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Development of a web-based system to enhance monitoring and evaluation of higher education centers of excellence in Africa

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NM-AIST

DEVELOPMENT OF A WEB-BASED SYSTEM TO ENHANCE MONITORING AND EVALUATION OF HIGHER EDUCATION CENTERS OF EXCELLENCE IN AFRICA

Asiimwe Desire

A Project Report Submitted in Partial Fulfillment of the Requirements of the Award of the Degree of Master of Science in Embedded and Mobile Systems of the Nelson Mandela African Institution of Science and Technology

Arusha, Tanzania

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ABSTRACT

The World Bank launched the Eastern and Southern Africa Higher Education Centers of Excellence Project (ACE II) in 2016 to establish regional education and research centers in Africa. The initiative aims to train a generation of Africans to solve African challenges in industry, health, agriculture, applied statistics, and education. The ACE II seeks to improve post-graduate education and promote joint research at 29 ACEs in Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, and Zambia. Monitoring and evaluation of ACE II thrives on data. However, using Microsoft Excel sheets for data capturing and storage is challenging due to its disintegration per center and time-consuming to analyze. The ACE II lacks cumulative and informative visual data for impact demonstration, a feedback mechanism for the beneficiaries, and a dedicated communication channel for stakeholders. The project report presents ACE II Insight Hub, a system developed to enhance the monitoring and evaluation of Higher Education Centers of Excellence in Africa. The study utilized qualitative and quantitative research methods, structured interviews and survey questionnaires for data collection. Twenty-five (25) participants were selected using purposive sampling. Participation was voluntary and anonymous. Quantitative data were analyzed using Google Forms as graphs and pie charts. Thematic analysis and document analysis were applied to qualitative data and review of documents previously submitted. The system was deployed on the IUCEA intranet, user was trained and validated the system by filling out an online questionnaire. The ACE II Insight Hub aims to enhance stakeholder engagement, evidence-based decision-making, project performance, impact assessment, and accountability for higher education Centers of Excellence in Africa.

DECLARATION

I, Asiimwe Desire, do hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this project report is my original work and that it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

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Prof. Shubi Kaijage		15/08/2024
Name of Supervisor 1	**Signature**	**Date**

Dr. Elizabeth Mkoba		15/08/2024
Name of Supervisor 2	**Signature**	**Date**

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology, a project report titled **"Development of a Web-Based System to Enhance Monitoring and Evaluation of Higher Education Centers of Excellence in Africa"** in partial fulfillment of the requirements for the degree of Master of Science in Embedded and Mobile Systems of the Nelson Mandela African Institution of Science and Technology.

Prof. Shubi Kaijage		15/08/2024
Name of Supervisor 1	**Signature**	**Date**

Dr. Elizabeth Mkoba		15/08/2024
Name of Supervisor 2	**Signature**	**Date**

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Lastly, I appreciate my parents and siblings for their love, care, and prayers. Their presence in my life motivates me to strive for excellence and make them proud. God bless them all.

DEDICATION

I dedicate this work to the young girls living in the rural areas of East Africa who aspire for greatness.

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LIST OF ABBREVIATIONS AND SYMBOLS

ACE	Africa Center of Excellence
ACE II	Eastern and Southern Africa Higher Education Centers of Excellence Project
API	Application Programming Interface
BI	Business Intelligence
EA	East Africa
EAC	East African Community
HEI	Higher Education Institution
IUCEA	Inter-University Council for East Africa
KPIs	Key Performance Indicators
M&E	Monitoring and Evaluation
MEIS	Monitoring and Evaluation Information System
MYSQL	My Structured Query Language
NGO	Non-Governmental Organization
PDO	Project development objectives
RFU	Regional Facilitation Unit
UI	User Interface
WBG	World Bank Group

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

The World Bank launched the Africa Higher Education Centers of Excellence (ACE) initiative to establish regional education and research centers in Africa to reinforce the longer-term capacity and train Africans who can study science and technology and apply it to provide solutions to Africa's problems (ACE II, 2023).

In 2013, the first phase, ACE I, was rolled out across seven West and Central African countries with a focus on three priority areas; STEM, Agriculture, and Health. In 2016, phase two known as the Eastern and Southern Africa Higher Education Centers of Excellence (ACE II), was rolled out and is the focus of this project work. The ACE II operates in 8 countries namely; Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, and Zambia, and prioritizes industry, health, education, agriculture, and applied statistics (ACE II, 2023). The 29 Eastern and Southern African higher education centers of excellence, as displayed in Appendix 1.

The Inter-University Council for East Africa (IUCEA) was selected as the Regional Facilitation Unit (RFU) for ACE II and as such, it coordinates, facilitates, and administers the activities of the project. The Inter-University Council for East Africa is an institution of the East African Community (EAC) and is mandated to "facilitate the strategic development of member universities, coordinate inter-university cooperation, and promote internationally comparable higher education standards and systems for sustainable regional development" (IUCEA, 2023).

To gauge the effectiveness of ACEs, various metrics are utilized. These include national and regional students enrolled in ACEs, the establishment of partnerships through a Memorandum of Understanding (MoU) to foster cooperation in research and training, accreditation of educational programs, the quantity of individuals directly benefiting from the project, the publication of research papers in supported fields that receive global recognition, the external income generated by ACEs, as well as the exchange of faculty and Philosophy of Doctorate (PhD) students to encourage research and teaching. A substantial amount of data is gathered on these metrics at the 29 centers of excellence for monitoring and evaluation purpose.

Monitoring and evaluation enable project managers to keep proper operational records and enables them to foresee the consumption of the resources allocated. It helps decision-making parties to strategize for the sustainability of the projects and guides for future events and keeps stakeholders engaged throughout the project's implementation (Biwott *et al.,* 2017).

While researching the key factors for effective monitoring and evaluation, it was established that having a budget allocated towards Monitoring and Evaluation (M&E), maintaining data quality, empowering the technical ability of teams, leadership development and use of Monitoring and Evaluation Information Systems (MEIS) are the key determinants. The study advocated for the adoption of Monitoring and Evaluation Information Systems in addition to the need for capacity building for the M&E technical teams who will interact with the adopted systems (Tengan *et al.*, 2019).

1.2 Statement of the Problem

Worldwide, organizations use M&E systems to monitor the advancement of projects and to measure output. While using these systems, organizations can enhance their productivity and effectiveness (Mleke & Dida, 2020).

The process of making decisions in higher education keeps getting complex over time, this has made the use of traditional platforms to process data ineffective for monitoring. Therefore, the use of technology to monitor and evaluate the education sector presents a workable solution to the challenges currently facing the expansion of the education field. To advance education at a higher level in China, big data technology has been adopted to gather complete and correct data that is used to evaluate education quality (Yuqian *et al.,* 2017).

Monitoring and evaluation of ACE II are highly dependent on data, however, the data from different Eastern and Southern higher education centers of excellence is collected and stored on Excel sheets which not only make it difficult to analyze due to its disintegration per center but also is time-consuming to process and derive insights from it. The ACE II lacks visual cumulative and informative data to tell its impact and a feedback mechanism for the beneficiaries to share their grievances and concerns, there is no dedicated internal communication channel for stakeholders.

According to the literature review, while numerous systems exist to address individual aspects of monitoring and evaluation, none holistically encompasses the functionalities of data

processing, visualization, dashboard creation, report generation, feedback and grievance capturing as well as stakeholder engagements in a single, cohesive solution.

This project aimed to develop a Web-based System to enhance the Monitoring and Evaluation of Higher Education Centers of Excellence in Africa (ACE II Insight Hub) while assisting, IUCEA in administering and managing the ACE II project more effectively.

1.3 Justification of the Study

The increased need for accountability and fact-based results has resulted in an associated need for improved result-based M&E policies, programs, and systems (Kusek & Rist, 2004).

Monitoring and evaluation of a project is an important feature of any project's implementation and management. However, in today's era, project managers consider M&E a necessity for success rather than an administrative tool used in planning and implementing the project. Moreover, projects that are not appropriately monitored and evaluated run at a high risk of not being completed successfully (Kissi *et al.*, 2019).

Through the process of data analysis, it becomes possible to determine whether a monitoring and evaluation program has successfully met its objectives. By analyzing qualitative data, patterns can be identified and the underlying ideas behind those patterns can be uncovered. Similarly, quantitative data analysis involves precise calculations to derive insights from the data (Measure Evaluation, 2020).

Therefore, the developed system, ACE II Insight Hub, eases data collected from the 29 ACEs, supports the storage of the collected data in a centralized database, enables all stakeholders to share and access information easily, and provides a streamlined and reliable channel for beneficiaries' feedback and grievances. The dashboard, reports and data visualization features contribute to improved and faster decision-making processes by ACE II implementers.

1.4 Objectives of the Study

1.4.1 General Objective

To develop a Web-based System to enhance the monitoring and evaluation of Higher Education Centers of Excellence in Africa.

1.4.2 Specific Objectives

The study aimed to achieve the following specific objectives:

(i) To engineer system requirements for developing the Web-based System to enhance monitoring and evaluation of Higher Education Centers of Excellence in Africa.

(ii) To develop a Web-based System to enhance the monitoring and evaluation of Higher Education Centers of Excellence in Africa.

(iii) To validate the developed Web-based System to enhance monitoring and evaluation of Higher Education Centers of Excellence in Africa.

1.5 Research Questions

The study intended to answer the following questions:

(i) What are the system requirements for the Web-based System to enhance the monitoring and evaluation of Higher Education Centers of Excellence in Africa?

(ii) How can the Web-based System to enhance monitoring and evaluation of Higher Education Centers of Excellence in Africa be developed?

(iii) Will the developed Web-based System to enhance the monitoring and evaluation of Higher Education Centers of Excellence in Africa meet the users' requirements?

1.6 Significance of the Study

As a means of refining the value of services in the education sector and improving efficacy and competence in the sector, institutions of higher education are intensifying IT-driven solutions both in developing and developed countries (De-Jesus & Buenas, 2023).

In Rwanda, research to assess the factors leading to proper administration of projects based in the community discovered that project performance can be enhanced through having working monitoring and evaluation systems that facilitate planning and aid the proper allocation and use of funds. The researcher found that the degree of stakeholder engagement impacts the effectiveness of monitoring and evaluation systems (Kiconco & Mulyungi, 2018).

Data obtained from monitoring and evaluation processes in their raw form may not provide significant insights and value for decision-making. However, through a thorough analysis and interpretation of the data, it can be transformed into valuable knowledge that can aid in making informed decisions. Therefore, it is crucial to have a proper system in place to analyze and interpret the data obtained from monitoring and evaluation processes (INTRAC, 2017).

The ACE II Insight Hub can enhance ACE II stakeholder engagement, evidence-based decision-making, project performance, impact assessment, and accountability for the Eastern and Southern Africa Centers of Excellence.

1.7 Delineation of the Study

The project was delineated to the monitoring and evaluation of Eastern and Southern Africa Higher Education Centers of Excellence using a web-based system with features like data input visualizations, reports, and feedback sharing portal internally and externally. The project was developed for the Inter-University Council for East Africa, the project's Regional Facilitation Unit, and can be used in 8 countries where the centers of excellence are located. The user interface (UI) is web-based and optimized for desktop/ laptop devices and usable on a mobile phone as well.

The developed system relies on accurate data and comprehensive data from different ACEs and integrating data from all the sources to come up with accurate, harmonized, and informative reports was challenging during the system development.

Given the limited time of the project development and implantation at the host institution, the users were not fully trained on how to use the system. The lack of user training may limit the usage of the developed system.

Some of the participants were reluctant to share data and information that was used to establish system requirements and in the development of the system in general. This was because they were used to the conventional ways of handling tasks and felt that digitizing these tasks was a thread of their jobs. However, they were able to cooperate and participate willingly in the study after being explained that the system was to help ease their work and not a threat to their jobs.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Key Concepts

2.1.1 Monitoring and Evaluation

Monitoring and evaluation refer to methods that policy-makers and project implementers use to weigh how a project is executed and to find out if there are any gaps between the planned results and achieved results (International Labour Organization, 2015)

2.1.2 Data Visualization

Data visualization is a vital process that transforms complex information into a visual format that can be easily grasped by individuals, resulting in the revelation of valuable insights. This can be achieved through the use of maps, graphs, and charts, all of which aim to reveal patterns and trends within the data (Brush & Burns, 2023).

2.2 Related Works

This subsection presents related works that have been reviewed to come up with the technical gap being addressed.

2.2.1 Higher Education Quality Monitoring and Evaluation Platform Based on Big Data

The Higher Education Quality Monitoring and Evaluation Platform combines disintegrated evaluation into methodical evaluation making the process of evaluation inclusive and more reliable. The system solves the problem of collecting uneven information, allows real-time browsing of data, and can process and analyze data based on the current need to deliver a practical and logical basis for administrators in the education sector to make decisions. The system uses big data technology to collect, process, and store data about teaching in universities and colleges. The data is then mined and analyzed using statistical analysis and model building to come up with reports graphically presented as charts (Yuqian *et al.,* 2017).

Much as the developers included the functionalities of acquiring data, processing it, and the results to enhance monitoring of teaching activities in schools in Nanjing, China, the system

does not cater for communication among the different stakeholders in education and school administrators (Yuqian *et al.*, 2017).

2.2.2 A proposed Architecture for integrating Business Intelligence in Higher Education Quality

For Higher Education to benefit from Business Intelligence (BI) analytics for monitoring and evaluation purposes, a study by Sorour *et al.* (2020) proposed an architecture that incorporates BI in Higher Education. The researchers created links between the main elements of the monitored indicators and the BI system. This study revealed that Stakeholders and management were the main users of the Business Intelligence and that they play a big part in drafting the strategy of Higher Education Institutions. As such, their needs were given the most priority when proposing the system architecture. The proposed BI system would support decision-making for HEI management by providing real-time performance measurements and analytics. The proposed architecture identified several input sources of data that feed the system. The significant role of social media in getting feedback on the quality of service provided by the HEI was considered. Diverse data storage mechanisms like cloud services and internal databases were put into consideration during the design. The analyzed data was visualized and presented to decision-makers as dashboards, reports, spreadsheets, and ad-hoc queries (Sorour *et al.*, 2020).

Although the suggested architecture is discussed in the context of HEIs, it can also be used to monitor other KPIs that are specific to the institution.

2.2.3 Business Intelligent Dashboards for Quality Monitoring in Higher Education Institutions Using Service Oriented Business Intelligence Tools

In a bid to solve the difficulties in monitoring quality in higher education, a study proposed and designed a three-path Business Intelligence architecture to cater to the needs of different Higher Education Institutions. The proposed architecture considers the varying capabilities of the institutions to handle large datasets from different sources. Institutions with limited resources can utilize web services to visualize data from the database on dashboards. The authors used Microsoft Power BI Desktop, Tableau, and the Cube.js Service Oriented Business Intelligence tool for developing the dashboard prototype. The proposed architecture enables decision-makers in HEI to monitor compliance with KPIS and recognize areas where exceptional consideration is needed to realize national accreditation (Sorour & Atkin, 2024).

This study focused on developing a framework for retrieving data from social media and presenting the data in summarized graphics to stakeholders.

2.2.4 A Big Data Architecture for Learning Analytics in Higher Education

According to their research, the researchers discovered that a lack of adequate conceptual architectures for big data suitable for higher education institutions has resulted in numerous failures to provide timely, relevant, and accessible information for decision-making. Therefore, they came up with a generic solution that seamlessly integrates data acquisition, pre-processing, storage management, analytics, visualization, and alerts to solve the challenge of big data analysis in higher education. The proposed system includes all objects and devices responsible for collecting raw data at each stage of higher education processes. The structured and unstructured data collected data from specific students are forwarded to the data management systems for analysis. The data storage system consists of a database management system with buffering and real-time query optimization. After data is analyzed using smart processing algorithms to extract meaningful and valuable information which is then visualized to depict the analysis results (Matsebula & Mnkandla, 2017).

This study proposed and presented an architecture of analyzing big data for purposes of monitoring quality in higher education institutions with a focus on learning analytics leaving out other measurable elements that can support decision-making in higher institutions of learning in Africa.

2.2.5 The MET Online Services System

The MET online service system is a business analytics-supported web and mobile application that was developed to systematize and improve the surveillance of important indicators for performance in learning institutions in the Philippines thus helping them to make better fact-based decisions. It is made up of responsive visualizations, reports, and dashboards that support the instant advancement of extension services, activities, and ongoing tasks and monitor the definite activities quarterly and annually (De-Jesus & Buenas, 2023).

On the other hand, MET Online services mainly focus on the monitoring of teaching activities in the learning institutions leaving out other key elements and processes for example, student engagement and satisfaction, and engagement of other stakeholders.

2.2.6 A Web-based Monitoring and Evaluation System for the Ministry of Health Projects

The researchers proposed a web-based system to enhance the monitoring and evaluation of projects that fall under the Ministry of Health in Tanzania. They suggested three modules namely, projects registration where new projects are added, projects tracking and project status module which provides alerts if the project has failed or succeeded before or after the project deadline. The significance of the system is that it would help in providing timely and accurate information which informs the progress of the projects being implemented (Mleke & Dida, 2020).

However, the researchers proposed the system without developing it therefore the developed ACE II Insight Hub and the proposed system by the researchers are not comparable in terms of the technology used.

2.2.7 Proactive Project Monitoring Model

The developers proposed a model based on modeling and prediction trends of time series to proactively monitor the execution time of a project and the deadlines of the projects. Testing results of the model showed that the model could estimate project times with a few constraints whose influence is easily established and regulated. The use of the model would enable project implementers to come-up with decisions at the early stages of the project thus solving the project planning and management challenges in Russia (Averina *et al.*, 2020).

However, the developers focused on only one aspect of project monitoring and evaluation, leaving out other important aspects that influence the success of a project such as stakeholder engagement, and budgetary constraints among others. The model developed by the researchers was based on time series trends of modeling and forecasting for prediction while the developed ACE II insight hub does not have a prediction functionality.

2.2.8 GeoFarmer

GeoFarmer is a customizable system that monitors farming projects in Tanzania, Uganda, Colombia, and Ghana and provides feedback to farmers. The system provides a mechanism for farmers can share their constructive and adverse experiences amongst themselves and consult specialists on how they can best manage their farms by facilitating a real-time flow of data.

GeoFarmer comprises a web dashboard and a smartphone application and the developers focused on simple and easy to learn and use, keeping in mind the low ICT literacy levels in most rural areas. The results of the study demonstrated that the system is cost-effective for collecting data and farmers can use it to increase productivity on their farms (Eitzinger *et al.,* 2019).

However, GeoFarmer is only restricted for use in agricultural projects and the researchers did not indicate how the systems can be customized and adopted for use in other sectors like community-based aid projects. In terms of technology, GeoFarmer offers feedback to its users only inform of dashboards.

2.2.9 LogAlto

LogAlto is a collaborative off-the-shelf web-based software for monitoring and evaluating international development projects using dashboards and data visualization. The software is available for use on the Internet and it offers a user-friendly interface, and cloud-based capabilities that allow usage from any location of the users and is highly flexible to serve the needs of large and small M&E systems. LogAlto is the best for international Non-Governmental Organizations (NGOs) with many implementing partners in different countries. It helps to track progress, measures the impact, and reports on all the projects (Logalto, 2023).

On the other hand, LogAlto is not the best fit for organizations that want their M&E System to be hosted in-house and those dealing with data that has a high degree of confidentiality since it is a cloud-based application.

2.3 Technical Gap

Particularly in East Africa, there is a clear technical gap in the existing systems used for M&E activities in project implementation. Based on the literature reviewed, the absence of a unified system that seamlessly integrates data processing, visualization, dashboard creation, report generation, grievance and feedback capturing as well as stakeholder communication is evident.

While numerous systems exist to address individual aspects of monitoring and evaluation, none holistically encompasses these functionalities in a single, cohesive solution.

2.4 Proposed System

The proposed and developed system is a Web-based System to enhance the Monitoring and Evaluation of the Eastern and Southern Africa Higher Education Centers of Excellence, known as ACE II Insight Hub. The system aims to improve the reporting and decision-making process by the stakeholders and the project implementing parties through project data visualization and report generation. The system supports three registered user groups, the World Bank Group (WBG) stakeholders, IUCEA, and ACE leaders, and can take in feedback and queries from unregistered users who do not need credentials to submit their concerns. It also allows registered users to communicate amongst themselves under the Comments module as shown in Fig. 1.

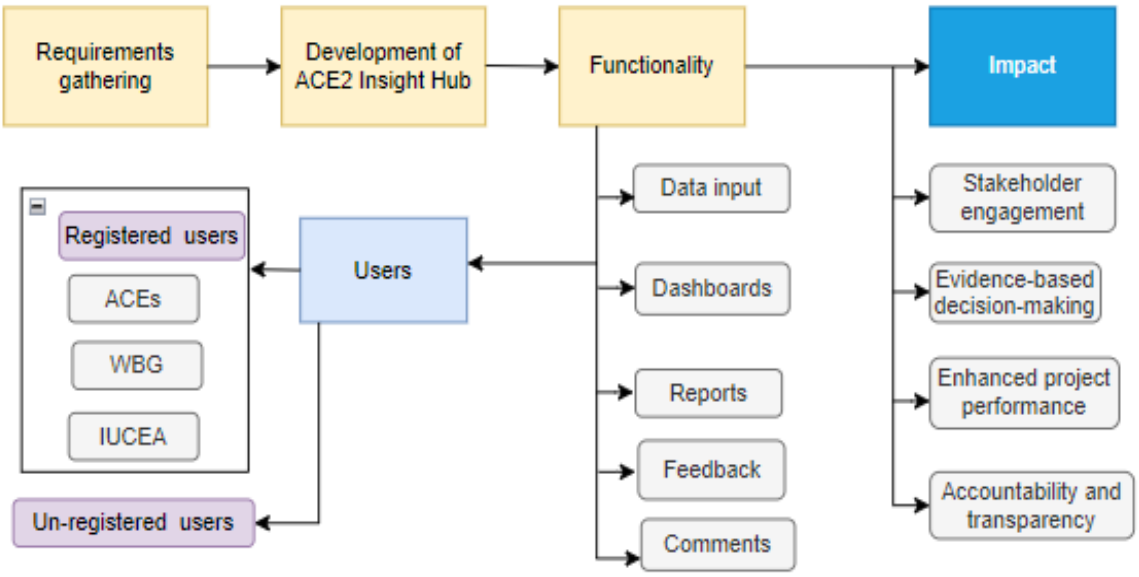


Figure 1: Proposed system

CHAPTER THREE

MATERIALS AND METHODS

3.1 Project Case Study

This project was executed at the Inter-University Council for East Africa (IUCEA) with its head offices located in Kampala, Uganda, as indicated on Google Maps in Fig. 2. Uganda is one of seven partner states of the EAC, to its west is he Democratic Republic of Congo, Kenya to the east, to the southwest is Rwanda, to the north is South Sudan, and Tanzania to the South. The project was carried out here IUCEA for it is the RFU- Regional Facilitating Unit for the ACE II project which is the focus area of study for this project. Therefore, the location offered an opportunity for direct contact with all the stakeholders which made requirement gathering and system development faster and easier given the continuous interaction with the intended users of the system.

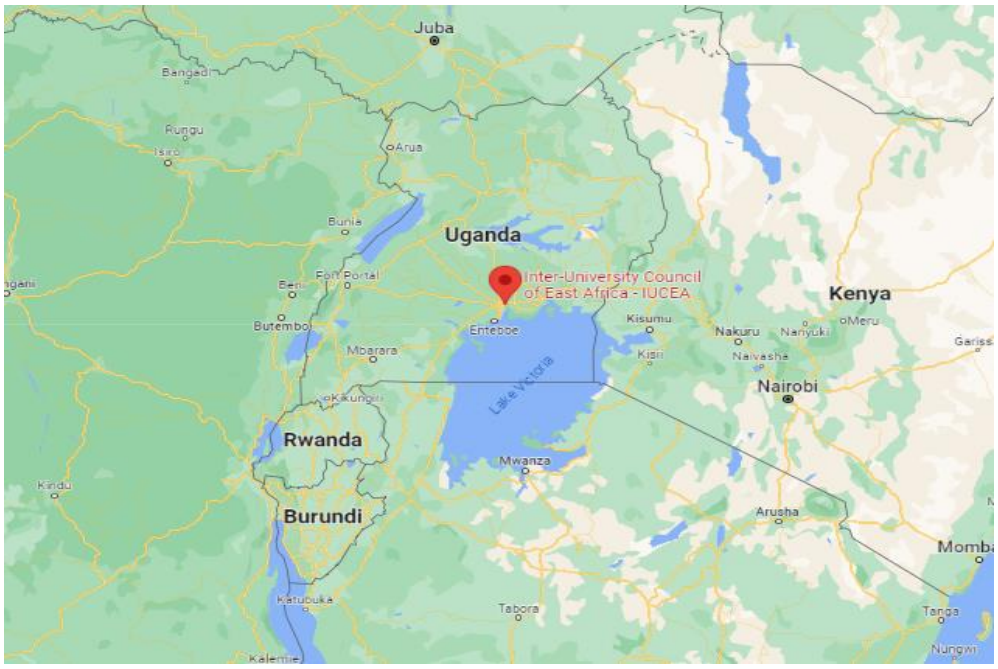


Figure 2: Location of Inter-University Council for East Africa, the project case study

3.2 Research Methods

Quantitative and qualitative research methods were used in collecting data about the monitoring and evaluation of ACE II. This was done to gain a clear understanding of how data is collected at the centers, how feedback is collected and transferred to the RFU for review and verification, and then used to support and inform decision-making by ACE II stakeholders.

Structured interviews facilitated the collection of qualitative data from the staff at the RFU. The interview guide is shown in Appendix 2. A survey questionnaire in Appendix 3 facilitated data collection from the ACE II staff at IUCEA and at ACEs to measure their satisfaction regarding how monitoring an evaluation of ACE II was being done. The document analysis method was used to review reports in Excel format that had been previously submitted for verification to the M&E department of the ACE II at IUCEA.

3.3 Target Population

This project targeted the 29 Africa Centers of Excellence located in the 8 African countries of Uganda, Kenya, Tanzania, Malawi, Mozambique, Ethiopia, Rwanda, and Zambia, IUCEA which is ACE II's regional facilitating unit and everyone else involved in the monitoring and evaluation of ACE II project.

3.4 Sampling Technique and Sample Size

The purposive sampling technique was utilized in data collection and requirements gathering. The study selected 25 representatives who work closely in the monitoring and evaluation of ACE II; 10 from the ACE II department at IUCEA-RFU, 12 M&E coordinators at different ACEs, and 3 for the IUCEA Systems department.

3.5 System Requirements

The following are the techniques and tools that were used to collect the system requirements for the project.

3.5.1 Data Collection Methods

Structured interviews and a survey questionnaire facilitated the collection of data using an interview guide in Appendix 2 and a survey questionnaire in Appendix 3 respectively. Using an interview guide made it easy to compare responses from all the selected participants in an even setting. The survey questionnaire facilitated quantitative data gathering.

3.5.2 Data Analysis

Google Forms were used to analyze quantitative data collected from the online survey forms and provided a summary of the respondents' responses graphically.

Thematic analysis was used to analyze interview responses of the staff involved in running ACE II at IUCEA by transcribing the recorded audio interviews and identifying common themes in the collected responses. Thematic analysis is used by researchers to examine common themes and patterns in qualitative data (Naeem *et al.*, 2023). The process involves the researcher getting familiar with the data, coding, generating themes, reviewing the themes to ensure all data is captured, renaming the themes and defining them and finally documentation (Caulfield, 2023). Inductive thematic coding was used to code the common themes, the results are shown in Table 2.

3.6 System Development Approach

This project adopted an agile software development approach, in particular, extreme programming (XP). The XP was used because it emphasizes code quality and continuous feedback, allows changes to be incorporated at any point of development, and emphasizes simplicity (Raeburn, 2022). The XP values of simplicity, feedback, and communication were vital during the system development. The process of XP is illustrated in Fig. 3.

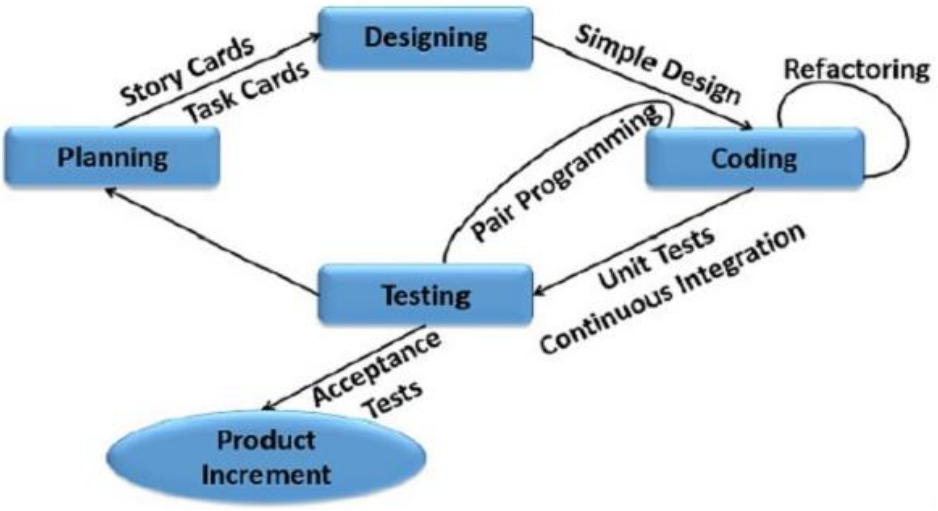


Figure 3: Extreme programming process cycle

3.7 System Design

After collecting the system requirements and analyzing them, Unified Modeling Language (UML) tools facilitated the designing of system architecture. System modeling was done using diagram.net software and MySQL workbench. The results of the system design are explicated in Chapter Four.

3.7.1 Context Diagram

Figure 4 shows the overall description of the developed system. The system back end is connected to the front end and the database using APIs. Data from the database is processed in the backend and system users access the processed data information of reports and dashboards through the user interface of the developed system. Users input data using the UI and the data are then sent and stored in the system database by means of APIs. APIs allow the user interface to securely interact with the database.

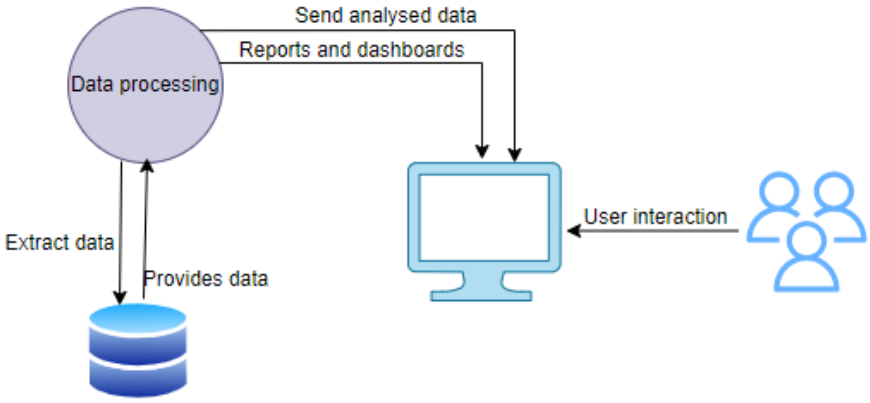


Figure 4: Context diagram for a developed web-based system to enhance monitoring and evaluation of ACE II

3.7.2 Entity Relationship Diagram

The system used a relational database by modeling the data entities and relationships required to capture the M&E data for visualization and reports.

Figure 5 illustrates the relationship that exists amongst the different entities of the developed web-based system to enhance the monitoring and evaluation of ACE II.

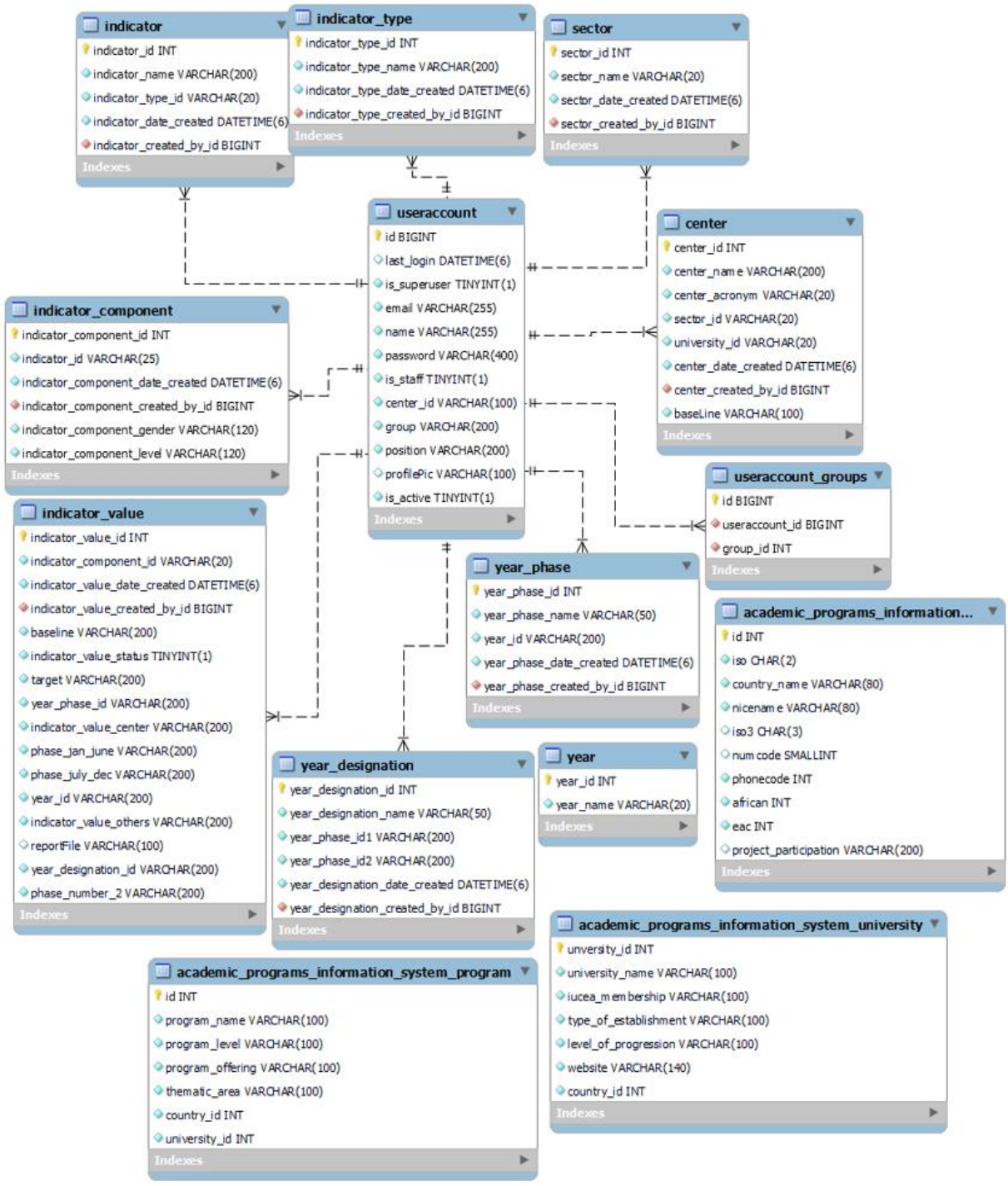


Figure 5: Entity Relationship Diagram for the developed system

3.7.3 Use Case Diagram

Figure 6 shows the different use cases for the developed system and how the different users interact with the system.

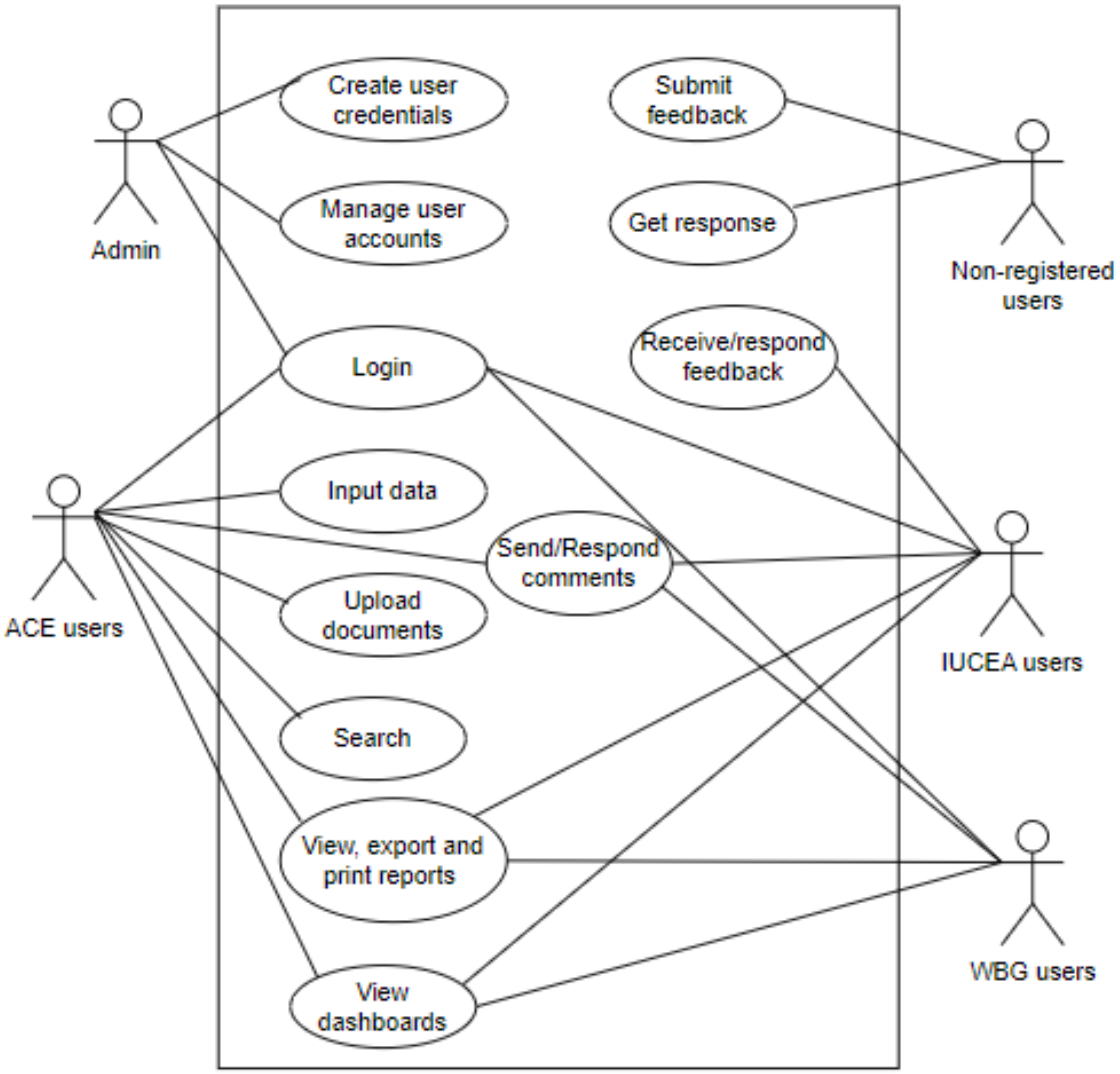


Figure 6: System use case diagram

3.7.4 Flow Chart Diagram

Figure 7 illustrates the flow of activities and processes within the developed ACE II Insight Hub.

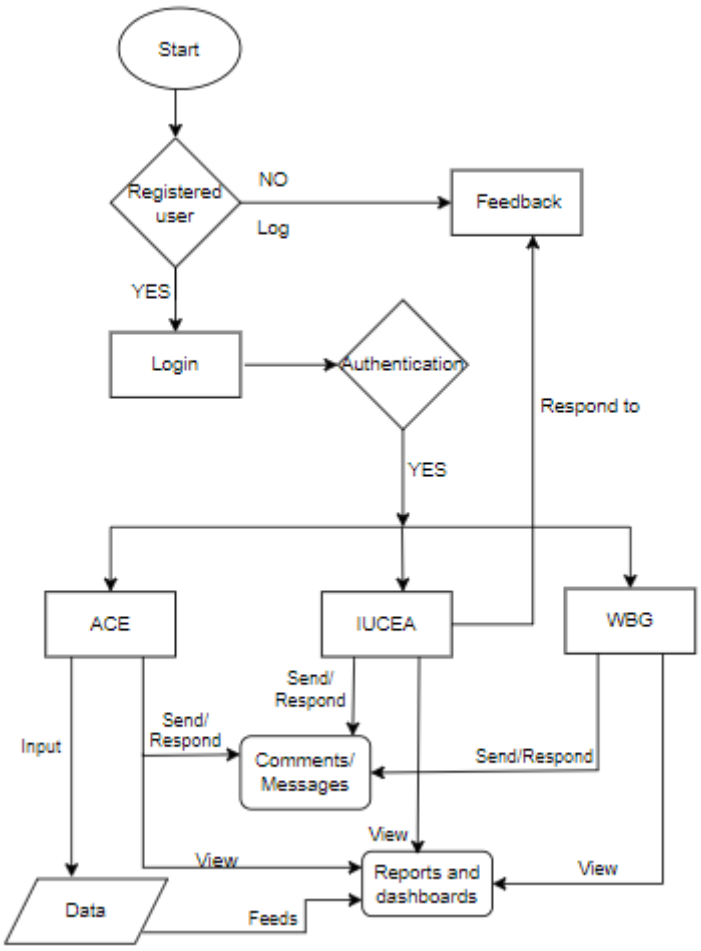


Figure 7: System flow chart diagram

3.8 System Development

The development of the ACE II Insight Hub was facilitated by software requirements and hardware requirements discussed in this section.

3.8.1 Software Requirements

The system is accessible on a variety of web browser software including but not limited to the latest supported versions of Google Chrome, Microsoft Edge and Mozilla Firefox.

The software development tool and technologies used in the development of the system are;

(i) ReactJS

React is a JavaScript library for building system user interfaces. The language allows for the building of reusable components. React was used to develop the system's frontend (Meta Open Source, 2023).

(ii) Django

Django is a Python web framework that enables faster development of secure and easy-to-maintain systems with great features and libraries. It was utilized to construct the back end of the web-based system to enhance M&E for ACE II (Django Software Foundation, 2023).

(iii) MySQL

MySQL is an open-source relational database administration tool (Oracle, 2023). It was utilized for storing and retrieving data and the MySQL workbench was used to create, edit, and manage SQL queries.

(iv) Visual Studio Code

Visual Studio Code, usually referred to as VS code, an Integrated Development Environment (IDE) was used for programming the front-end and back-end of the developed system (Microsoft, 2023).

(v) GitHub

GitHub was used to back up the code using the Git repositories during the development process (GitHub, 2023).

3.8.2 Hardware Requirements

The hardware components used in the development of the system are elaborated in Table 1.

Table 1: System hardware requirements

S/N	Hardware	Purpose
1.	Laptop; Intel(R) Core (TM) i5-5300U CPU @ 2.30GHz	Hosting system development tools and technologies
2.	Smartphone	Communication
3.	Server: Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-83-generic x86_64)	Hosting the system

3.9 System Testing

The system was continuously tested to ascertain that the code was functional throughout the development process using the V-Model method of testing.

3.9.1 Unit testing

During coding, codes for each system component were tested to check if they are running and performing as expected and to check for errors in the code.

3.9.2 Integration Testing

Different components of the system were tested to check for compatibility and to confirm that the code components that were tested independently can work well in combination with other components as per the integration plans that were developed during the system design.

3.9.3 System Testing

At this stage, the system was checked in comparison with the user requirements gathered to check if it meets the expectations of the users.

3.10 System Validation

The system was validated using the user acceptance testing (UAT) method. A validation team composed of the ACE II coordinator at IUCEA, the M&E officer, the head of Information and Communication Technology (ICT), and some selected users at IUCEA were engaged to interact with the developed system to ensure that it conforms to the specified needs requirements. A validation survey form was prepared and issued to the validation team; the responses were analyzed to determine whether the developed ACE II Insight Hub meets the user requirements.

The non-functional requirements like, usability and performance speed were tested at the validation stage. The results are explained in Chapter Four.

3.11 Ethical Consideration

3.11.1 Approval and Consent

Prior to conducting this project, formal approval was obtained from the administration of the Inter-University Council for East Africa, where the project was developed, to ensure compliance with the organization's ethical guidelines. The project was conducted with a commitment to upholding the ethical standards and regulations of IUCEA.

3.11.2 Voluntary Participation and Data Confidentiality

Participation in this study was entirely voluntary. Comprehensive information regarding the project's purpose, procedures, and benefits was provided to the participants before their involvement. Informed consent was obtained from each participant and their right to stop their involvement in the study at any point with no consequences was emphasized.

All data collected during this study was handled with utmost confidentiality and privacy. Personal identifiers were removed and anonymity of the participants was ensured at all stages of project execution. Moreover, the data collected will be exclusively used for the reasons outlined in the consent form and not be disseminated to be utilized with any other third parties and for other objectives.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Systems Requirements Gathering Results

System requirements were gathered using the interview method, interview guide in Appendix 2 and a survey questionnaire in Appendix 3. From these, the system's functional and non-functional requirements were identified.

4.1.1 Interviews Results

An interview was held with staff at IUCEA about how the project is currently being monitored and evaluated and how the data collected from the project is stored, shared among the stakeholders, and analyzed. Below are some of the responses from the discussion held.

(i) What are your main responsibilities in running the ACE II?

Respondent 1 said, *"My key responsibility is to evaluate if the centers of excellence are running well and achieving results in alignment with ACE II project development objectives"*

(ii) How is data collected from Centers to the Regional Facilitation Unit, IUCEA?

Respondent 2 said, *"The data from the different centers is captured in Microsoft Excel format. The data is then sent to IUCEA in the same Excel format as attachments on emails"*

(iii) How is the data being stored?

Respondent 1 answered, *"Once collected, the data is stored on our computers and we share it amongst the stakeholders when the need arises"*

(iv) Do you ever use the data to make presentations or for decision-making? If yes, in what format is it easier for you to manipulate?

Respondent 3 said that, *"Yes, we make graphs from Excel format because it is easier to use. However, it is time-consuming and tedious to analyze data from each center one by one*"

(v) How often do the centers have to report to IUCEA per year?

Respondent 3 said that, *"Twice a year, there are two phases each year, Jan- June and July to December and reporting is done at the end of each phase"*

(vi) How do students at different centers and other people give feedback concerning the ACE II?

Respondent 4 said that, *"At the moment there is no streamlined feedback mechanism in ACE II apart from emails that are used to communicate amongst the different stakeholders internally"*

(vii) Do you think a web-based system will be beneficial in enhancing the monitoring and evaluation of ACE II in terms of, data collection, storage, reporting, and decision-making?

Respondent 1 replied, *"Yes, the biggest challenge we face having to analyze the data from all the centers that are stored on different Excel workbooks. Having a system where all data can be accessed at a single point will be helpful in deriving quick reports thus getting insights from the data faster and much easier. It will also make the interaction among the stakeholders faster and more effective"*

(viii) What features would you want to be considered in the development of the proposed web-based system to enhance monitoring and evaluation of ACE II?

Respondent 4 answered, *"We need to be able to generate reports from the system, the reports will be better if they are generated in Excel so that we are able to do more manipulation at our end. Dashboards on how the project is running will also be good and a feedback mechanism where students and other people involved in the project can raise their views and concerns."*

From the interview on the current practice, it was found that the data from the different centers are captured in Microsoft Excel format. The data are then sent to IUCEA, the regional facilitation unit in the same Excel format as attachments on emails. The staff at IUCEA work to manipulate the Excel documents to come up with different reports that are shared with the World Bank, funders of the project, for decision making.

4.1.2 Interview Thematic Analysis Results

Thematic analysis of the interviews was done to generate the common themes from the interview responses. Table 2 shows the commonly identified patterns where different codes were combined to get the themes.

Table 2: Common themes identified from thematic analysis of the interviews

Code	Identified Theme
C1: Evaluation, Results, Project Development Objectives	Monitoring and evaluation
C2: Centers of Excellence, IUCEA, People involved in the project	Stakeholders
C3: Time-consuming, tedious analysis, generating insights faster, Quick reports, System generated reports	Data analysis
C4: Graphs, Dashboards	Data Visualization
C5: Decentralized storage of data, Excel workbooks, Centralized data collection	Data storage
C6: Data sharing, Emails, Communication, Collaboration	Stakeholder engagement
C7: Feedback mechanism, Views and concerns	Feedback

The first theme identified was Monitoring and evaluation from C1 and it encompasses evaluation, results and PDOs. From C2, we generated the theme stakeholders which encompasses the key players and people involved in ACE II. Data analysis theme was generated from C3 and it encompasses the terms that relate with how meaning is derived from raw data. The 4th theme, Data visualization and it defines how data is presented to the users graphically. Data storage theme was coined from C5 and it defines how data is stored for use. Stakeholder engagement theme from C6 describes how the different people involved in the project interact and communicate and the Feedback theme represents the views of the project stakeholders and beneficiaries concerning ACE II.

4.1.3 Questionnaire Results

A total of 18 responses from IUCEA, staff and students at different ACEs and from World Bank Group were received from the online survey questionnaire out of the 25 targeted respondents. Figure 8 shows that all the 18 participants who responded consented to be a part of the survey.

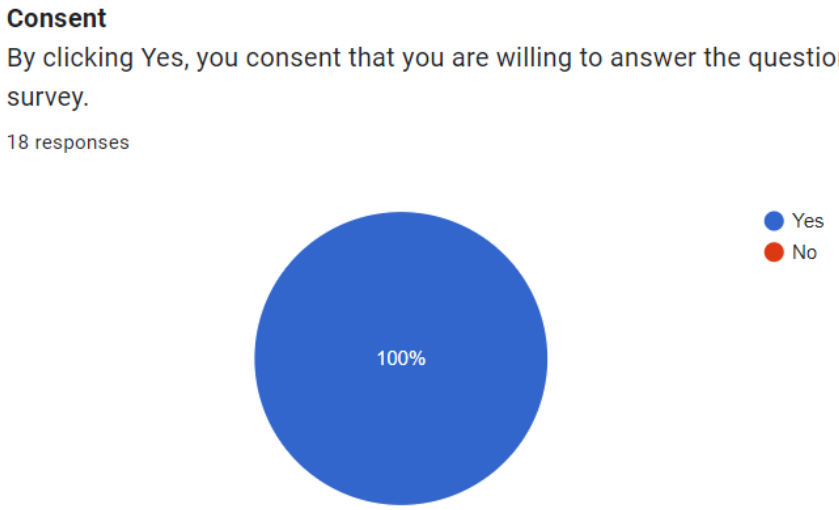


Figure 8: Consent to participate in the survey

Figure 9 illustrates the respondents' gender distribution where 72.2% of them were male while 27.8% were female. The results entail that most of the respondents were male.

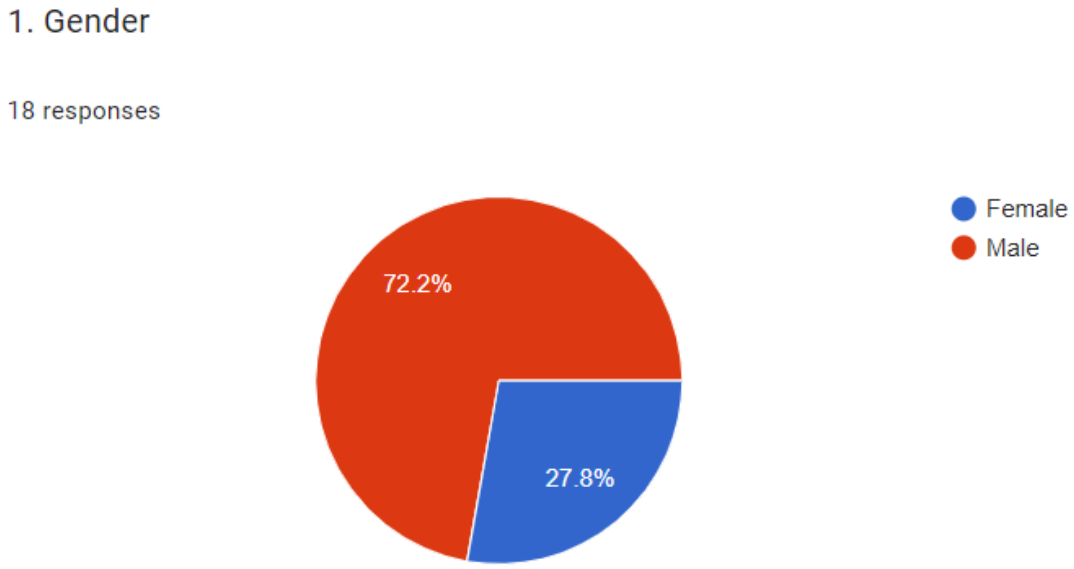


Figure 9: Respondents gender distribution

As illustrated in Fig. 10, the most respondents (38.9%), were aged between 46-55 years, followed by the respondents (33.3%) aged between 26-35 years and respondents (27.8%) aged between 36 -45 years.

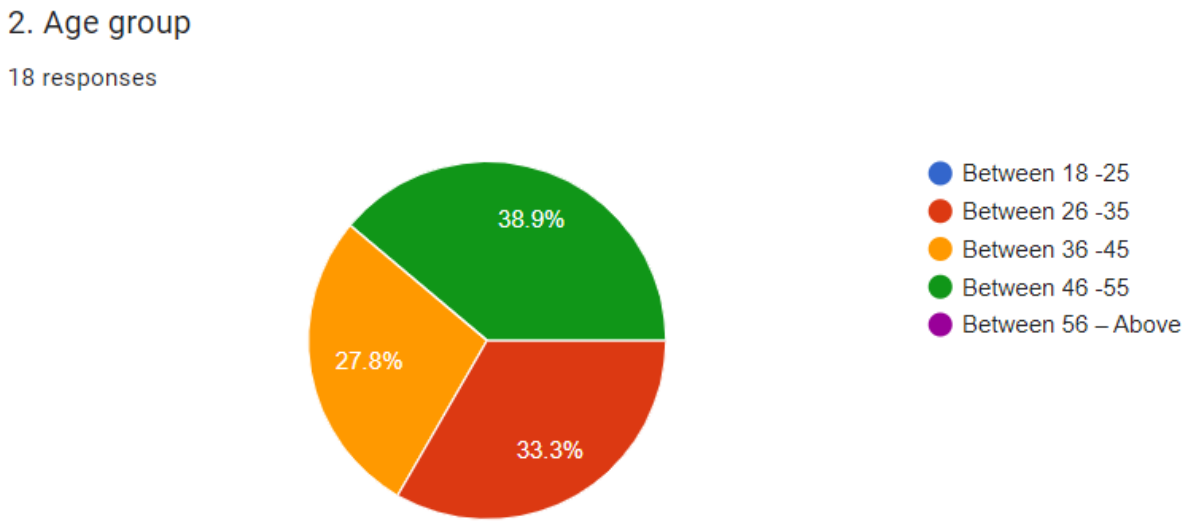


Figure 10: Respondents' age distribution

Figure 11 shows that most of the respondents (44.4%) were IUCEA staff, followed by ACE staff, 27.8%. The number of students who responded in the survey was 22.2% and the staff from World Bank made 5.6% of the total responses.

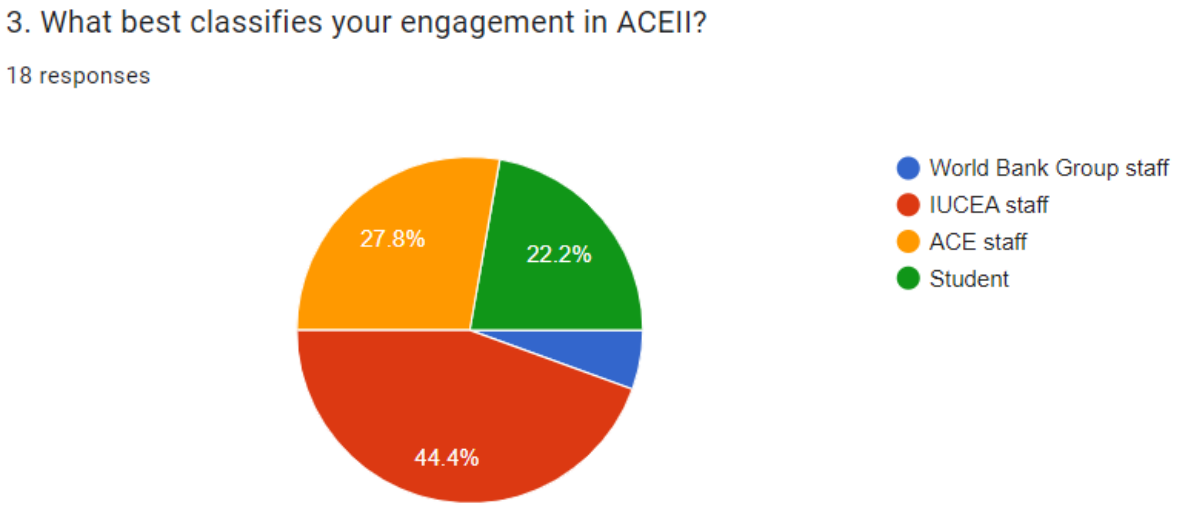


Figure 11: Role of the participant in ACE II project

Figure 12 illustrates that 88.9% of the respondents were aware that data were collected for M&E of ACE II while 11.1% were not sure. This implied that most of the respondents knew that data is a necessary factor in the process of monitoring and evaluating ACE II.

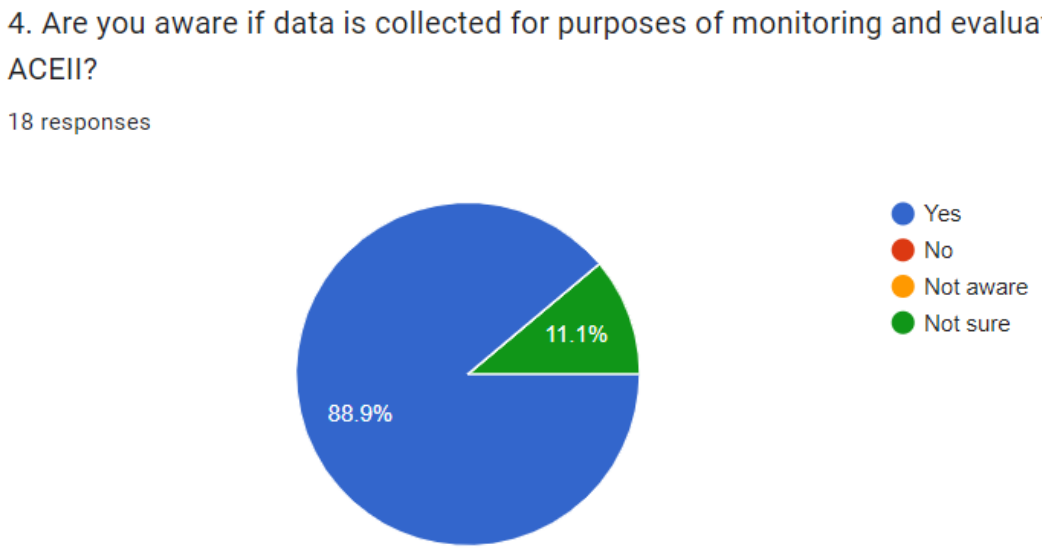


Figure 12: Results of respondent knowledge about data collection for M&E in ACE II

Figure 13 shows that 66.7% of the respondents indicated that the data were collected as Microsoft Excel files, 50% as Word documents, 16.7% responded that there is a centralized system, another 16.7% were not aware of how the data were collected and 5.6% responded that data were collected using other means. The results indicate that to a greater extent, data are submitted in the form of Microsoft Excel and Word files.

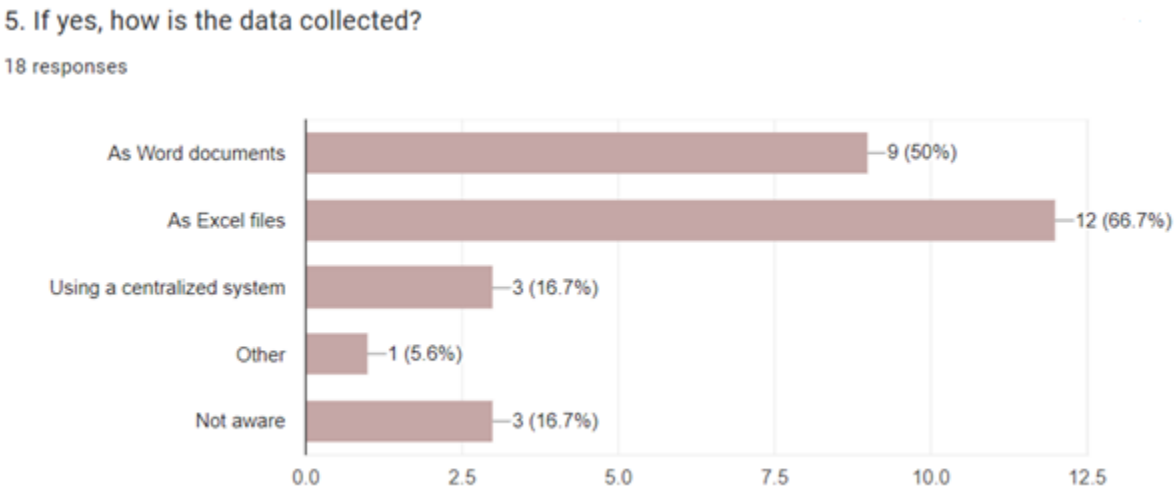


Figure 13: Results of respondent's knowledge on how data were previously collected from ACEs

From Fig. 14, 66.7% of the responses were that data is submitted twice a year, 16.7% respondents responded that that data is submitted whenever a need arises, 11.1 % was not sure of when centers submit the data and 5.6% of the respondents responded that data is submitted once a year.

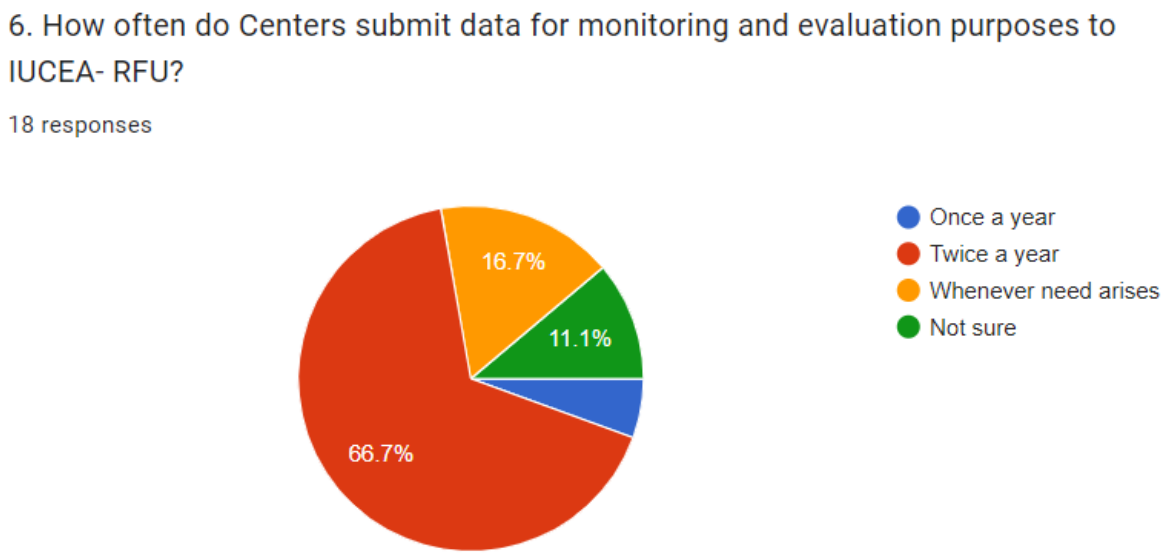


Figure 14: Results of how often ACEs submit data to IUCEA-RFU

When asked about the format in which the respondents are able to easily analyze and understand data, 66.7% of the respondents responded with graphs, dashboard and simpler excel reports, while 5.6% of the responses were for other formats (Fig. 15).

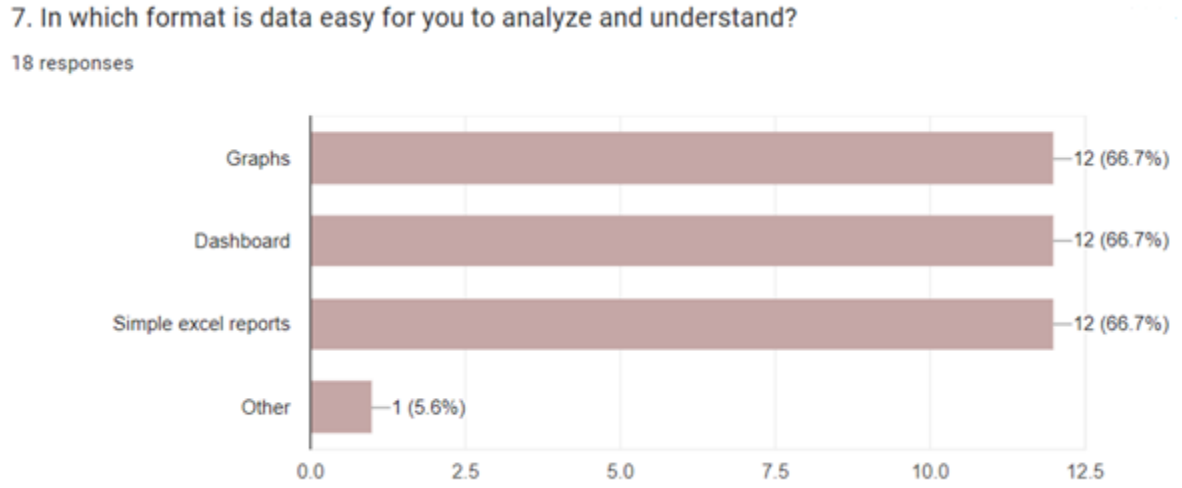


Figure 15: Results of the format in which data is easy for the users to analyze and understand

All the respondents, 100%, responded that communication among stakeholders happens by the use of emails and other methods used accounted for 27.8 % (Fig. 16).

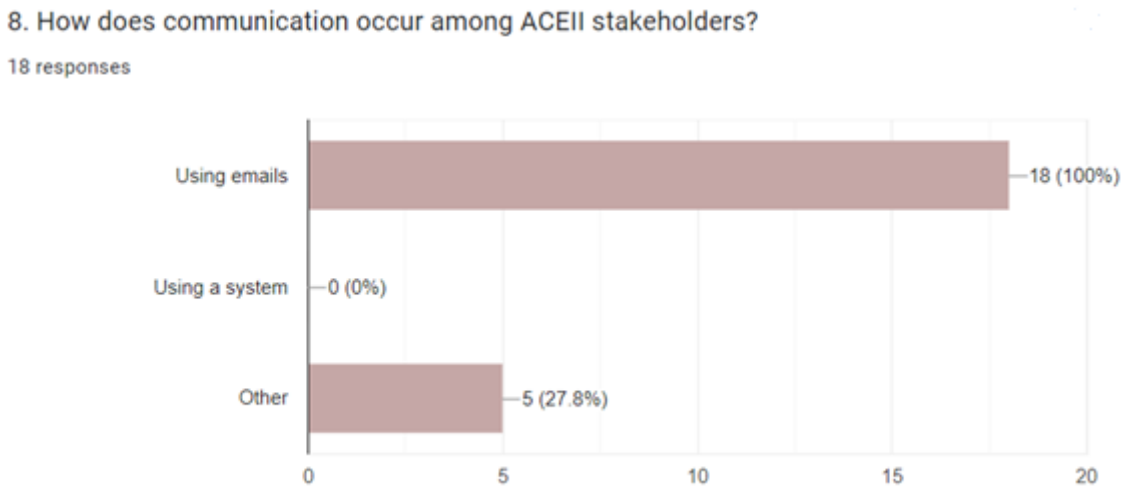


Figure 16: Results on how communication takes place among ACE II stakeholders

When asked about if there is a centralized system for feedback and grievance collection on the project, 88.9% of respondents indicated that there was no centralized system used for feedback and grievance collection while 11.1% of them indicated there was a mechanism in place (Fig. 17).

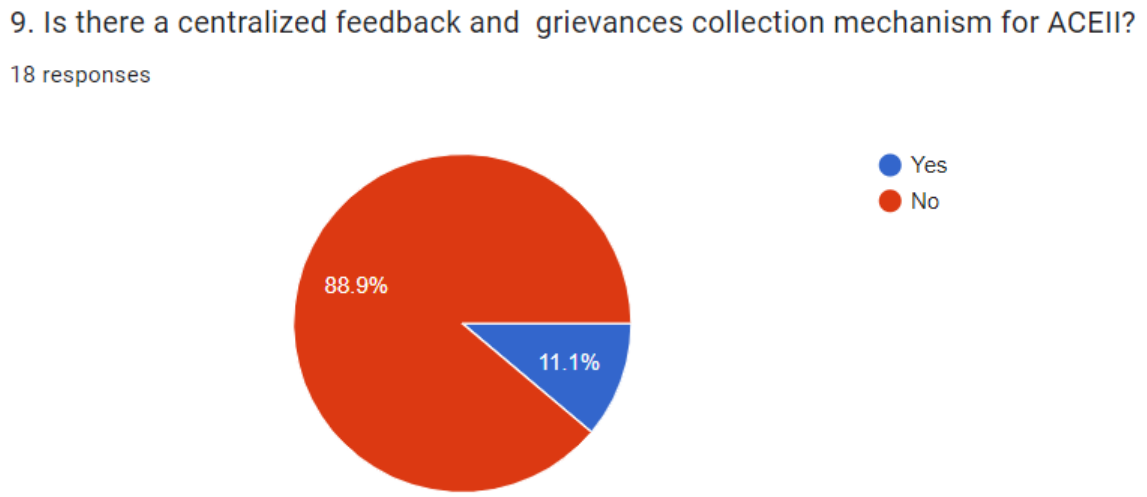


Figure 17: Results on whether there is a centralized feedback mechanism for ACE II

4.2 Identified Requirements

The identified system requirements were categorized under functional and non-functional requirements. These requirements are discussed in this subsection. These requirements were obtained from the interview and survey questionnaire results in Section 4.2.

4.2.1 Functional Requirements

The functional requirements for the developed Web-based System to enhance the Monitoring and Evaluation of ACE II are described in Table 3.

Table 3: System functional requirements

Feature	Requirement description
Account Registration	(i) REQ1. The system administrator should register the users who shall be authorized to access the system (ii) REQ2. The users should be registered under three user groups, ACE, IUCEA, and WBG. (iii) REQ3. The system shall store the information in the relational database.
Account Login and Logout	(i) REQ4. The system should allow only users who are registered to access their accounts. (ii) REQ5. The system shall require an email address and password from the user to log in. (iii) REQ6. The system shall verify username and password, and the user should be able to log in. (iv) REQ7. The system shall allow a logged-in user to log out from their account.
User password reset	(i) REQ8. The system shall trigger a password reset link that should be sent to the registered email of the same on request for a password reset. (ii) REQ9. The user shall be able to change their password by following the shared link and inputting a new password.
Data input	(i) REQ10. The system shall allow users from the ACE user group to input data using an easy-to-use interface. (ii) REQ11. The users shall have access to verify the input data and will be able to edit the data in case of any errors. (iii) REQ12. The system shall allow users to upload data in form of documents using a data attachment mechanism
Search Dashboards	REQ13. The system shall allow a user to search for information on all the pages. (i) REQ14. The system shall allow users access to dashboards on logging in. (ii) REQ15. The dashboards shall be different according to one's user group. (iii) REQ16. The dashboards shall be dependent on real-time data, any changes made in the database shall reflect on the dashboard.
Reports	(i) REQ17. The system shall allow IUCEA and WBG user groups access to reports (ii) REQ18. The reports shall be generated from the database. (iii) REQ19. The users shall be able to print out the reports and export the reports in CSV format.
Feedback	(i) REQ20. The system shall allow non-registered users to log feedback without the need for credentials to log into the system. (ii) REQ21. The feedback logged shall be visible to the IUCEA user group. (iii) REQ22. The system shall allow users under the IUCEA user group to respond to the logged feedback

	(iv) REQ23: The system shall send the response to the email of the user who logged the feedback.
Communication among the users	REQ24: The system shall allow users from different user groups to communicate and share information.

4.2.2 Non-functional Requirements

The non-functional requirements of the developed system are described in Table 4.

Table 4: System non-functional requirements

Feature	Requirement description
Usability	REQ25. The system shall have interactive components which are simple and easy to use.
Security	(i) REQ26. The system shall have access control for different users. (ii) REQ27. The system shall allow access to only registered and authorized users. (iii) REQ28. The system shall have protection for SQL injection. (iv) REQ 29. The system shall run on a secure sockets layer.
Performance and speed	(i) REQ 30. The system shall use technologies to provide improved speed. (ii) REQ 31. The system shall support database optimization.
Maintainability	(i) REQ 32. The system shall be properly documented. (ii) REQ 33. The system shall support code reuse.
Scalability	REQ34. The system shall use technologies that allow scalability
Reliability	REQ35. The system shall meet the reliability threshold with minimal downtime.

4.3 System Development Results

The results from the second specific objective of the project are discussed in this section.

4.3.1 System Overview

The developed Web-based System to enhance Monitoring and Evaluation of ACE II has five modules i.e., data input, reports, feedback, and dashboards and communication/comments. The UI of the system was developed with ReactJS. ReactJS allows for the development of different modules called components which are then integrated using APIs to come up with one bigger

and complete system. The backend logic was developed using Django which is a high-level Python-based framework. MySQL database was utilized for data storage and retrieval. Different users of the system view different pages of the system depending on their roles. The system's codes are shown in Appendix 5.

4.3.2 System's Home page

The home page for the system is in Fig. 18. On this page, registered users have the option to log in or log feedback. Non-registered users have the option to log feedback by clicking on the Feedback button. The users can access information about scholarship opportunities on the IUCEA website and the ACE II Website by clicking on the Scholarships and ACE II website buttons respectively.

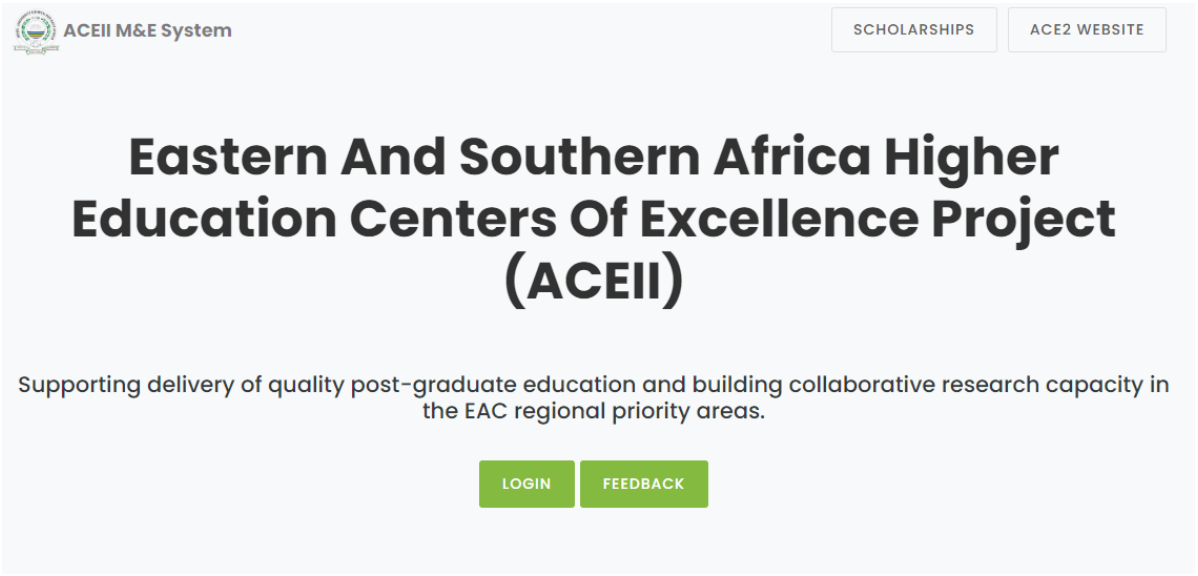


Figure 18: System Home Page

4.3.3 Login Page and Password Reset

A registered user is required to input their credentials, email, and password, for authentication. Once authenticated, the user is allowed access to the system. To ensure security, the password is hashed once input. From the login page in Fig. 19, the user is provided with the option to go back to the landing page or reset their password.

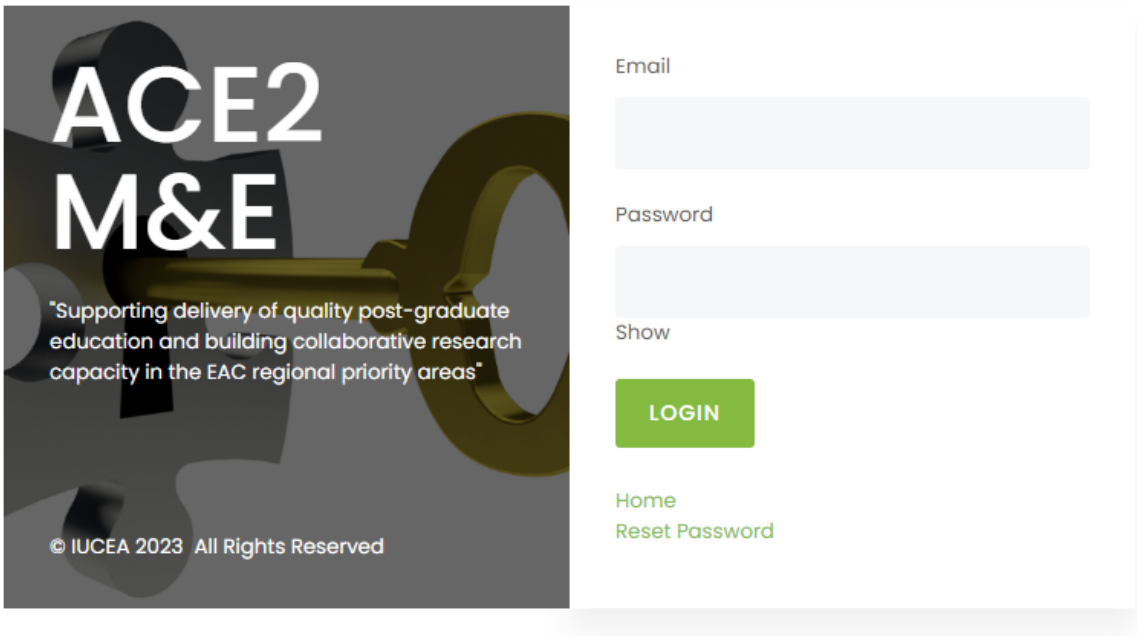


Figure 19: System login page

When a user selects the option to reset a password, an email for password reset is sent to the user's email address with the link that leads to the password reset page in Fig. 20.

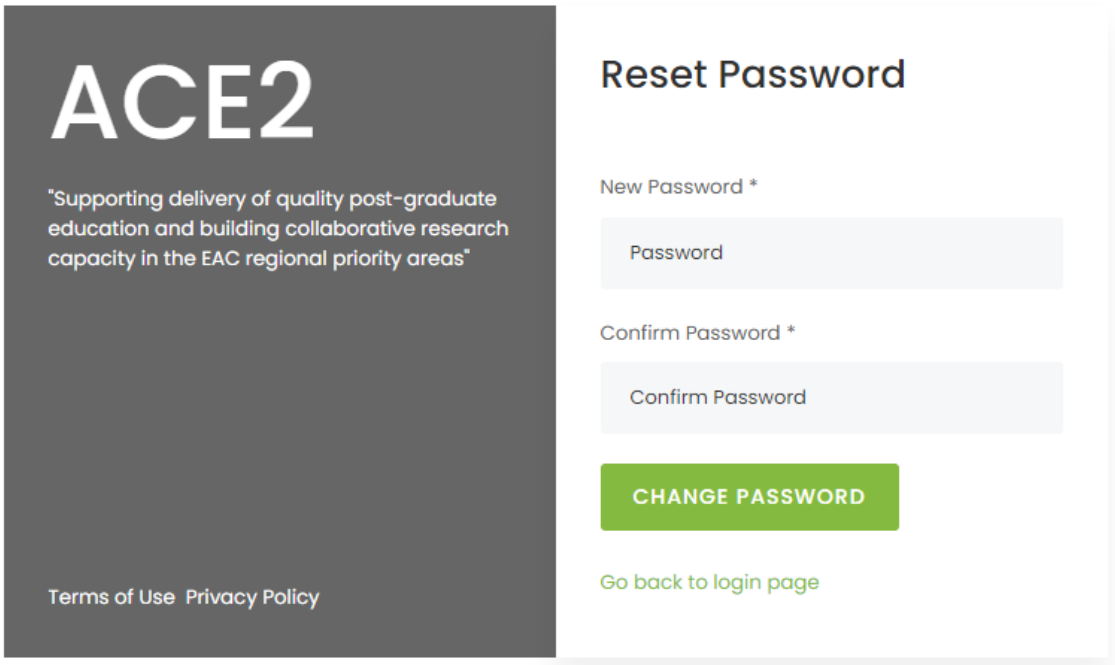


Figure 20: Password reset page

4.3.4 System Administrator's Interface

Figure 21 shows the interface for the system admin after login. The admin has access to all modules of the system.

Figure 21: System administrator's interface

The system admin registers users to access the system using the interface in Fig. 22. On registration, the user group must be captured as it is this that determines the system functionality that a particular user gets access.

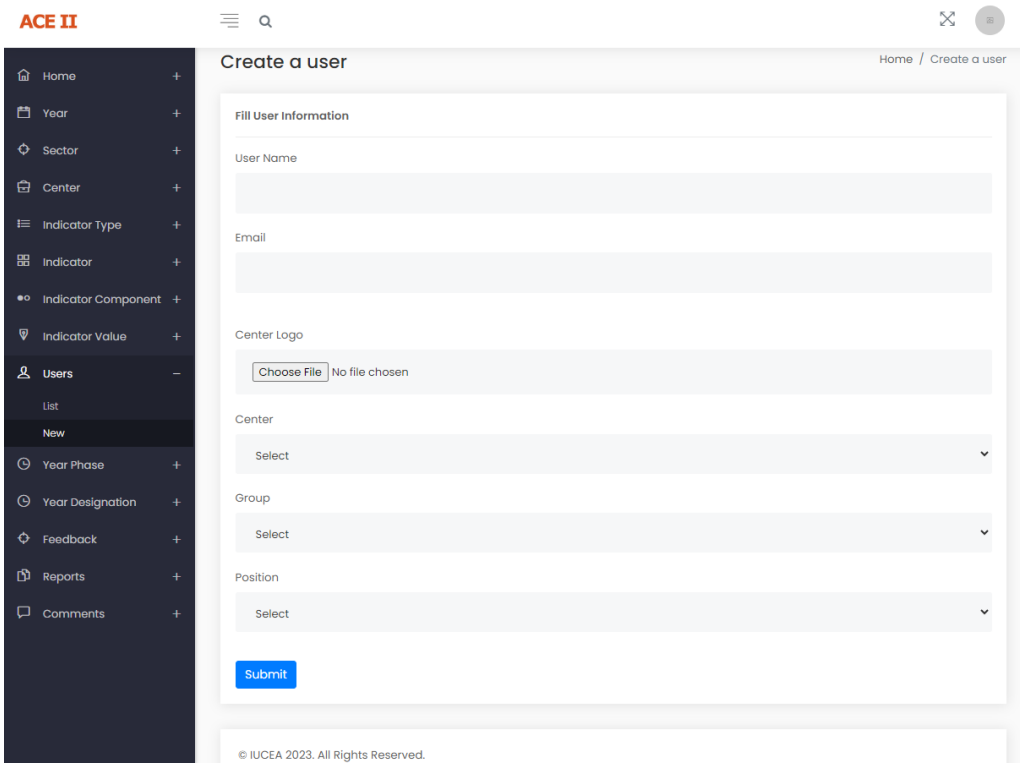


Figure 22: User registration interface

4.3.5 The ACE Users' Interface

On logging in, a user from a center of excellence is able to view a dashboard with data from the center to which he is affiliated. The name of the center and the center logo are reflected on the page as well as seen in Fig. 23. The menu on this page is only limited to the functionality that matches the user's needs at this level.

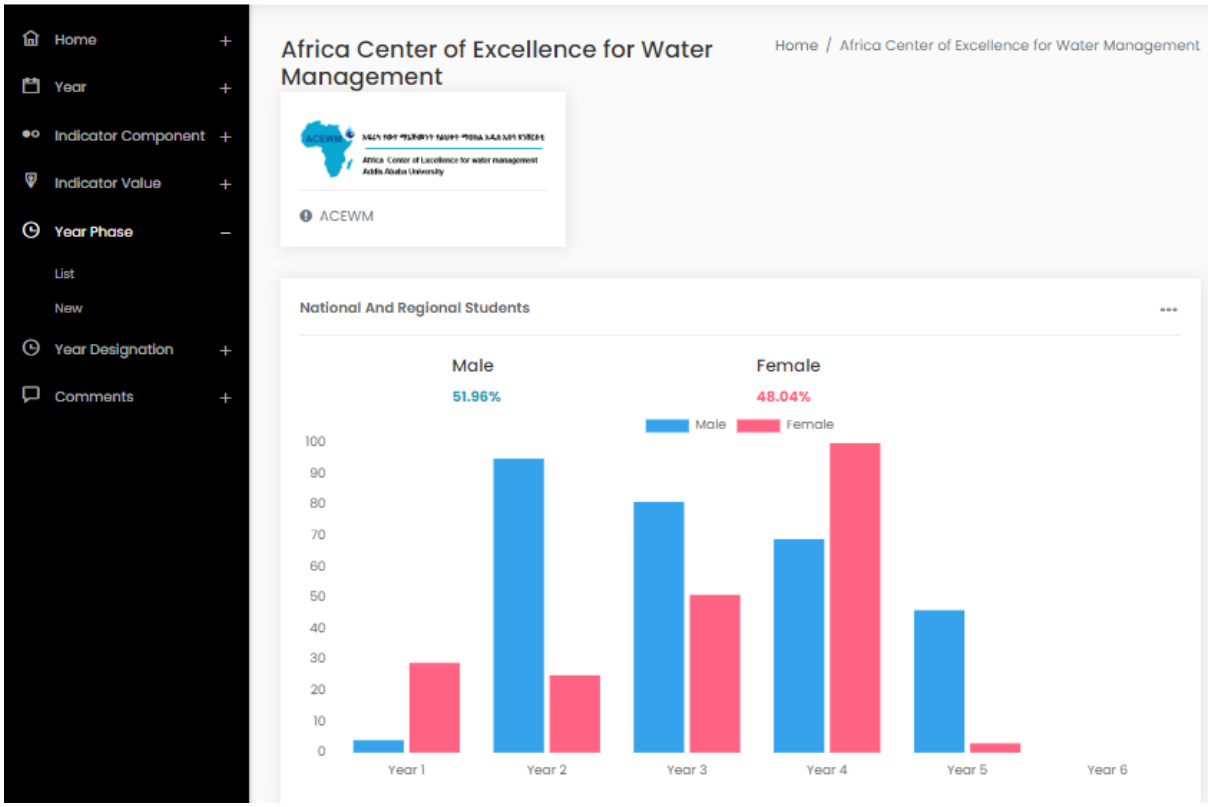


Figure 23: The ACE users' interface

4.3.6 Data Input Module

The users from different centers are the ones who input data related to a particular center of excellence. The data is input following the four areas of the project implementation that are monitored, that is PDOs. Component 1, Component 2, and Component 3. The interface for data input is in Fig. 24. The system was designed in such a way that it prevents double entry of values and this helps to avoid data duplication that may in turn lead to errors in reporting.

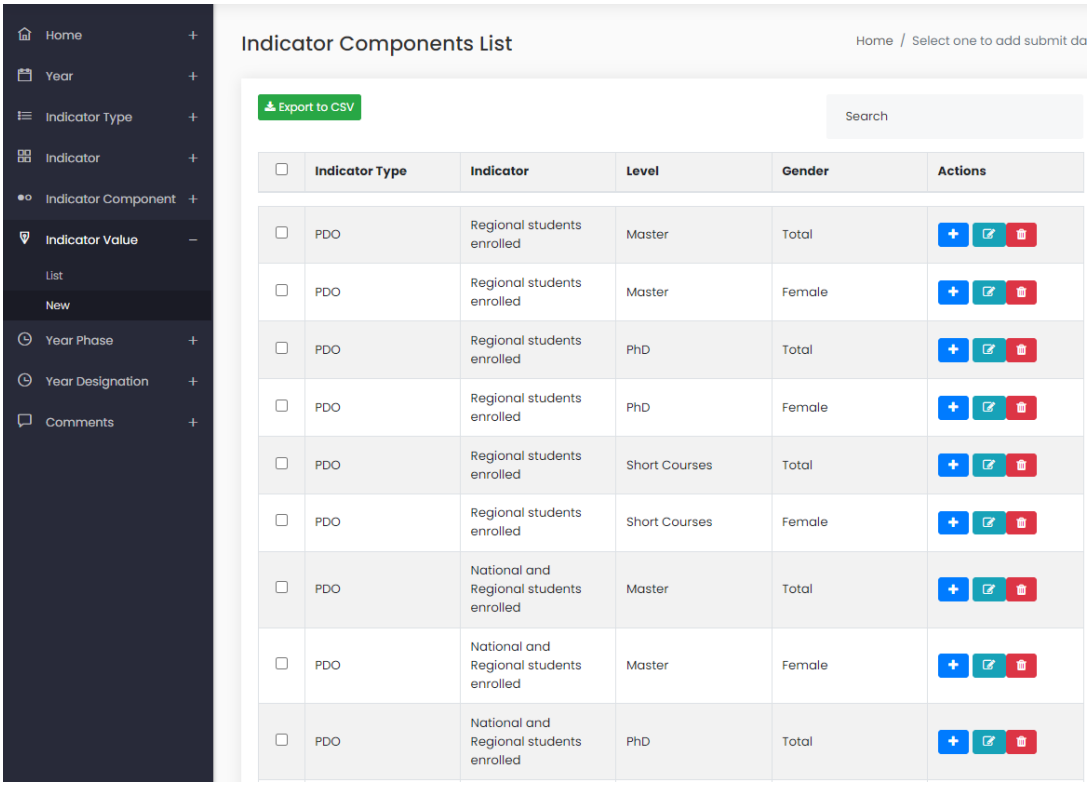


Figure 24: Indicator components list page

The + symbol once clicked leads to a page where data is entered as shown in Fig. 25 where the user can enter the required data values.

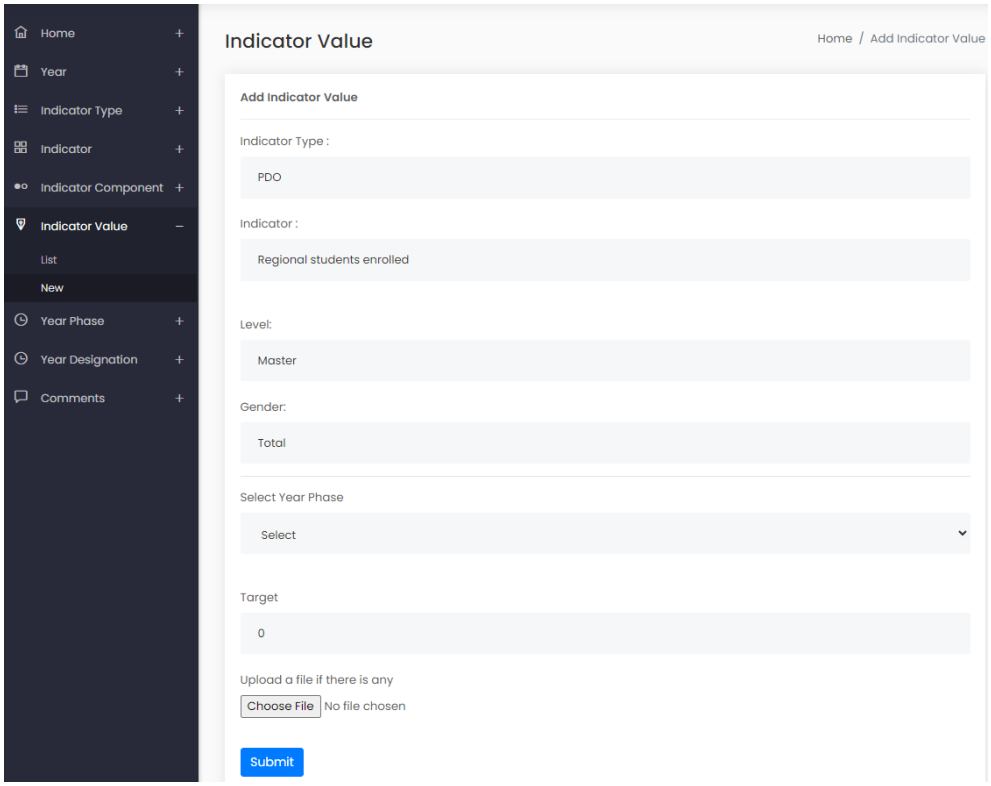


Figure 25: Data input interface

4.3.7 The IUCEA Users' Interface

The interface for IUCEA users is made of a dashboard that reflects different project information that is vital for decision-making at this level and also a unique menu tailored specifically to suit the needs of users under this user group.

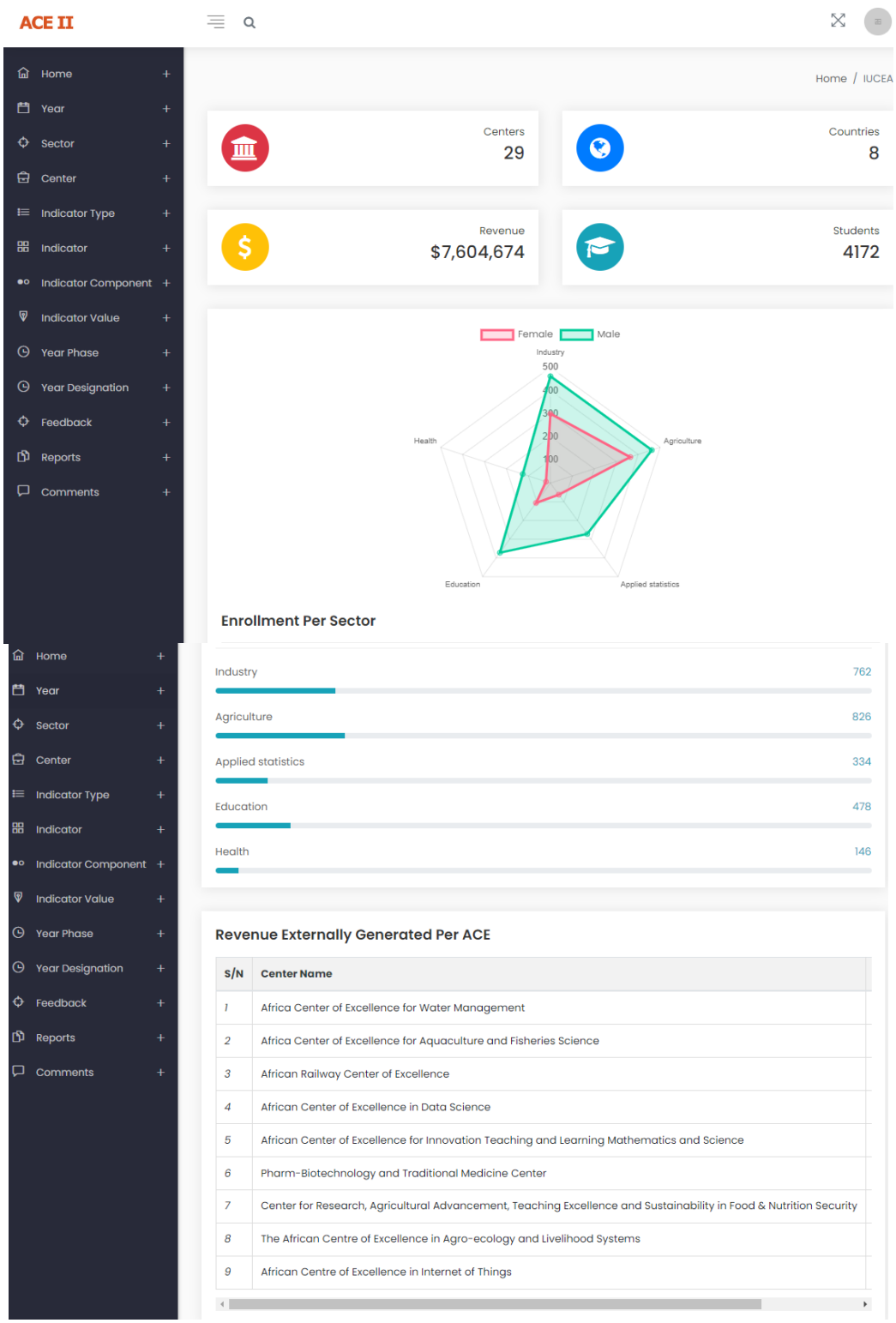


Figure 26: The IUCEA users' interface

4.3.8 The WBG Users' Interface

The interface for WBG users also contains dashboards that help this user make informed decisions from the data faster and has a menu designed for this particular user group as in Fig. 27.

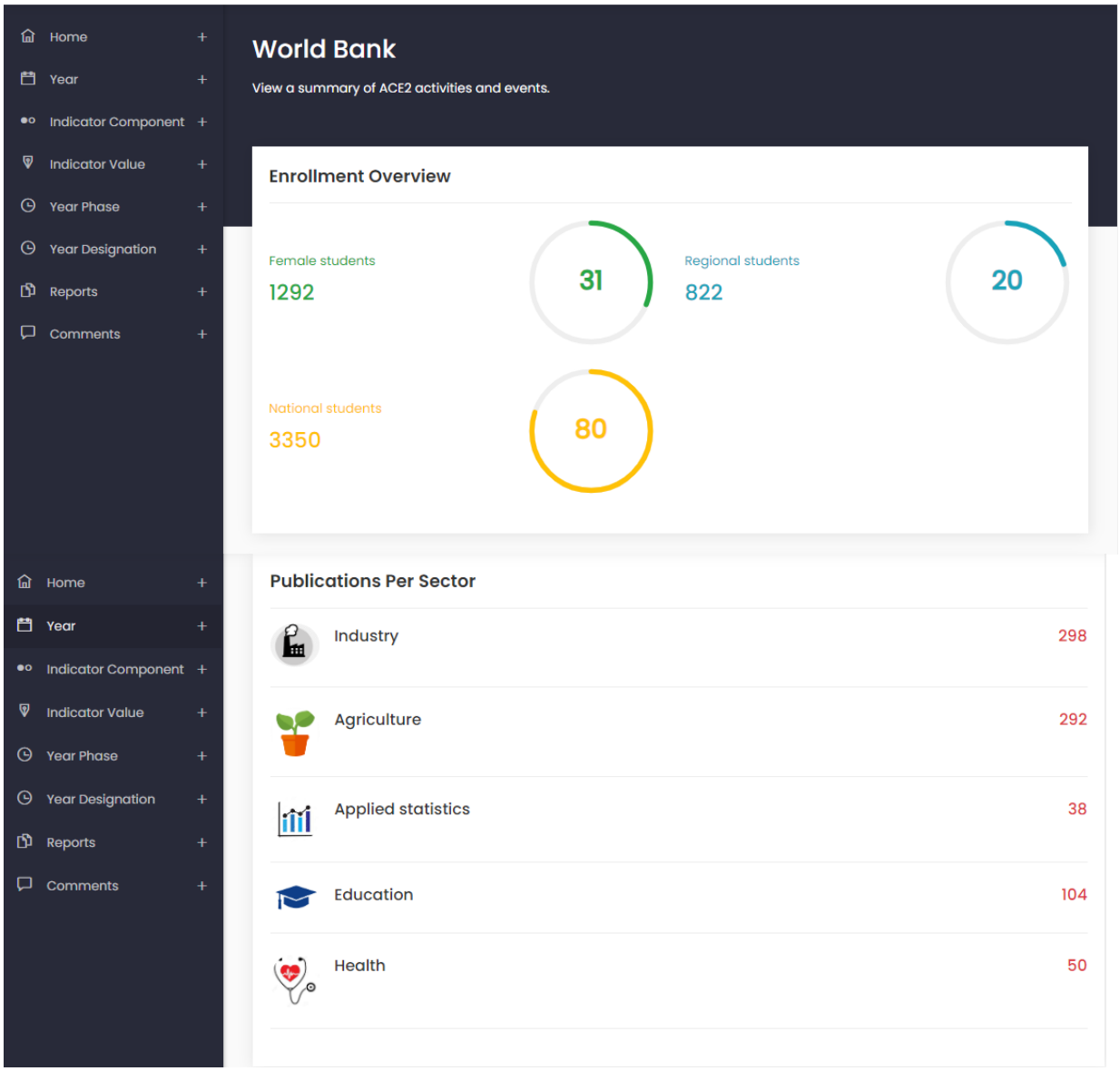
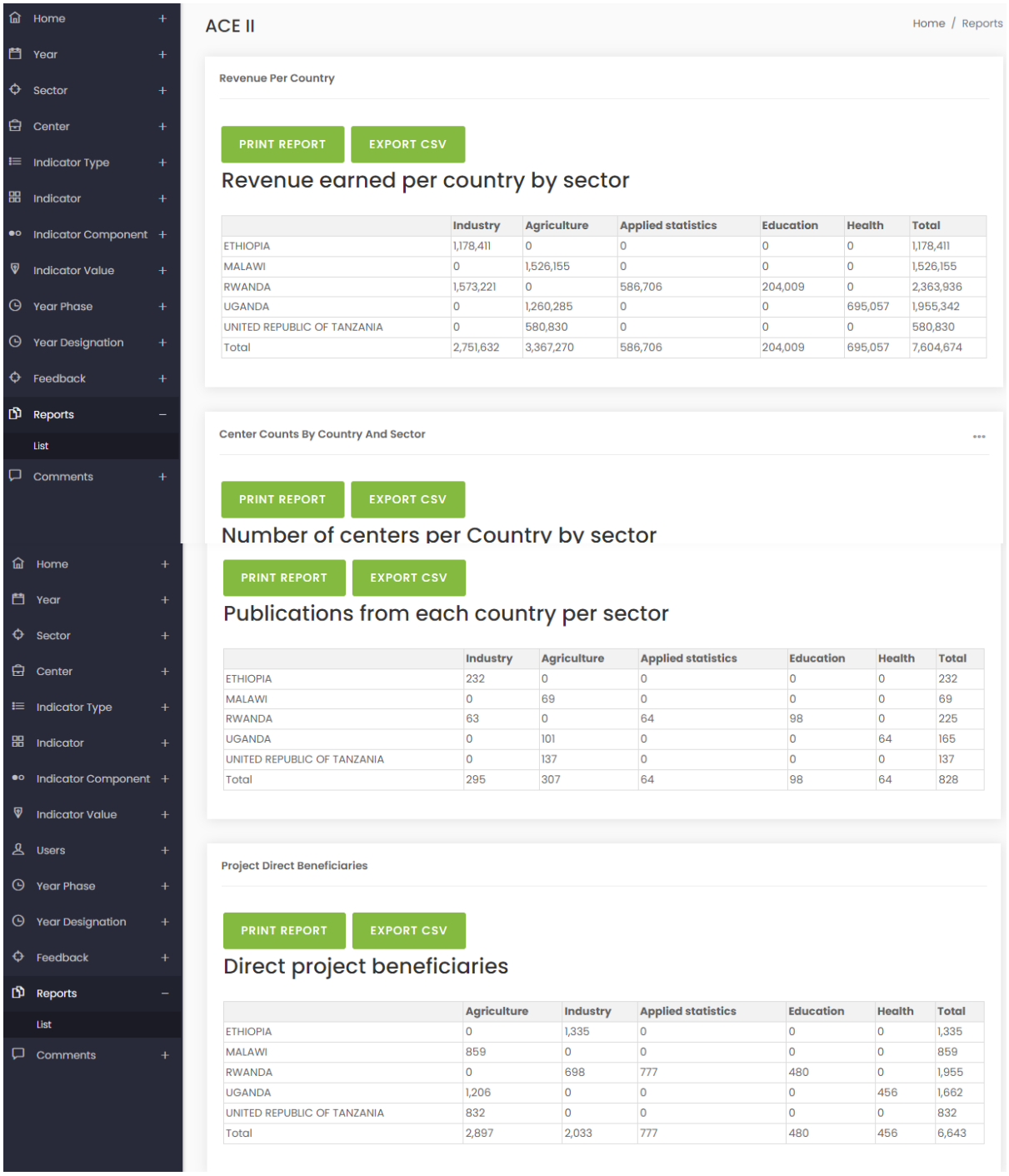


Figure 27: The WBG users' interface

4.3.9 Report Module

This page contains system-generated reports (Fig. 28). The reports are generated based on the needs of the users and they are data-driven. Any changes in the data stored in the database lead to changes in the reports and the feature allows for scalability. The reports can be exported in CSV format and later saved as Excel to allow for further manipulation by users. The system

also allows the printing of the report being by directly connected to the available printer as illustrated in Fig. 29.



	Industry	Agriculture	Applied statistics	Education	Health	Total
ETHIOPIA	1,178,411	0	0	0	0	1,178,411
MALAWI	0	1,526,155	0	0	0	1,526,155
RWANDA	1,573,221	0	586,706	204,009	0	2,363,936
UGANDA	0	1,260,285	0	0	695,057	1,955,342
UNITED REPUBLIC OF TANZANIA	0	580,830	0	0	0	580,830
Total	2,751,632	3,367,270	586,706	204,009	695,057	7,604,674

	Industry	Agriculture	Applied statistics	Education	Health	Total
ETHIOPIA	232	0	0	0	0	232
MALAWI	0	69	0	0	0	69
RWANDA	63	0	64	98	0	225
UGANDA	0	101	0	0	64	165
UNITED REPUBLIC OF TANZANIA	0	137	0	0	0	137
Total	295	307	64	98	64	828

	Agriculture	Industry	Applied statistics	Education	Health	Total
ETHIOPIA	0	1,335	0	0	0	1,335
MALAWI	859	0	0	0	0	859
RWANDA	0	698	777	480	0	1,955
UGANDA	1,206	0	0	0	456	1,662
UNITED REPUBLIC OF TANZANIA	832	0	0	0	0	832
Total	2,897	2,033	777	480	456	6,643

Figure 28: System reports' interface

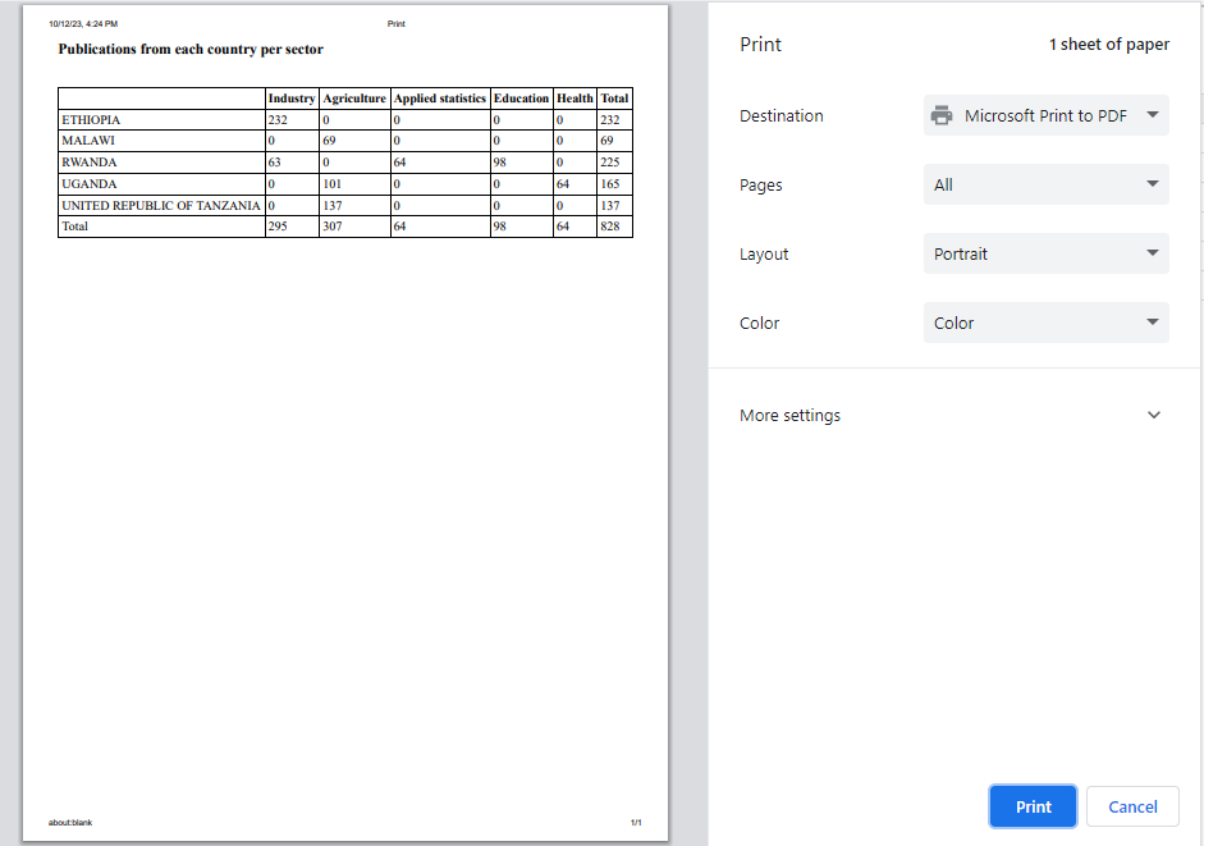


Figure 29: Interface for printing system reports

4.3.10 Feedback Module

A non-registered user can make an inquiry or submit feedback in the system by clicking on the Feedback button on the landing page. This functionality does not require the users to be registered in the system in order to access this service. The interface is shown in Fig. 30.

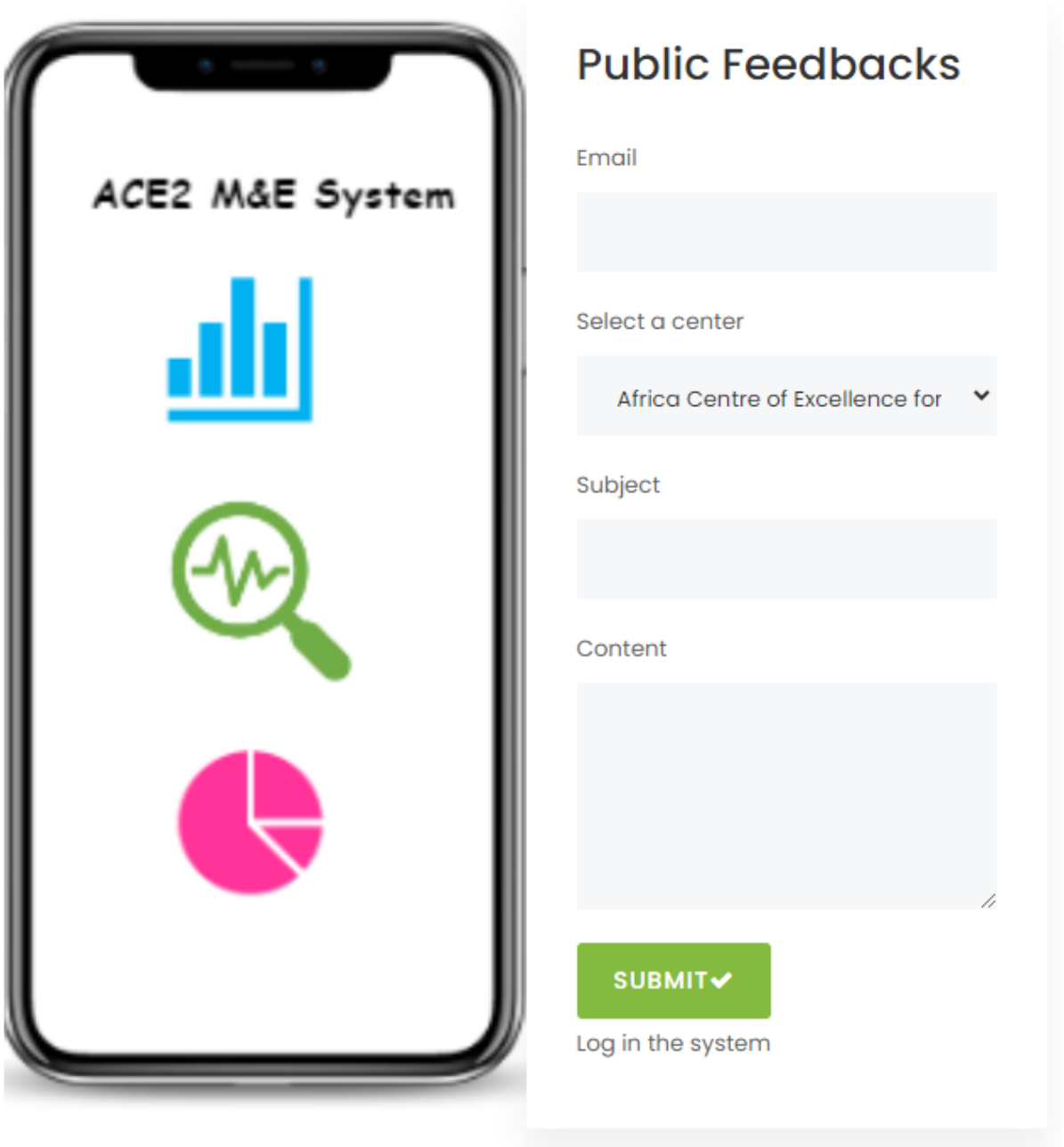


Figure 30: Public Feedback logging interface

The logged feedback is visible to the IUCEA user group (Fig. 31) as they are the administrators of the project.

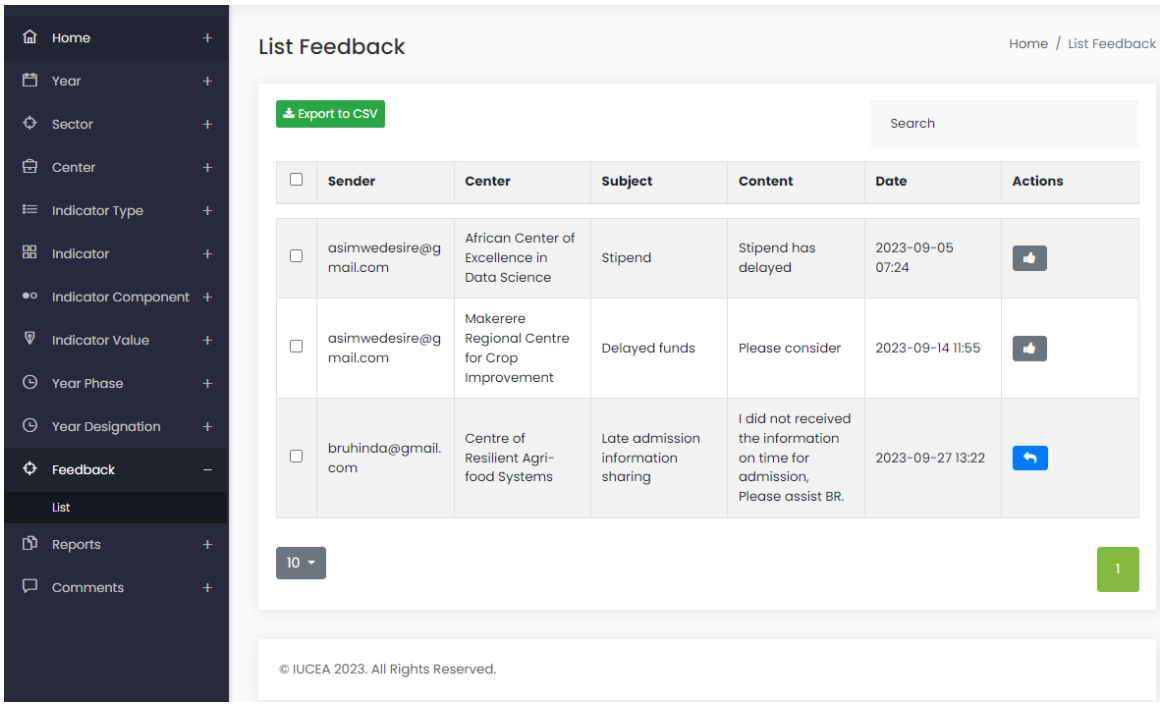


Figure 31: Submitted feedback list

To respond to the feedback, a designated user from IUCEA clicks on the respond icon to get to the response interface in Fig. 32 and can respond.

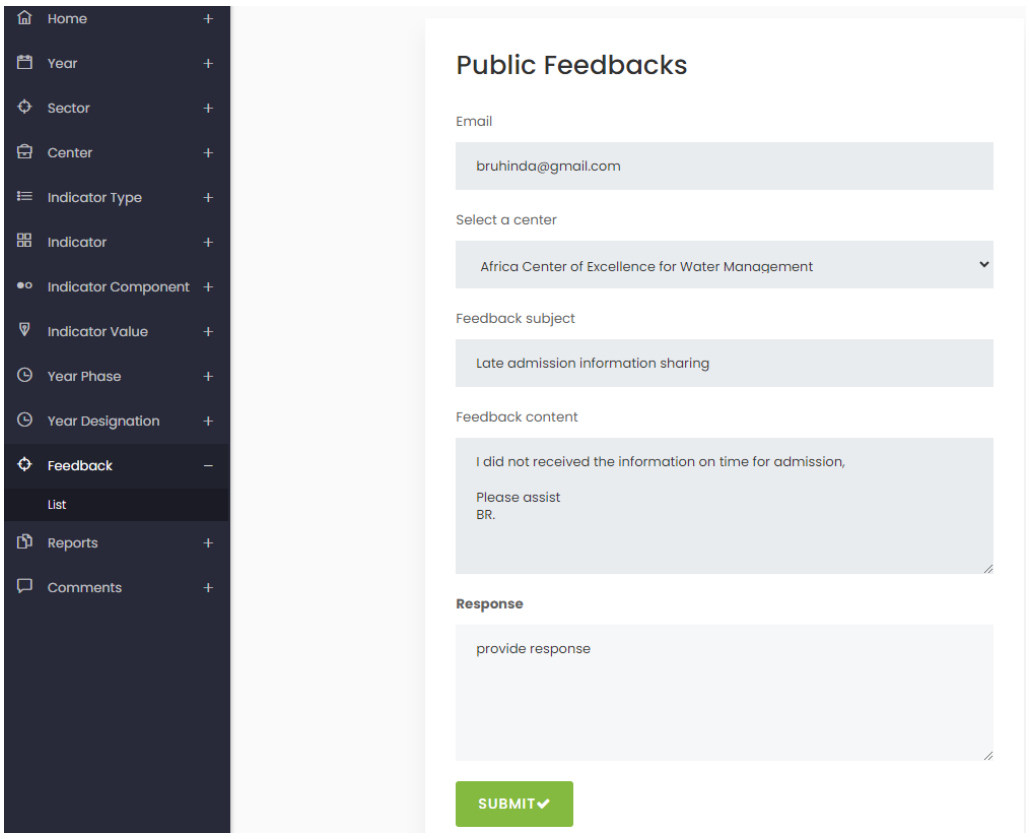


Figure 32: Interface for responding to the logged feedback

The user who submitted the query will be able to receive a response through the email they provided at the time of logging their inquiry/feedback.

4.3.11 Comments Module

This module caters to internal communication amongst the stakeholders within the project. A user from an Africa center of excellence is able to communicate with user under IUCEA and WBG user groups. Figure 33 shows the interface of sending a message.

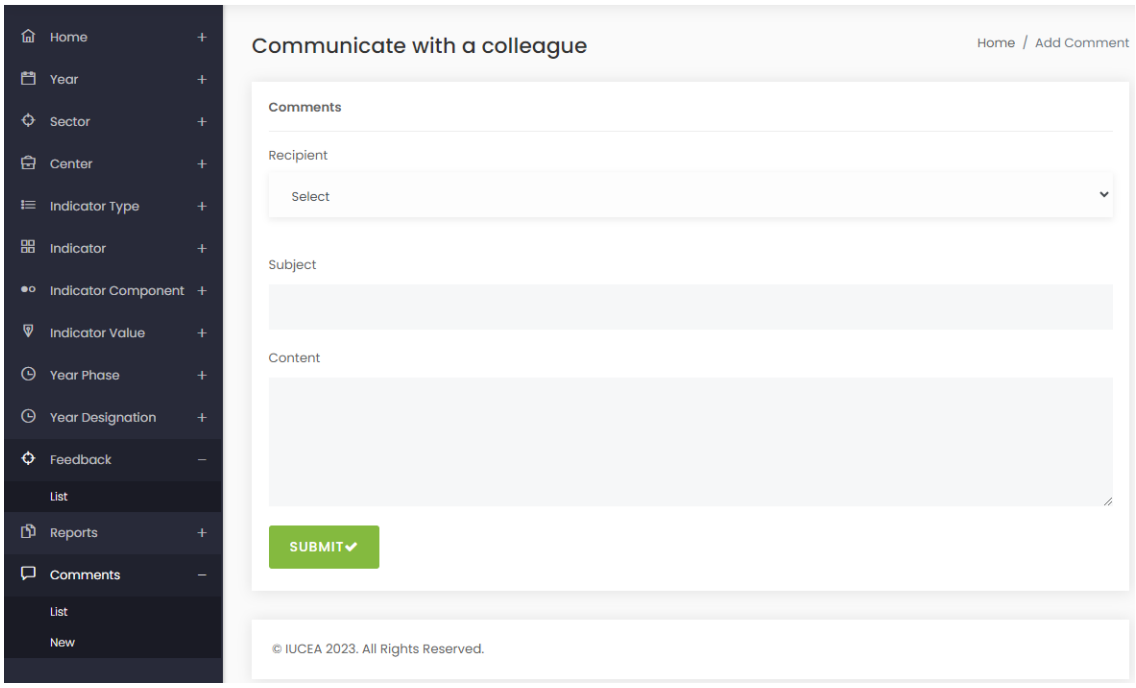


Figure 33: Interface for submitting a message internally

Figure 34 shows the view of several communication trails.

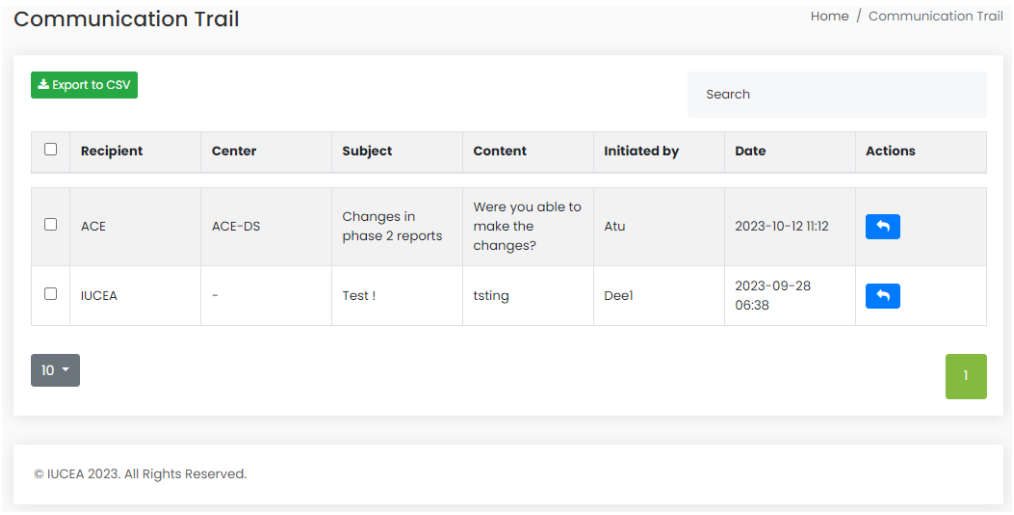


Figure 34: View of a user's communication trail

The dialogue is tracked in form of a trail as shown in Fig. 35

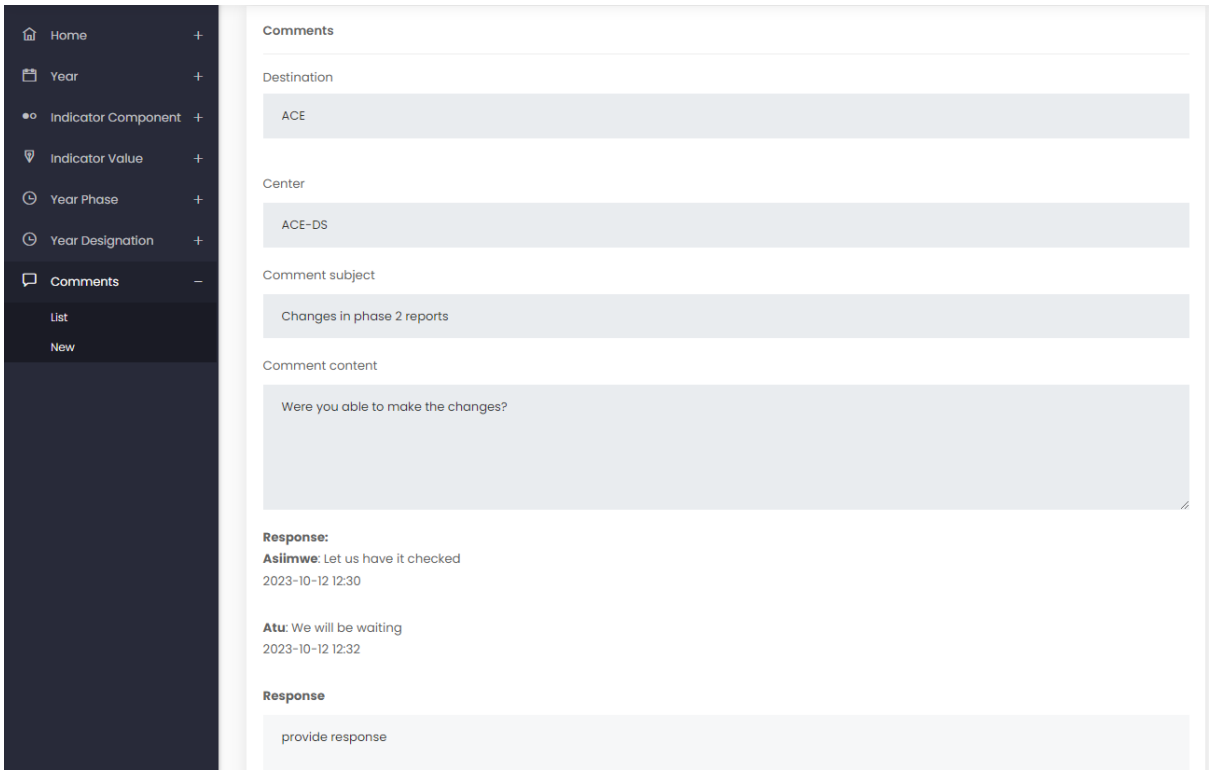


Figure 35: View of a tracked ongoing communication

4.4 System Testing Result

The system underwent three types of tests including unit tests, integration tests, and UI/ system tests. Unit testing was performed using the functional requirements as the baseline and it went on throughout the development process as each module was implemented. The tests confirmed that each component of the system gives a practical output. The tests also helped to access the functionality of the different components of the system. Integration testing confirmed that the different components work together well in combination. User Interface testing confirmed that users were able to use the system without any difficulties. Table 5 displays the details and results from unit tests.

Table 5: Unit testing results

Function	Test Description		Result
Account Registration	(i)	Admin can register users.	Pass
	(ii)	Registered users receive an email to reset their password.	Pass
	(iii)	The app displays relevant error notifications when incorrect credentials are entered.	Pass
Account Login and Logout	(i)	Users can log in after registration.	Pass
	(ii)	The system denies user login when details are incorrect and unregistered users	Pass
	(iii)	Users can successfully log out of their accounts	Pass
User password reset	Users receive an email with a link to reset their password reset successfully		Pass
Data input	(i)	User can enter using the system interface.	Pass
	(ii)	The input data can be found in the database.	Pass
Dashboards	(i)	The dashboards reflect correct data from the database.	Pass
	(ii)	Users are able to understand data represented by different visualizations.	Pass
Reports	(i)	The reports reflect correct data from the database.	Pass
	(ii)	Users can export and print out reports	pass
Feedback	(i)	Both registered and non-registered users can log their concerns in the system	Pass
	(ii)	Logged feedback can be responded to	Pass
	(iii)	The logger can receive a response to the concern logged via email.	Pass
Communication among the users	Different user groups to communicate with each other.		Pass
Search	User is able to search for specific information on each page.		Pass

4.5 System Validation Results

4.5.1 System Validation Overview

User Acceptance testing was carried out to validate the system functionality against the user requirements that were initially collected. The system was deployed on the IUCEA network and users were trained on how to use the system. A total of 15 people from ACE II and the

IUCEA ICT Unit interacted with the system. The users were requested to fill in an online questionnaire in Appendix 4 to share their user experience with the system.

4.5.2 System Validation Results Analysis

The summary of the responses given by the respondents in the system validation survey is presented in Fig. 36. As shown in Fig. 36, 60% the total respondents strongly agreed that the developed ACE II insight hub is easy to navigate and use while 40% of the respondents simply agreed.

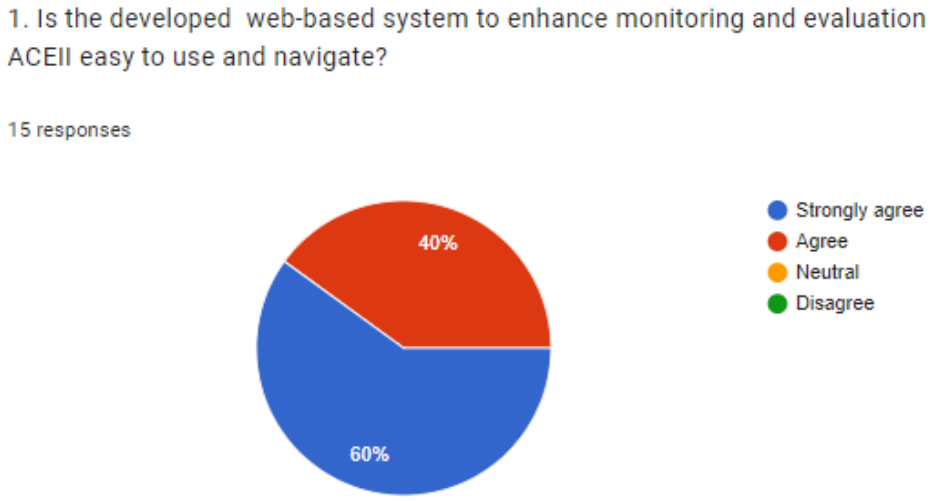


Figure 36: Results of whether the system is easy to use and navigate

Eighty percent (80%) of respondents strongly expressed that the system meets their needs and requirements, while 20% of them agreed that the system meets their requirements (Fig. 37).

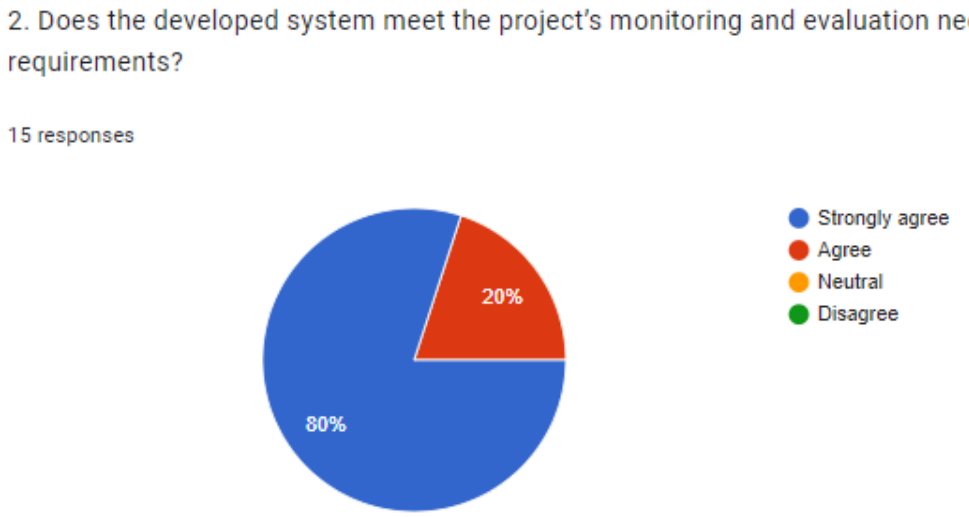


Figure 37: Results of whether the system meets the user requirements

Fifty-three and three cents (53.3%) of the respondents strongly agreed that the system is intuitive, 40% agreed, while 6.7% expressed neutrality about the system's intuitiveness (Fig. 38).

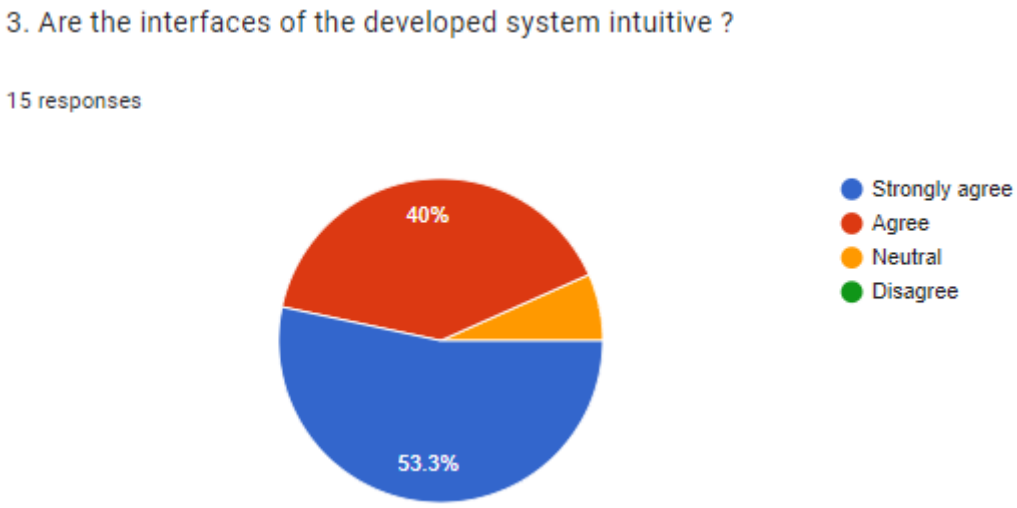


Figure 38: Results of whether the developed system is intuitive

In terms of system speed, 66.7% the respondents agreed the developed system responds as desired and 33.3% strongly agreed that the system performs at a desired speed (Fig. 39).

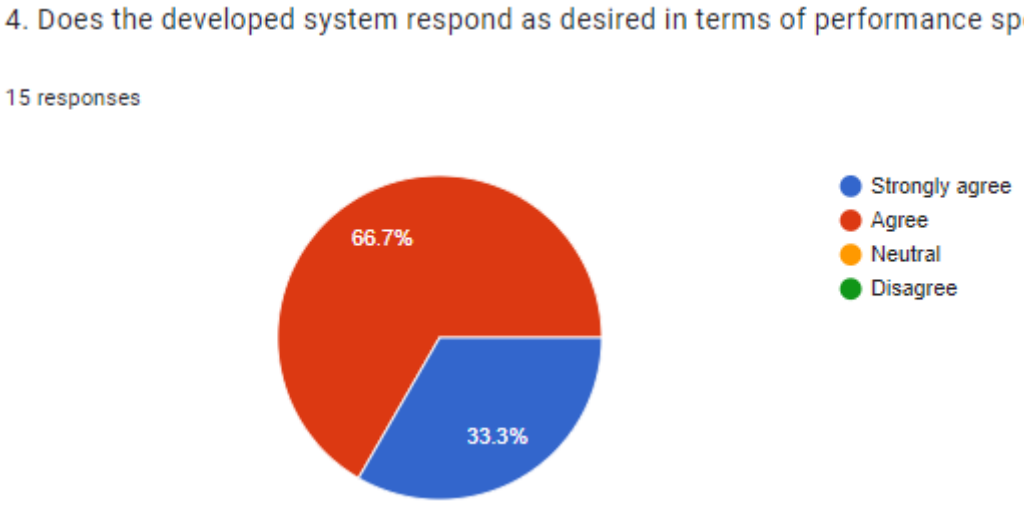


Figure 39: Results of system speed performance

Ninety-three and three cents (93.3%) of the respondents strongly agreed that they can relate to the content of the system and that it is easy to understand, while 6.7% simply agreed that they can relate to the content of the system and understand it (Fig. 40).

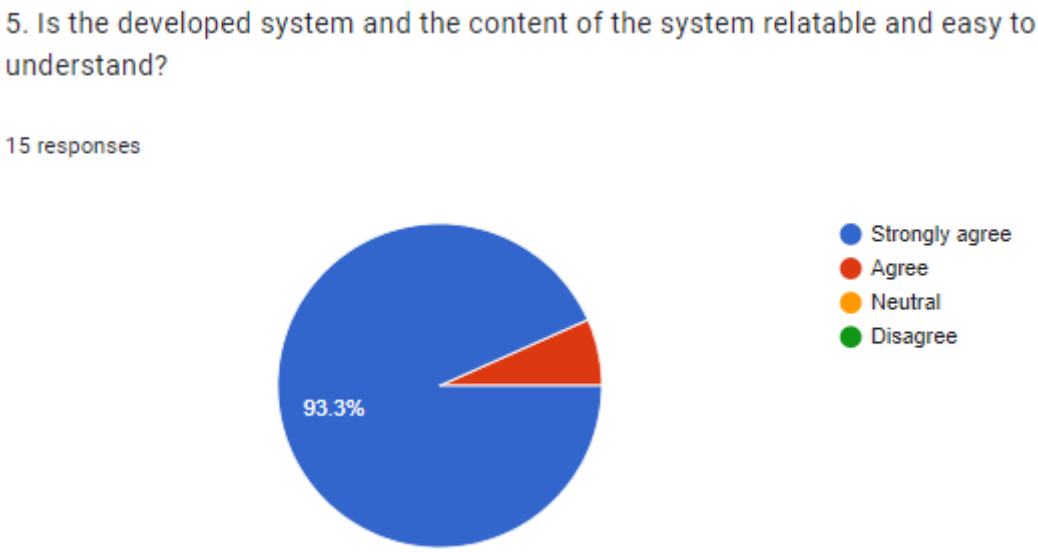


Figure 40: Results of whether system's content is easy to understand and users can relate to it

All 15 respondents unanimously agreed that they would recommend the system to be used in the monitoring and evaluation of other projects in East Africa (Fig. 41).

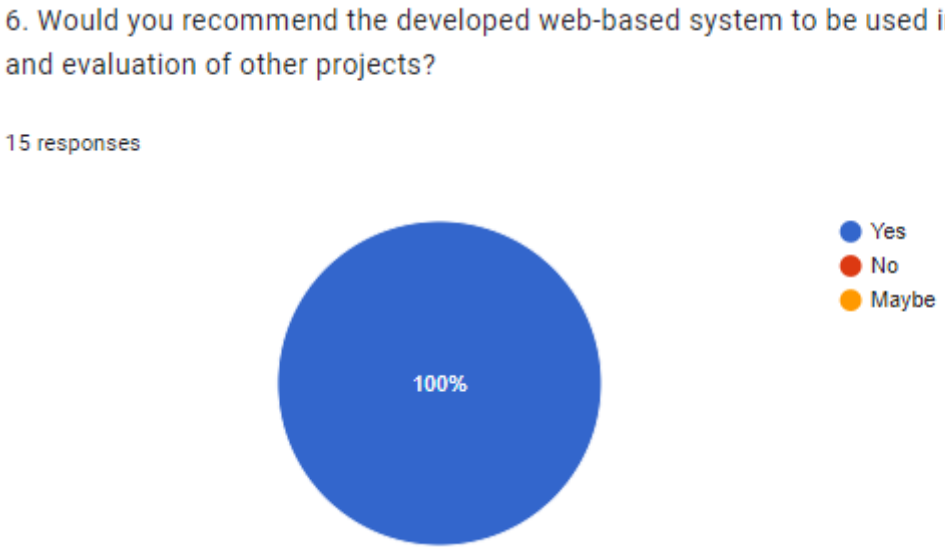


Figure 41: Results of if the respondents would recommend the developed system to be used in other M&E projects

4.6 Discussion

Although effective completion of a project is vital to consumers, it is important to consider the factors that affect project implementation processes. Thus, the recurrent practice of monitoring and evaluation is crucial in ensuring that projects are accomplished with high success rate (Kissi *et al.,* 2019). Based on the findings of the study, most respondents

revealed that data collection and storage at centers were done using MS Excel sheets and on Word documents. This disintegration made data analysis at the RFU level tedious and time-consuming thus limiting and delaying the development of decisions.

The other findings from interviews and survey questionnaires revealed that ACE II project stakeholder engagement and communication are important in the monitoring and evaluation of projects. This finding correlate with the study by Kiconco and Mulyungi (2018) which found that stakeholder involvement in the project influences the effectiveness of the project's monitoring and evaluation and has an impact on the general success of the project.

According to Kissi *et al.* (2019), in today's era projects that are not properly monitored and evaluated run at a high risk of failure. A study by Mleke and Dida (2020) suggested that organizations that use M&E systems to monitor the advancement of projects achieve enhanced productivity and effectiveness. Based on these findings, the developed ACE II Insight Hub can play an essential role in the monitoring and evaluation of ACE II project and in turn lead to enhanced productivity and efficiency if the project.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study found that numerous systems exist to address individual aspects of monitoring and evaluation, but none holistically encompasses the functionalities of data processing, visualization, dashboard creation, report generation, feedback and grievance capturing as well as stakeholder engagements in a single, cohesive solution. This project focused on developing a Web-based system to enhance the monitoring and evaluation of higher education centers of excellence in Africa, a case of Eastern and Southern African higher education centers of excellence project (ACE II). Quantitative and qualitative research methods were used in data collection, survey questionnaires, and structured interviews. The purposive sampling technique was utilized in data collection and requirements gathering. Extreme programming was used in system development. ReactJS was used in system coding and MySQL was used for database management. The project's output is the ACE II Insight Hub, the developed web-based system.

The developed web-based system will significantly enhance the monitoring and evaluation processes leading to more effective and efficient management of higher education centers of excellence in Africa. This system will support continuous improvement and ensure the long-term success of the World Bank's initiative to reinforce the longer-term capacity and train Africans who can study science and technology and apply it to provide solutions to Africa's problems.

5.2 Recommendations

5.2.1 Implications to the Policy Makers

Legislators especially in the EAC should advocate for the implementation of the system developed in monitoring and evaluation of education projects within the region. The IUCEA-RFU, being an organ of the EAC should advocate that the ACE II insight hub is adopted and improved for use to monitor and evaluate all the education-related projects within the East African countries. The implementation and use of the developed system are the first steps in the right direction toward effective handling of data in the education sector in the region.

5.2.2 Implication to the Practitioners

The ACE II implementers in project monitoring and evaluation should use the developed system. Although there are other tools for monitoring and evaluation of different projects on the market, the ACE II insight hub provides considerably higher benefits and value in terms of reliability and ease of use. It was tailor developed with the specific needs of the users in mind thus offering services that meet the monitoring and evaluation needs of the users. Furthermore, the system being developed and hosted in-house guarantees a certain level of data security in terms of confidentiality, integrity, and authorization.

The management of IUCEA should allocate resources towards training the users on how to use the system so that it is fully utilized and that they can reap the benefits of using the developed system while monitoring and evaluating ACE II projects.

5.2.3 Future Work

In the future, machine learning models should be incorporated into the system to enable prediction and forecasting of the project results for example; total external revenue from a given ACE after a certain period, number of students that will be enrolled at the ACEs at a certain time in the future among other monitored indicators of the ACE II project.

A multi-factor authentication mechanism should be incorporated to further enhance the security of the system.

This project focused on the Eastern and Southern Africa Higher Education Centers of Excellence project (ACE II). The developed system should be adopted to accommodate the specific needs of other Africa Higher Education Centers of Excellence projects.

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APPENDICES

Appendix 1: List of all Eastern and Southern Africa Higher Education Centers of Excellence in ACE II

S/N	Africa Center of Excellence (ACE)	ACE Acronym	Sector	Country
1	Africa Center of Excellence for Water Management	ACEWM	Industry	Ethiopia
2	African Railway Center of Excellence	ARCE	Industry	Ethiopia
3	Center for Innovative Drug Development and Therapeutic Trials for Africa	CDT-Africa	Health	Ethiopia
4	African Center of Excellence Climate Smart Agriculture and Biodiversity Conservation.	Climate SABC	Agriculture	Ethiopia
5	Center of Excellence in Sustainable Agriculture and Agribusiness Management	CESAAM	Agriculture	Kenya
6	African Center of Excellence in Sustainable Use of Insects as Foods and Feeds	INSEFOODS	Agriculture	Kenya
7	Center of Excellence for Phytochemicals, Textile and Renewable Energy	PTRE	Industry	Kenya
8	Africa Center of Excellence for Aquaculture and Fisheries Science	AquaFish	Agriculture	Malawi
9	Center of Excellence in Transformative Agriculture Commercialization and Entrepreneurship	TACE	Agriculture	Malawi
10	Agricultural Policy Regional Centre of Excellence	APRCE	Agriculture	Malawi

S/N	Africa Center of Excellence (ACE)	ACE Acronym	Sector	Country
11	Africa Centre of Excellence in Public Health and Herbal Medicine	ACEPHEM	Health	Malawi
12	Centre of Resilient Agri-food Systems	CRAFs	Agriculture	Malawi
13	African Centre of Excellence in Underutilized and Neglected Biodiversity	ACENUB	Agriculture	Malawi
14	Center of Studies in Engineering and Technology of Oil and Gas	CS-OGET	Industry	Mozambique
15	Centre of Excellence in Agri-Food Systems and Nutrition	CEAFSN	Agriculture	Mozambique
16	African center of Excellence in Data Science	ACE-DS	Statistics	Rwanda
17	African Centre of Excellence in Energy for Sustainable Development	ACE-ESD	Industry	Rwanda
18	African Centre of Excellence in Internet of Things	ACEIoT	Industry	Rwanda
19	African Center of Excellence for Teaching and Learning Mathematics and Science	ACEITLMS	Education	Rwanda
20	African Centre of Excellence for Innovative Rodent Pest Management and Bio-sensor Technology Development	IRPM&BTD	Agriculture	Tanzania
21	Southern Africa Center for Infectious Disease Surveillance	SACIDS	Health	Tanzania
22	Center for Research, Agricultural Advancement, Teaching Excellence and Sustainability in Food & Nutrition Security	CREATES-FN	Agriculture	Tanzania
23	Water Infrastructure and Sustainable Energy	WISE FUTURES	Industry	Tanzania

S/N	Africa Center of Excellence (ACE)	ACE Acronym	Sector	Country
24	African Centre for Agroecology & Livelihood Systems	ACALISE	Agriculture	Uganda
25	Africa Centre of Excellence Materials, Product Development and Nanotechnology	MAPRONANO	Industry	Uganda
26	Makerere Regional Centre for Crop Improvement	MaRCCI	Agriculture	Uganda
27	Pharm-Biotechnology and Traditional Medicine Center	PHARMBIOTRAC	Health	Uganda
28	Africa Center of Excellence for Infectious Diseases of Humans and Animals	ACEIDHA	Health	Zambia
29	Africa Centre of Excellence for Sustainable Mining	ACESM	Industry	Zambia

Appendix 2: Interview Guide for Data Collection

DEVELOPMENT OF A WEB-BASED SYSTEM TO ENHANCE MONITORING AND EVALUATION OF HIGHER EDUCATION CENTERS OF EXCELLENCE IN AFRICA

Interview guide

Section A: Opening Questions

1. What are your main responsibilities in running the ACE II?

Section B: Key Questions

2. How is data collected from Centers to the Regional Facilitation Unit, IUCEA?

3. How is the data being stored?

4. Do you ever use the data to make presentations or for decision-making? If yes, in what format is it easier for you to manipulate?

5. How often do the centers have to report to IUCEA per year?

6. How do students at different centers and other people give feedback concerning the ACE II?

Section C: Concluding Questions

7. Do you think a web-based system will be beneficial in enhancing the monitoring and evaluation of ACE II in terms of, data collection, storage, reporting, and decision-making?

8. What features would you want to be considered in the development of the proposed web-based system to enhance monitoring and evaluation of ACE II?

Appendix 3: Survey Questionnaire for Data Collection

DEVELOPMENT OF A WEB-BASED SYSTEM TO ENHANCE MONITORING AND EVALUATION OF HIGHER EDUCATION CENTERS OF EXCELLENCE IN AFRICA

Survey Questionnaire

Dear Participant,

I am a final year master's student at The Nelson Mandela African Institution of Science and Technology, Arusha- Tanzania and I invite you to participate in this survey. The aim of this survey is to collect reliable information that will be used to develop a web-based system to enhance monitoring and evaluation of Higher Education centers of excellence in Africa.

You have been identified as a key participant in this survey because of your role and responsibility in ACE II Project. The survey will take about 3-5 minutes of your time and participation is voluntary. Your responses will be kept confidential and only be used for this project. The findings of this study will be published in an academic journal.

If you have any queries with regards to this project, please contact the researcher: Desire Asiimwe via email: asiimwed@nm-aist.ac.tz / dasiimwe@iucea.org , Mobile Phone number +256 775 896 589. Thank you for your valuable time and participation!

Consent:

By clicking yes, you consent that you are willing to answer the questions in this survey.

☐ Yes

☐ No

SECTION A: Demographic Data

1. Gender

☐ Female

☐ Male

2. Age group

☐ Between 18 -25

☐ Between 26 -35

☐ Between 36 -45

☐ Between 46 -55

☐ Between 56 – Above

3. What best classifies your engagement in ACE II?

☐ World Bank Group Staff

☐ IUCEA Staff

☐ ACE Staff

☐ Student

SECTION B

To develop a web-based monitoring and evaluation system for ACE II.

4. Are you aware if data is collected for purposes of monitoring and evaluation of ACE II?

☐ Yes

☐ No

5. If yes, how is the data collected?

☐ As Word documents

☐ As Excel files

☐ Using a centralized system

☐ Other

☐ Not aware

6. How often do Centers submit data for monitoring and evaluation purposes to IUCEA- RFU?

☐ Once a year

☐ Twice a year

☐ Whenever need arises

☐ Not sure

7. In which format is data easy for you to analyze and understand?

☐ Graphs

☐ Dashboard

☐ Simple excel reports

☐ Other

8. How does communication occur among ACE II stakeholders?

☐ Using emails

☐ Using a system

☐ Other

9. Is there a centralized feedback and grievances collection mechanism for ACE II?

☐ Yes

☐ No

Appendix 4: System Validation Questionnaire

DEVELOPMENT OF A WEB-BASED SYSTEM TO ENHANCE MONITORING AND EVALUATION OF HIGHER EDUCATION CENTERS OF EXCELLENCE IN AFRICA

System validation form

This form is meant for validation of the developed web-based system to enhance monitoring and evaluation higher education centers of excellence in Africa.

1. Is the developed web-based system to enhance monitoring and evaluation of ACEII easy to use and navigate? *

- ○ Strongly agree
- ○ Agree
- ○ Neutral
- ○ Disagree

2. Does the developed system meet the project's monitoring and evaluation needs and requirements? *

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree

3. Are the interfaces of the developed system intuitive ? *

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree

4. Does the developed system respond as desired in terms of performance speed? *

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree

5. Is the developed system and the content of the system relatable and easy to understand? *

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree

6. Would you recommend the developed web-based system to be used in monitoring and evaluation of other projects? *

- ◯ Yes
- ◯ No
- ◯ Maybe

Submit Clear form

Appendix 5: ReactJs Code for the Developed System

Code for logging in

```
class Login extends React.Component {
  constructor(props) {
    super(props);
    this.state = {
      email: "",
      loginPassword: "",
      error: null,
      showPassword: false,
    };
    this.validators = validators;
    this.onchange = this.onchange.bind(this);
    this.login = this.login.bind(this);

    this.displayValidationErrors = this.displayValidationErrors.bind(thi
    this.updateValidators = this.updateValidators.bind(this);
  }
  onchange(event) {
    this.setState({
      [event.target.name]: event.target.value,
    });
    this.updateValidators([event.target.name], event.target.value);
  }
  updateValidators(fieldName, value) {
    this.validators[fieldName].errors = [];
    this.validators[fieldName].state = value;
    this.validators[fieldName].valid = true;
    this.validators[fieldName].rules.forEach((rule) => {
      if (rule.test instanceof RegExp) {
        if (!rule.test.test(value)) {
          this.validators[fieldName].errors.push(rule.message);
          this.validators[fieldName].valid = false;
        }
      } else if (typeof rule.test === "function") {
        if (!rule.test(value)) {
          this.validators[fieldName].errors.push(rule.message);
          this.validators[fieldName].valid = false;
        }
      }
    });
  }
```

```
isFormValid() {
  let status = true;
  Object.keys(this.validators).forEach((field) => {
    if (field == "email" || field == "loginPassword") {
      if (!this.validators[field].valid) {
        status = false;
      }
    }
  });
  return status;
}

toggleShowPassword = () => {
  this.setState((prevState) => ({
    showPassword: !prevState.showPassword,
  }));
};

displayValidationErrors(fieldName) {
  const validator = this.validators[fieldName];
  const result = "";
  if (validator && !validator.valid) {
    const errors = validator.errors.map((info, index) => {
      return (
        <span className="error" key={index}>
          * {info}
          <br />
        </span>
      );
    });
    return <div className="col s12 row">{errors}</div>;
  }
  return result;
}

navigateToHome() {
  const { history } = this.props;
  history.push("/alerts");
}
login(event) {
  const { history } = this.props;
  const { email, loginPassword } = this.state;
  User.connectYou(email, loginPassword)
    .then((response) => {
      // console.log("data here",localStorage.getItem("centerName"));
      let connectInfo = JSON.parse(localStorage.getItem("connectedUser"));
      // console.log(' history Login',history)
      if (connectInfo.is_superuser) {
```

```
login(event) {
  const { history } = this.props;
  const { email, loginPassword } = this.state;
  User.connectYou(email, loginPassword)
    .then((response) => {
      // console.log("data here",localStorage.getItem("centerName"));
      let connectInfo = JSON.parse(localStorage.getItem("connectedUser"));
      // console.log(' history Login',history)
      if (connectInfo.is_superuser) {
        localStorage.setItem("homeUser", "/dashboard1");
        history.push("/dashboard1");
        // window.location.href = "/";
      } else if (Number(connectInfo.group) === 2) {
        localStorage.setItem("homeUser", "/dashboard2");
        history.push("/dashboard2");
        // window.location.href = "/dashboard2";
      } else if (Number(connectInfo.group) === 1) {
        //  history.push("/");
        localStorage.setItem("homeUser", "/dashboard1");
        history.push("/dashboard1");
        // window.location.href = "/dashboard1";
      } else if (Number(connectInfo.group) === 3) {
        localStorage.setItem("homeUser", "/dashboard3");
        history.push("/dashboard3");
        // window.location.href = "#/dashboard3";
      }
    })
    .catch((error) => {
      alert("Invalid login id or password.");
      localStorage.setItem("access", "");
      localStorage.setItem("connectedUser", "");
    });
}
render() {
  const { email, loginPassword, showPassword } = this.state;
  return (
    <section
      className="height-100vh d-flex align-items-center page-section-ptb login"
      style={{ backgroundImage: "" }}
    >
```

```
  <div className="login-fancy">
    <h2 className="text-white mb-20"> ACE2 M&E </h2>
    <p className="mb-20 text-white">
      "Supporting delivery of quality post-graduate education and
      building collaborative research capacity in the EAC regional
      priority areas"
    </p>
    <ul className="list-unstyled  pos-bot pb-30">
      <li className="list-inline-item">
        <a className="text-white" href="#">
          {" "}
          © IUCEA 2023
        </a>{" "}
      </li>
      <li className="list-inline-item">
        <a className="text-white" href="#">
          {" "}
          All Rights Reserved
        </a>
      </li>
    </ul>
  </div>
</Col>
<Col lg={4} md={6} className="bg-white">
  <div className="login-fancy pb-40 clearfix">
    {/* <h3 className="mb-30">Welcome</h3> */}
    <div className="section-field mb-20">
      <label className="mb-10" htmlFor="name">
        Email{" "}
      </label>
      <input
        id="email"
        className="web form-control"
        type="text"
        // placeholder="Email"
        value={this.state.email}
        name="email"
        onChange={this.onchange}
      />
      {this.displayValidationErrors("email")}
    </div>
    <div className="section-field mb-20">
      <label className="mb-10" htmlFor="loginPassword">
        Password{" "}
      </label>
      <input
        id="loginPassword"
        className="Password form-control"
```