population was 30 students at UNZA. UNZA students from different respective schools were asked to use the system in a controlled environment. And they gave their responses according to their interaction with the INRP.

*3.4.2 Sampling techniqu***e**

Purposive, random and cluster sampling technique was used to identify the participants in the study. To test effectiveness and efficiency random sampling was used. Participants who were not busy and available at the time the study was conducted were the ones who were used.

3.4.3 Procedure

The participants were exposed to the conventional way of researching information, the UNZA repository and the UNZA journals website and the INRP. They were given a search phrase and time was tied to their search of information either using the conventional or the integrated system. After the interaction with the system each participant was asked questions on the time spent while using the two different ways of researching for information, and how much relevant information was found on each of the research types. Lastly, they were asked which method of researching information was more effective using interviews. Below is the procedure followed.

- Participants were put in three groups of 10 individuals per group and the experiment was conducted in 3 sessions.
- All participants were be in the same venue
- Testing was to start at the same time
- Each participant was assigned a number from 1 to 10
- Participants that had been assigned even numbers were asked to start their search using the INRP first and then later on the conventional way, while those with prime numbers started with the conventional way and then the INRP
- A brief introduction of the system and the research study was given
- All participants were required to take a maximum of 20 min.
- All participants were asked to respond to the questions provided by the team, however, participants will not be forced to respond to the questions.
- All participants were given the same search query to carry out their search by using both the conventional way and using the INRP.

The following were the instructions for the experiment conducted:

1. For the experiments, each participant will be required to carry out a research using both the INRP platform and the conventional way based on the search query or phrase that will be provided to all participants.
2. Ensure that you have been assigned a number.
3. Participants that have been assigned even numbers must start their search using the INRP first and then later on the conventional way, while those with prime numbers must start with the conventional way and the the INRP
4. Each participant is required to keep track of the time when they begin their search and when they stop for both the search methods using the stopwatch on their phones.
5. Each participant is required to to pay attention to the number of records that they get; how many they find useful and how many were relevant to their search for the two time they carry out the experiment
6. For this experiment, you are required to use the following search phare or query; "**WHAT ARE THE CAUSES OF CHILD ABUSE IN ZAMBIA**"
7. Ensure that you stop the timer at the end of the search.

8. Quietly raise your hand when you are done with your search and you will be attended to in no time.
9. After your search answer the following experimental questions listed below.
   Note: An observer must ask you the experimental question and take down your answers. You are not required to write down the answers anywhere.

The following were the questions asked at the end of the experiment.

1. How long did it take for you to find relevant information? using the conversational approach or INRP.
2. How easy was it to find information?
3. How many results did you get after your research?
4. Which approach do you think is better ?
5. To what extent is the system useful?

3.4.4 Data Analysis

From the interviews responses, data that was collected from each participant was analyzed. Narrative analysis was used to analyze the information. The participants were narrating their experiences with the two methods for research. And from the different responses, conclusions were generated.

3.5 Integration of different institute portals within one central portal.

To build the Integrated National Research Portal different research portals were integrated together. The different systems that were integrated together were the UNZA Institutional repositories and the UNZA Journals website. A system called elastic search was used to index the different Json files from these different portals. Elastic search was connected to searchkit and configured so as to meet the specific requirements.

3.5.1 Target Population

Due to the fact that the integrated system was built using systems, there was no need to target a population to conduct the research. Different systems were observed and researched on and a decision was made to use elastic search and searchkit to build the system.

3.5.2 Sampling technique

During the implementation of the integrated system, no sampling technique was used. As earlier mentioned, only the different components were tested and integrated together.

3.5.3 Procedure

Document analysis was used to research the integration of the INRP. This is a form of qualitative research that uses a systematic procedure to analyze documentary evidence and answer specific research questions. This helped out research to build the system. Documentation on elastic search,

searchkit configuration and indexing of the Json files was analyzed and solutions answering to our problem were found.

3.5.4 Data Analysis

Content analysis was used to analyze the data. Documentations on elastic search and searchkit were analyzed and useful information was used to come up with the final understanding of the implementation of the Integrated National Research Portal.

3.6. Evaluation

The system was evaluated to measure whether the system meets its goals including testing all the stages and processes of the system.

3.6.1. Unit Testing

The different components of the system were tested independently such as the Integrated National Research Portal user interface which is the platform for users to search for publications through the use of the search bar . Search engine, Third party system and the Database.

3.6.2 Public End User Interface

This component of the system was tested by the user by searching through the search bar for publications using meta data such as date,author name,year of publication and others. The response from the system was successful as it managed to display the publications.

3.6.3 The Third Party System

The third party system was tested by inserting different URLs in the database from which the third party system would pull metadata from, and it was able to pull the different URLs for the research sites on the Integrated National Research Portal and it was able to create a JSON file for each URL entered. The third party also has the administrator component used by the administrators to add the different URLs. It is these different URLs that the third party system creates the JSON files for which are then fed to searchkit [22] .

3.6.4 System Testing

The overall testing of the system was done where all the components of the system were done as a whole. The system was also tested for effectiveness. An experiment was conducted to measure effectiveness.

4. Design and Implementation

4.1 Overview

The system was implemented using the incremental development model and integration and configuration model. Incremental development was used as the system was sliced into different components which were being developed each separately by different people. Integration and configuration was also used as part of the system was developed by configuring and customizing an open source platform. Below are listed the different components of the system and the different open source platforms that were used to configure and customize some of the components of the system. The system was divided into three major components; the public end user interface (PEUI), the third party system and Elastic Cloud deployment. Figure x below shows how the three major components of the system interact with each other.

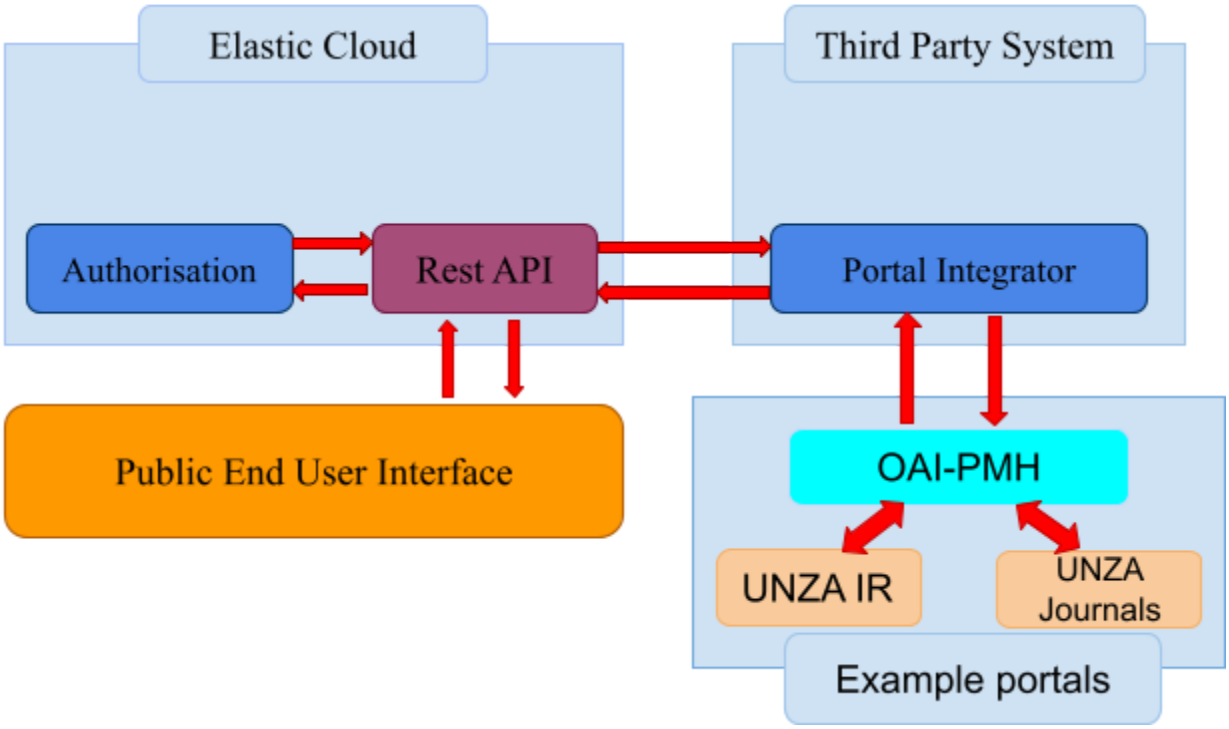

Figure 5: Illustration of The Interaction of INRP Components

4.2. Third Party System

Also called the Admin Side, The third party system provides the interface for configuration of the system by the System Administrators. Figure 8, below shows the admin login panel of the INRP

third party system and Figure 6, shows the Menu or UI of the third party system. This is where new portals that are to be aggregated within the integrated national research portal are added, stored and deleted by the administrator of the system.

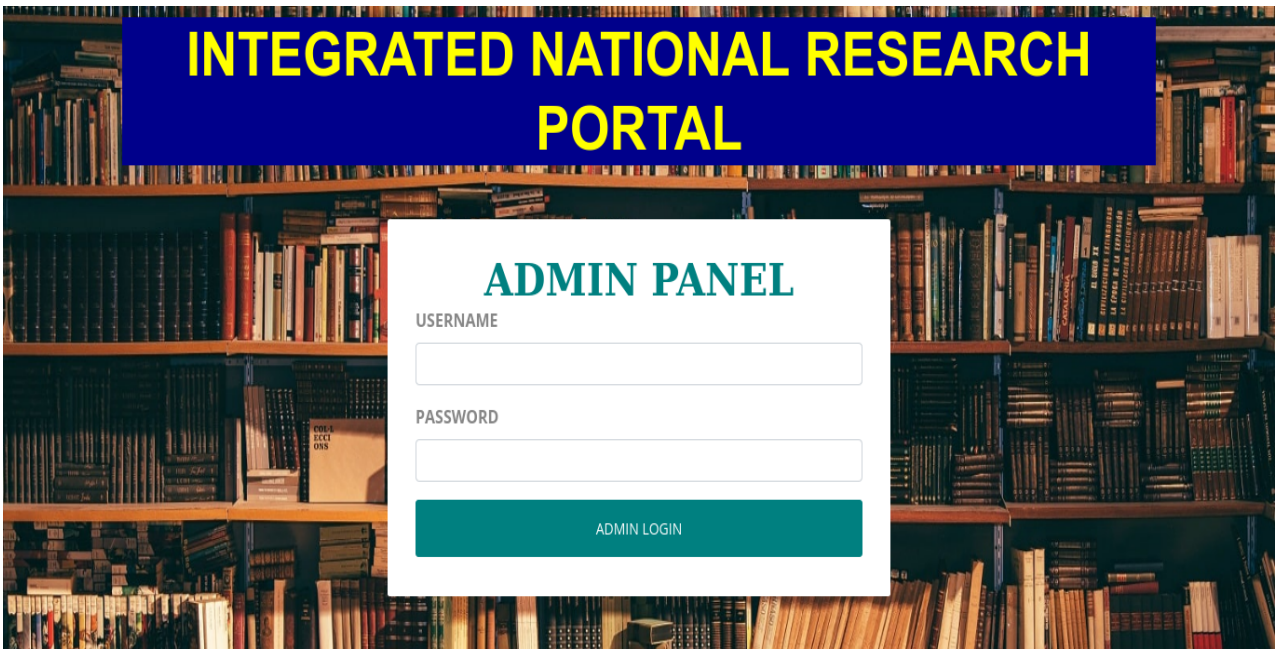

Figure 6: Shows the Admin Login Panel of the INRP Third Party System

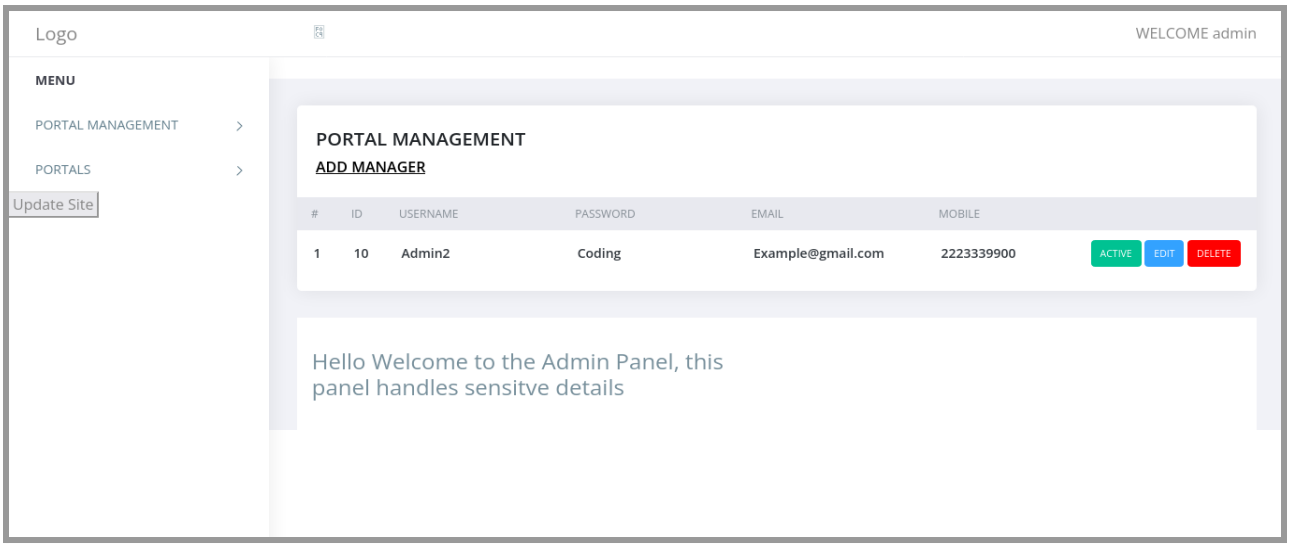

Figure 7: Dashboard or UI of the Third Party System.

The Graphical User Interface (GUI) for the third party system was implemented in Hypertext Preprocessor (PHP) and Cascading Style Sheets (CSS). PHP enables the creation of dynamic

content for the third party system and its interaction with the database[23]. PHP is also known for its simplicity, speed, and flexibility features that have made it a cornerstone in web development. On the other hand CSS was used to make the front-end of a third party system appealing and create a great user experience**.**

Further, the third party system is where the system is updated by the system administrators. It is connected to a database that stores the Universal Resource Locator (URL) for the different institutional portals that are aggregated within the INRP, it also stores the name of the research portal and its domain. Figure 10, shows the Portals page where the System Administrator enters the research institute name, portal URL and domain in the database, while figure 11 shows the Portal Management page, where the System Administrator is able to edit, activate or deactivate and delete the elements stored in the database. The database was created using XAMPP, which is a software distribution which provides the Apache web server, MySQL database (actually MariaDB), Php and Perl (as command-line executables and Apache modules) all in one package needed to create and manipulate the database [3]. Structured Query Language (SQL), it is a standard language to maintain and manage a database. With SQL it is possible to store, retrieve, manage and manipulate data within a database management system.

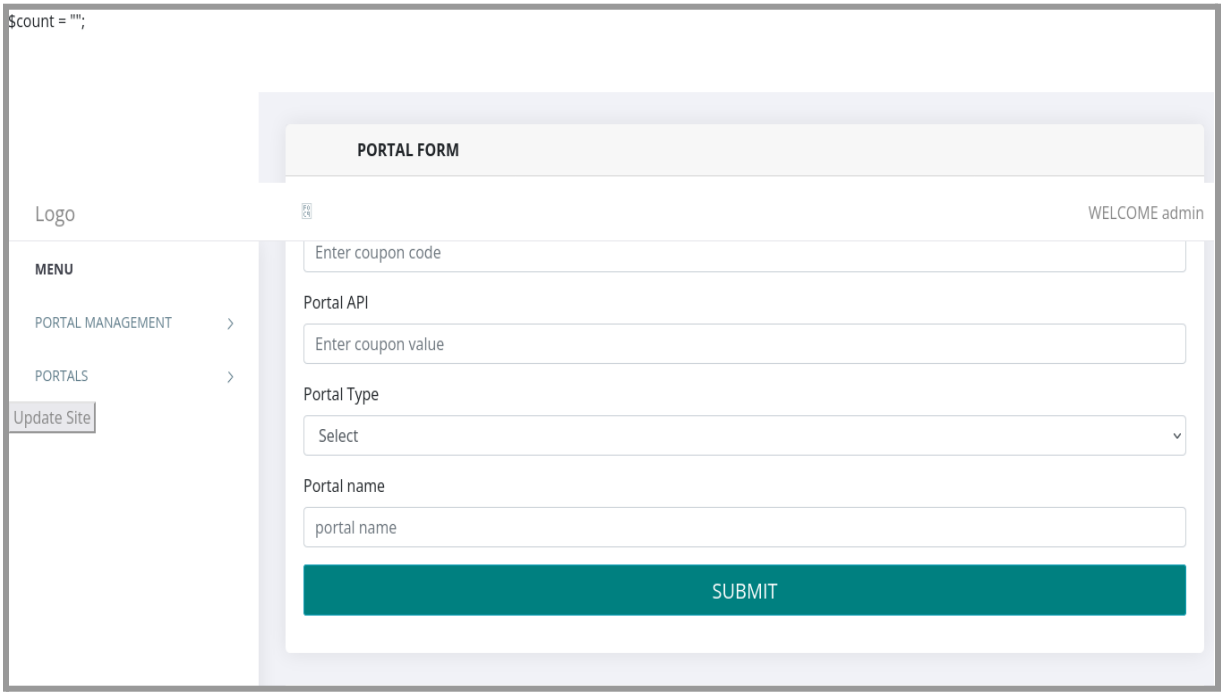

Figure 8. Third Party System's Portals Page (for adding research portal's details such as the portal's URL)

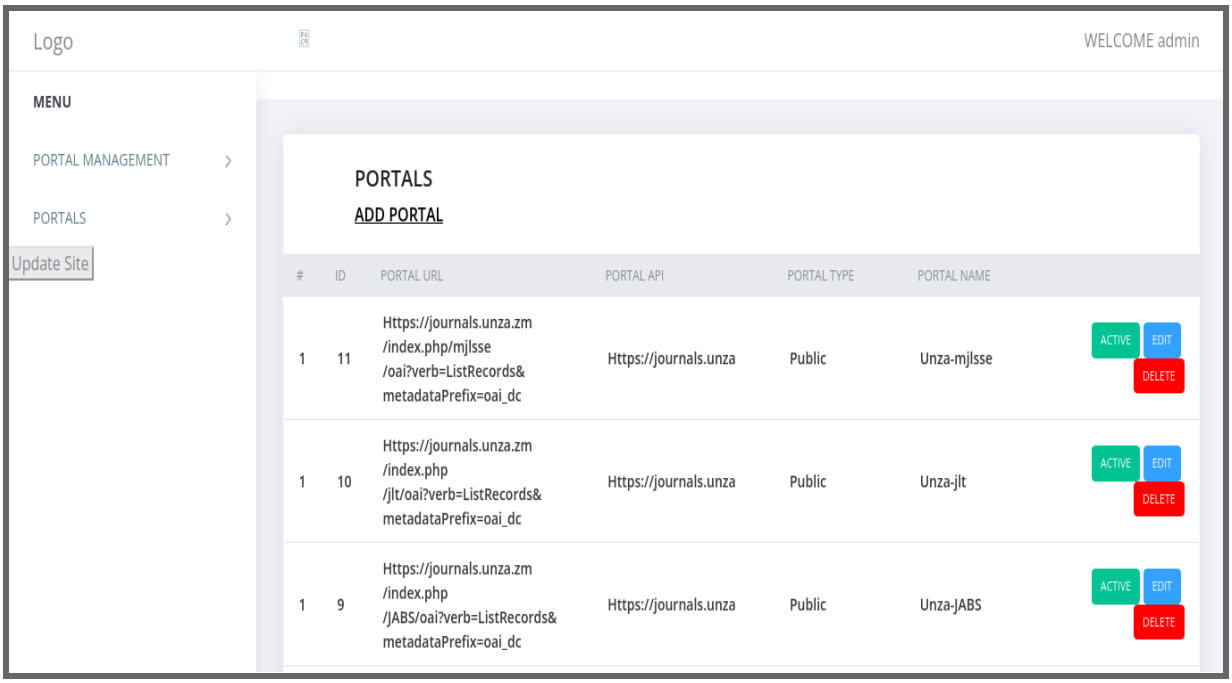

Figure 9. Third Party System's Portal Management(for managing the database)

Apart from configuring the system and storing the URLs of the institutional portals, the third party system is also embedded with a back end code which pulls metadata in XML format from the stand alone research portals using the OAI-PH protocol and uniformly converts the metadata into Json file [21]. This backend code is implemented in python due to the following reason:

- Code is easy to read, use and maintain.
- It supports multiple programming paradigms.
- It has a large standard library, even one that helps with integrating or aggregating information or portals.
- Simplifies the complexities of software development.

The python code is responsible for feeding the metadata json files to elastic search which searches and indexes the data to searchkit.

4.3. Public End User Interface (PEUI)

The PEUI is often talked about in conjunction with user experience (UX), which may include the aesthetic appearance of the website, response time and the content that is presented to the user within the context of the PEUI. It is also the way through which a user interacts with the integrated national research portal [13]. The user interface for INRP was built by customizing and configuring an open source platform called searchkit. Searchkit as aforementioned in the Related

Work is a suite of User Interface (UI) components built in react. The aim of searchkit is to rapidly create beautiful search applications using declarative components. It is a powerful and streamlined C language framework for indexing and searching text in most human languages. It provides fast information retrieval in System Preferences, Address Book, Help Viewer, and Xcodeis [7]. It is an open source software or library which helps you build a great search experience with elasticsearch.It allows multiple features to work together. Elasticsearch is a distributed, free and open search and analytics engine for all types of data , including textual,numerical,geospatial, structured and unstructured. The diagram below, Figure 7, shows the PEUI of INRP after the configuration and customization of searchkit.

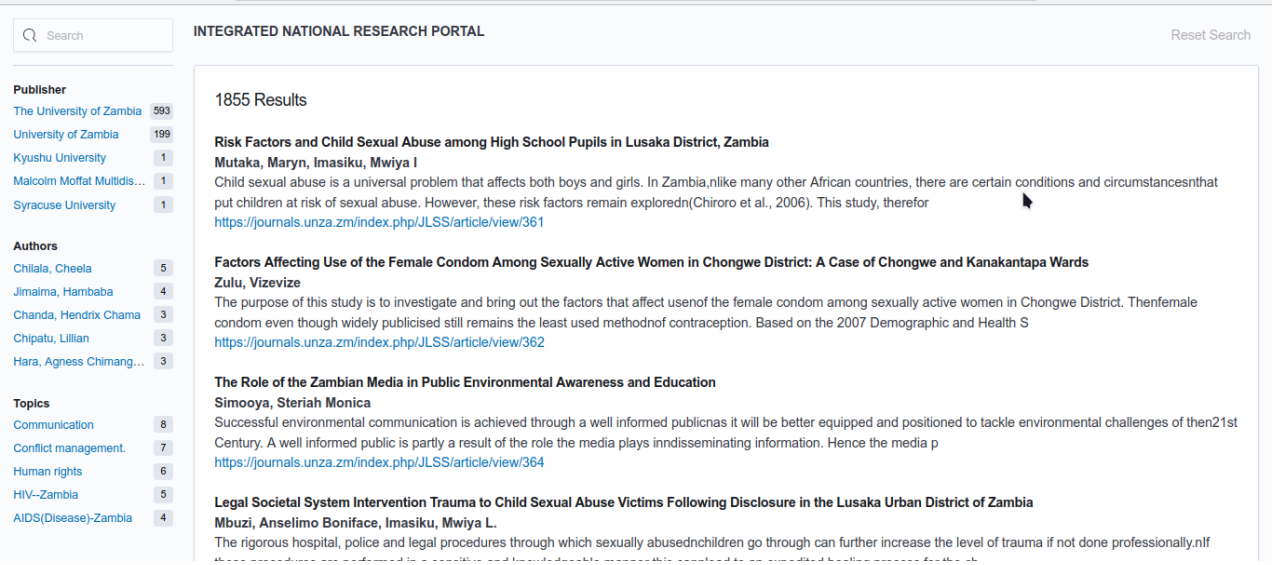

Figure 10. PEUI Of The Integrated National Research Portal

INRP used elastic cloud for searching and indexing metadata of research publications. One of the benefit of elastic cloud is research and development of projects, and testing and deployment of projects. Elastic cloud hosts elasticsearch which is used for indexing the metadata of different publications rendered in the system. To use elastic cloud for the INRP system, an elastic cloud instance was created and an elastic deployment called INRP was created. In the INRP deployment an index called search_inrep was created. The search_inrep index stores the metadata that the third party system aggregates or pulls from the independent portals or stand alone portals. After aggregation of the metadata from stand research portals like the UNZA repository, the third party system feeds the data it pulled to the index, search_inrep in elastic cloud. Elasticsearch then searches and indexes the data to searchkit for display to the end users. In order for publications to be displayed on the PEUI, searchkit must be configured to point to the elastic cloud index using

the elastic cloud endpoint, the elastic cloud deployment API-Key and the index name as shown in Figure 11. Figure 12, shows the index that was created in the INRP elastic cloud deployment.

```
} from "@elastic/eui";

import "@elastic/eui/dist/eui_theme_light.css";

const config = {
  //host: "https://commerce-demo.es.us-east4.gcp.elastic-cloud.com:9243",
  host: "https://unza22-ict4014-groupbkm2.es.us-central1.gcp.cloud.es.io",
  connectionOptions: {
    //apiKey: "NWF4c2VYOEJzRDhHMzlEX1JDejU6YnJXaS1XWjlSZ2F5ek1Cc3V4aXV6dw=="
    apiKey: "MnUtRWU0UUItdTFTc01xaDh2X1M6U0dqZkowWm5SV3l6dl9uZnRBaXBkdw=="
  },
  //index: "imdb_movies",
  index: "inrp_unza_portals",
  hits: {
    fields: ["title"]
  },
  query: new MultiMatchQuery({
    fields: [
      "title",
      "description"
    ]
```

Figure 11: Searchkit Configuration

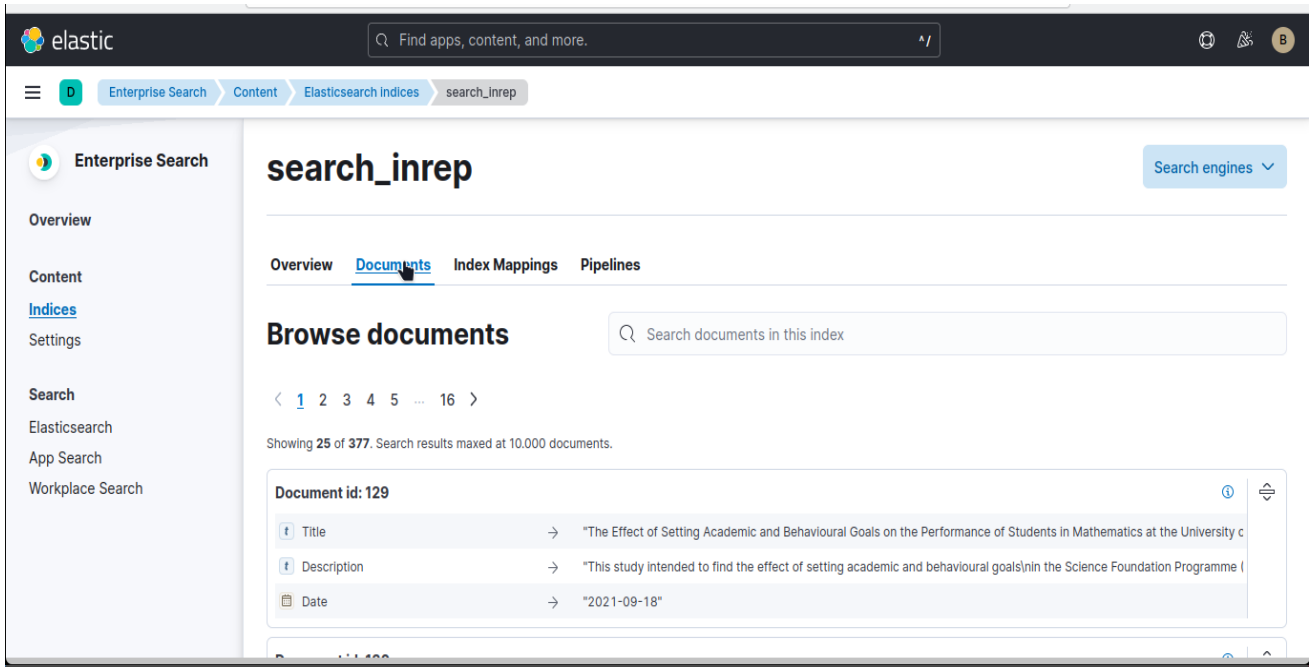

Figure 12. Elastic Cloud “search_inrep” Index

5. Results And Discussion

5.1 Overview

The system was evaluated to measure whether the system meets its goals including testing all the stages and processes of the system.

5.2 Feasibility Of Implementing The INRP

A study was conducted as part of measuring how feasible the implementation of the INRP would be. The study aimed at finding out how the Information or publications would be structured and displayed to the user, the metadata about a document that should be displayed and any other vital feature that the users wanted included to the system that was not in the initial development plan. A survey was conducted for this study using online Questionnaires, (APENDIX section shows a copy of the online questionnaire). The questionnaire was distributed to both the undergraduate and postgraduate students at UNZA. After a period of 4 weeks, 30 responses were recorded. Out of the 30 responses 93.3% were undergraduates and 6.7% were postgraduate students as shown in the pia chart, Figure 13 below.

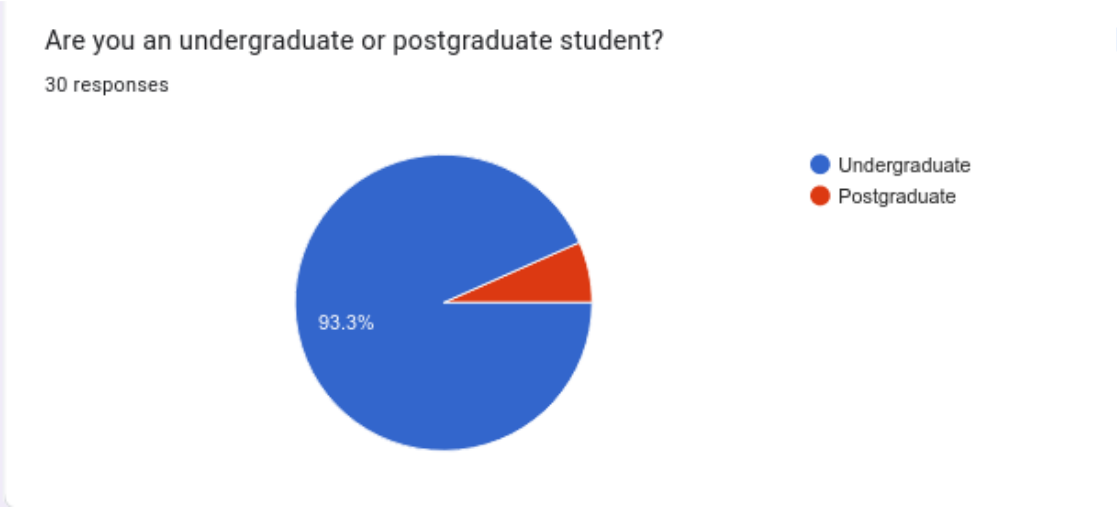

Figure 13: Number of Undergraduate and Postgraduate Students

From the 30 responses, a greater number of schools at the University of Zambia participated in the survey. Out of 13 schools at UNZA, 8 schools participated in the survey as shown below in Figure 14.

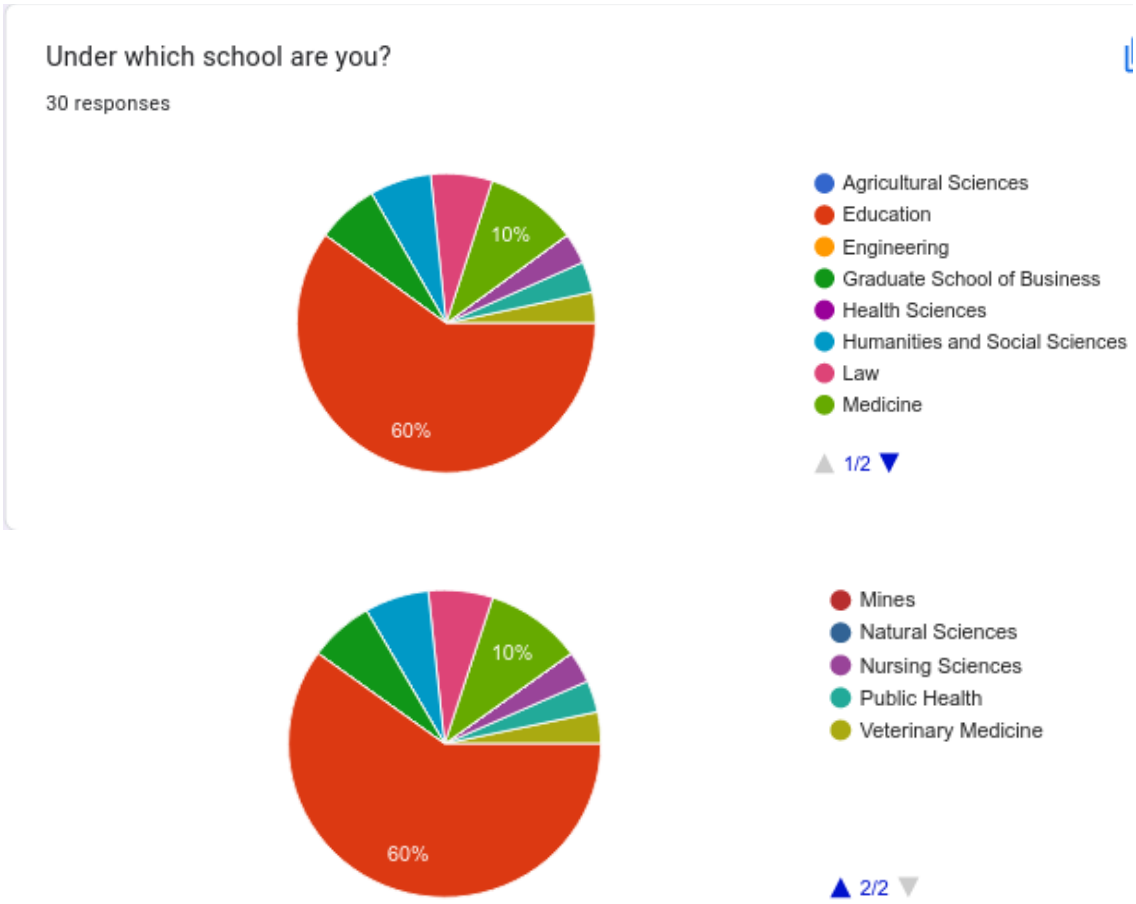

Figure 14: School at UNZA that Participated in the Survey

The following are some of the responses on the different questions that were asked in the questionnaire as shown in Figure 15.

- 6 participants responded that it was easy to find information, 3 responded that it wasn't easy to access information on separate research portals and 21 participants were neutral.
- 12 participants responded that it took so much time to find information on the separate portals, 6 participants responded that it took them less time to find information on the separate portals and 12 participants were neutral.
- 12 participants responded that it was hard to find information, 5 responded that it was easy to find information and 13 participants were neutral.

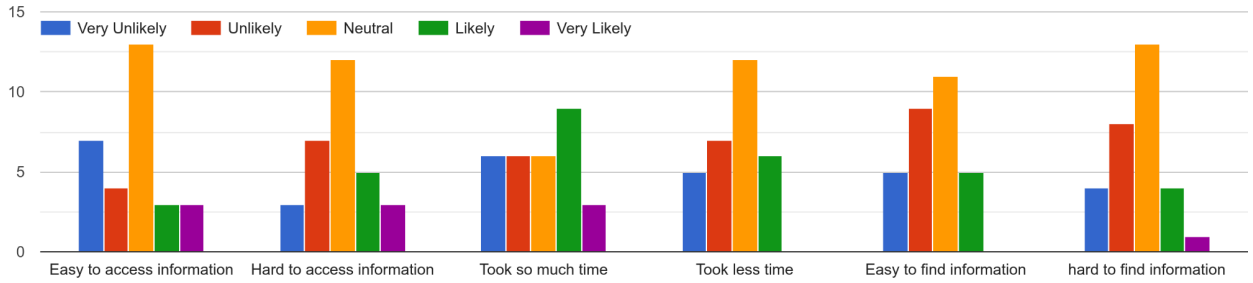

Figure 15: Illustration of how Participants Viewed their Experience when Search using the Conventional way in terms of how Easy and Fast it was.

On finding out what metadata about a publication should be displayed to the user. The following were the responses given as shown in Figure 16.

- 15 suggested adding the title of the document, 12 said no to the title of the document, and 3 were neutral.
- 14 suggested adding the date of publication, 11 said no to the date of publication and 5 were neutral.
- 12 suggested adding the publisher, 13 said no to the publisher and 5 were neutral.
- 15 suggested adding author name, 10 said no to the author name and 5 were neutral
- 15 suggested by Publication link
- 12 suggested by the Author institution
- 14 suggested adding the type of document, 12 said no to the type of document and 4 were neutral.
- 12 suggested adding an Abstract, 12 said to the abstraction and 6 were neutral.

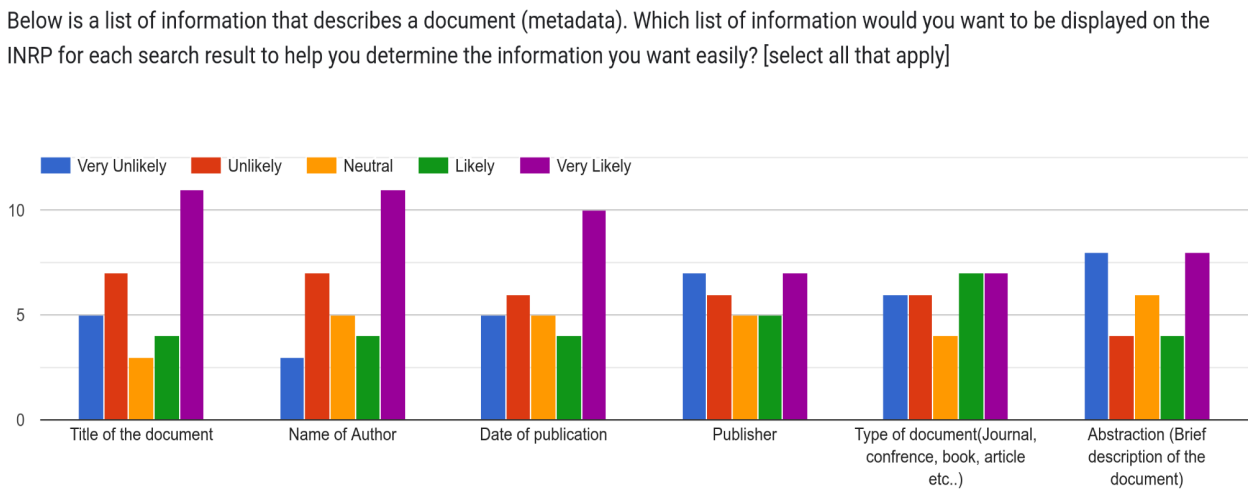

Figure 16: Shows Histograms of the different metadata aspects and their likeliness to be added to the system

Figure 17 below shows the responses in terms of the extent to which the users or respondents would like to browse the INRP using the different browsing aspects or options.

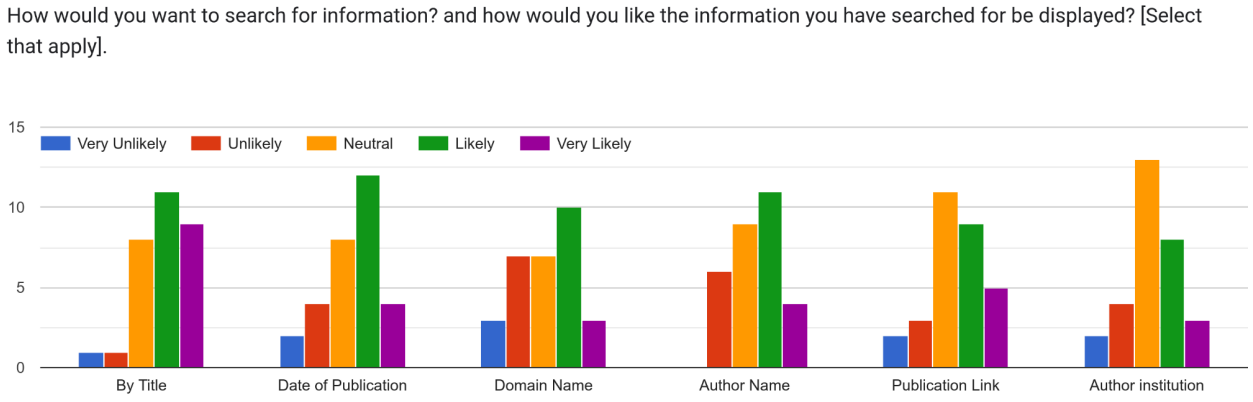

Figure 17: Show the different browsing aspects and their respective likeliness of being added to the system.

When asked what other vital features the users wanted to be included in the system , the following are the responses as shown in Figure 18.

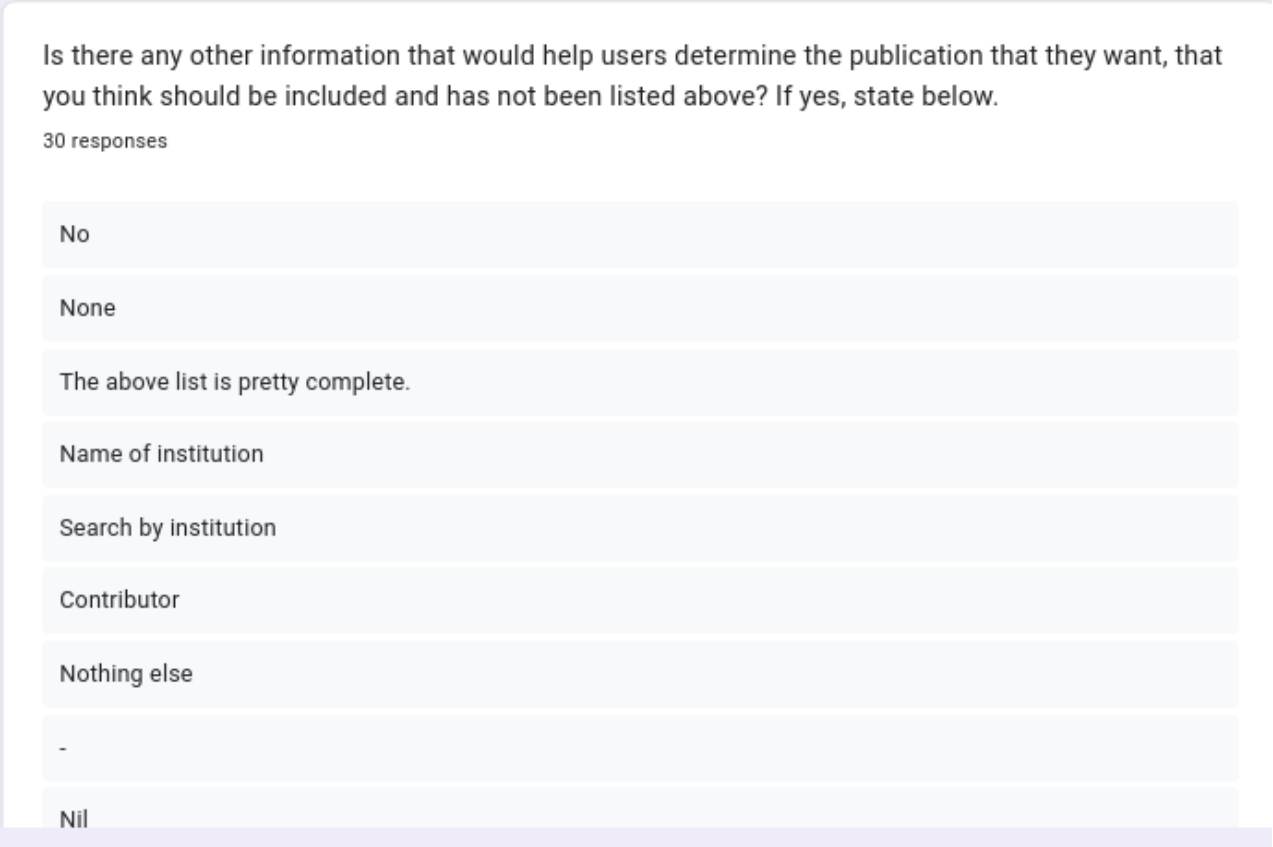

Figure 18: Example of actual responses as given by the participants regarding the new features to be added.

- Some suggested that Name of institution should be added
- Contributor should be added
- New publications based on search should be added
- Year of publication
- Reference of the same document
- Reviews of the document
- A sorting button
- Reference styles

5.3 Effectiveness of The INRP

As aforementioned, an experiment was conducted to measure the effectiveness of the INRP. A total of 30 students participated in the experiment and the results were as follows;

5.3.1 Time It Took The Participants To Complete The Experiment.

All the participants kept track of the time they spent carrying out the experiment on both the INRP and the conventional way. Table 1 below shows the lowest and highest recorded time for both the INRP and the conventional way of searching for information. From the experiment, the lowest time was recorded using the INRP while the highest time was recorded using the Conventional Method.

Table 1: Lowest and highest Time recorded for the experiment

Method	**Lowest Time Recorded**	**Highest Time recorded**
INRP	2 min	16 min
Conventional Method	4 min	24 min

5.3.2 How Easy It Was To Find Relevant Information.

Participants gave their experience on how easy it was to find the information they were looking for using either the INRP and the Conventional method. Figure 19 below shows the comparison between the two methods of search for information in terms of how easy it was using either way. It is obvious from the results that it was easier to find information using the INRP than the Conventional method.

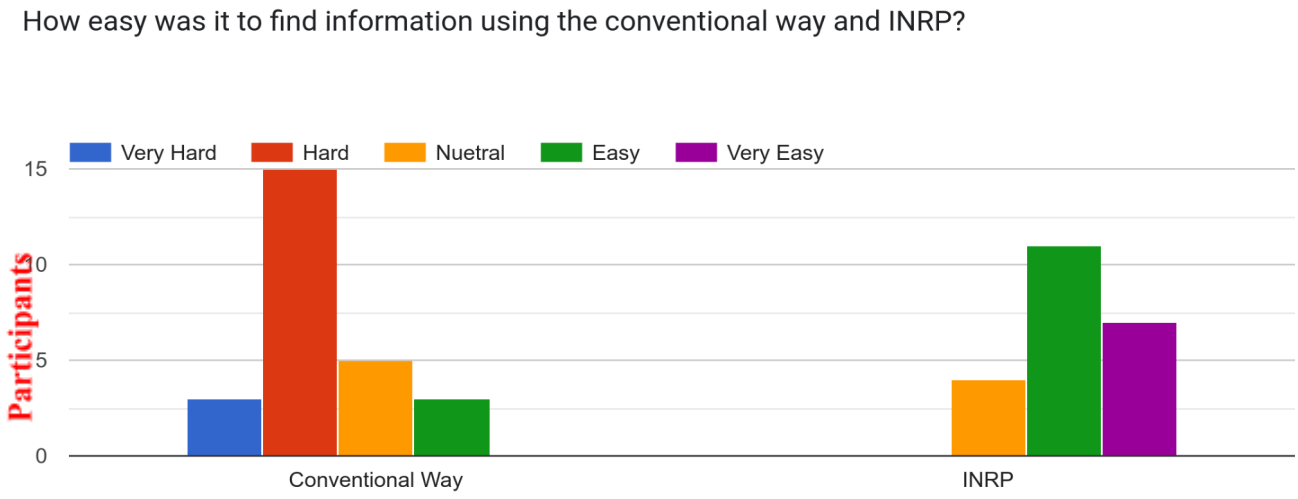

Figure 19. Illustration Of How Easy Finding Information Was Using The Conventional and INRP Method

5.3.3 Number Of Relevant Information Found using either the INRP Or Conventional Method

The participants were also asked to indicate the number of records they found relevant to their query in the first 15 records they got from using the INRP or the Conventional method. Figure 20 below illustrates the responses obtained which suggests that more records or more relevant information was obtained using the INRP.

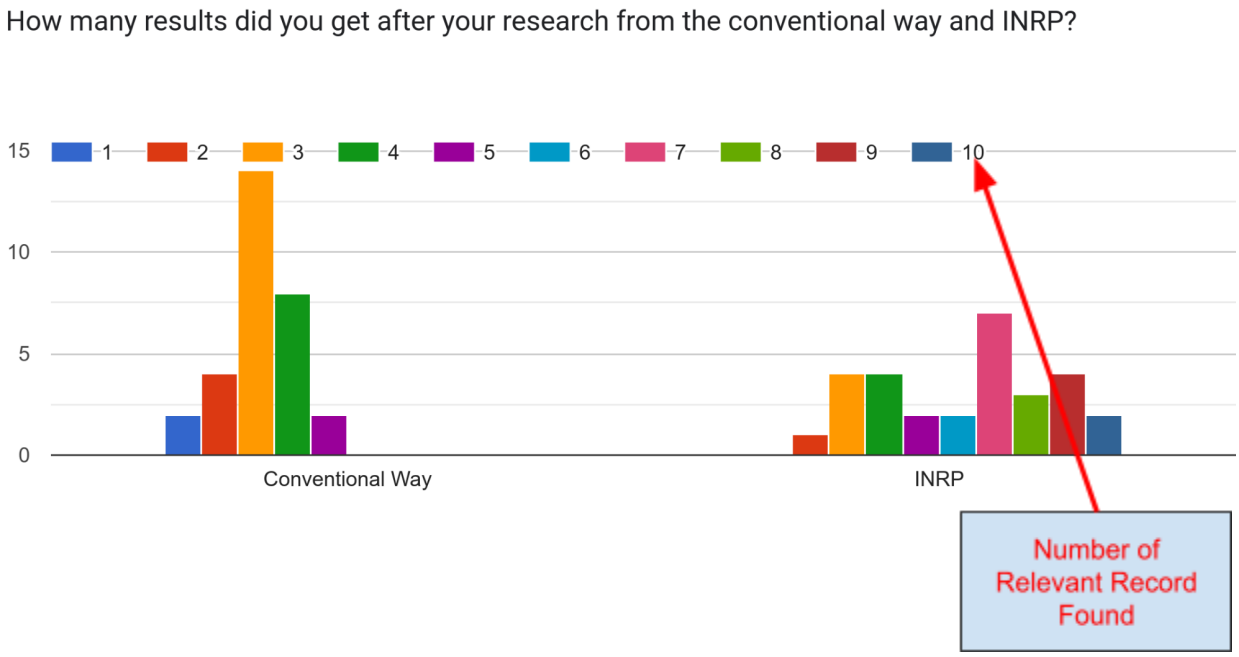

Figure 20: Number Of Relevant Records Found Using The INRP and Conventional Method

5.4 Integration of various research institutes' portals

According to the document analysis it was discovered that this provision of integration of the research portal is reliant on interoperability, Similarly the Integrated National Research portal has been able to integrate the different research institute portals such as the Unza Journal and Unza Institutional Repository through the use of interoperability.Interoperability is a term used to describe the exchange of data among information systems which is built upon the agreement on standards and protocols such as OAP-HI as mentioned in related work section.

To evaluate the integration, The team tested the integration of the Unza Journal and Unza Institutional Repository, which was successful and research publications were aggregated.

5.5 Discussion

Regarding the results obtained from the survey, it was observed that the implementation of the INRP was actually feasible. Participants cited many reasons to from how quick this portal would be and how it would make information more discoverable.According to the results obtained from the experiment, it has been established that INREP is effective , because the results shows that INREP is faster than the conversional way at making publications available to the public.It is also easy to navigate and find relevant information on the INRP than the conventional way, as it is central point of access and user friendly as cited by the participants.

Table 2: Comparison Of The INRP And The Conventional Method

Comparison Aspect	INRP	Conventional Method
How Fast Access to Information was?	Faster	Slow
How easy it was to find relevant information	Easier	harder

Furthermore, it was revealed that, by using Integrated National Portal (INRP) more information was made publicly available than on the single portals thus, discoverability.

6 Conclusion

Our first objective of the research study looked at the feasibility of implementing the integrated national portal. The availability of similar integrated portals proved the possibility of implementing an integrated national portal. This study revealed that a lot of portals have been implemented across the globe where integration of different resources are made.

Regarding the second objective of the research study, which is the effectiveness of the system. The system was evaluated by a group of 30 people through the experiment by using both the conventional and integrated national portal. The result was that the integrated national research portal was effective as compared to the conventional way.Lastly, the integration of the unza journals portal and the unza institutional repository was made possible with the use of protocols and APIs.

Appendix

Questionnaire

1. Are you an undergraduate or postgraduate student?
2. Under which school are you?
3. Which department are you from?
4. Have you ever used a institutional website like (eg UNZA website, CBU website, NIPA website, MULUNGUSHI website etc) .
5. Have you ever found yourself in a situation where you have to search for the same information from different research websites, such as NIPA website, Mulungushi website and UNZA website?
6. If the answer to the above question is yes, how easy or hard, how long did it take to find the information and how easy was it to find the information? using the scale of (1-5)
7. How would you want to search for information? and how would you like the information you have searched for be displayed? [Select that apply].
8. Below is a list of information that describes a document (metadata). Which list of information would you want to be displayed on the INRP for each search result to help you determine the information you want easily? [select all that apply]
9. Is there any other information that would help users determine the publication that they want, that you think should be included and has not been listed above? If yes, state below.
10. Is there any important information or feature that you would want to be displayed or rather included on the results page together with the results?
11.If the answer to the above question is yes, what information or feature should be included and where should it be displayed?

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