Design and Implementation of a Secure Web-Based Knowledge Repository System for Ministry of Communication and Information Technology

Alemayehu Belay Kassa
Morgan State University

Temtim Assefa
Addis Ababa University

Kevin Kornegay
Morgan State University

The Ministry of Communication and Information Technology (MCIT) of Ethiopia has a mission to develop, deploy, and utilize information and communication technology to promote the country's development. To meet this mission, it collaborates with various federal, regional, and international organizations to create and share knowledge. The Ministry collaborates with these organizations and scholars to undertake various research projects, IT initiatives, training programs, and workshops. However, the Ministry has a gap in systematically capturing, storing, sharing, and reusing the knowledge created through these activities. The purpose of this study is to identify the current knowledge management gap and propose a secure web-based knowledge repository system. The research employed questionnaires, interviews and observation methods to identify user requirements, and UML modeling tools were used to develop the prototype. When the proposed system is fully implemented, it will contribute to solving the existing knowledge management problems of the Ministry and enhance its innovation capability by improving its knowledge management capabilities. The proposed system will be implemented on the existing IT infrastructure of MCIT.

Keywords: knowledge management, knowledge management system, knowledge repository system

INTRODUCTION

Information technology is becoming ubiquitously available with different functionalities. These technologies enable the creation of new capabilities and easy access to existing knowledge. Organizations should create a system that systematically captures, stores, disseminates, and applies in value creation business activities. Knowledge Management (KM) implementation has become a crucial tool for governments in achieving their country's macro-goals. KM is an important means of leveraging existing knowledge to generate social, business, and economic benefits, as well as investments for a country's government (Permadi, H., & Sensuse, D. I, 2021). However, the practice of knowledge management did not get full recognition from both the government and private organizations. Knowledge is found scattered in different locations and is not easily accessible to users. It is also stored in various formats; therefore, it

is challenging to integrate and utilize in problem-solving activities. There is also no mechanism to motivate people to share their knowledge, as they are the primary knowledge creators and users (Desta, T. A, 2013).

The Ministry of Communication and Information Technology (MCIT) of Ethiopia collaborates with various federal, regional, and international organizations to implement various IT projects. In the 2016 budget year, the Ministry allocated 200 million Ethiopian birr to develop a project on standardization and regulation, telecom fraud management, frequency monitoring, and transactional services. Moreover, it allocates an annual budget for various IT research and training initiatives. The Ministry, by collaborating with various training institutions, provides training for regional and federal organizations to achieve its objectives. The number of trainees in each year varies based on the budget availability. In 2016, 9 million Ethiopian birrs were allocated to provide training for 784 professionals in the areas of Android application development, content management with Liferay, storage area network, wireless security, IT-based support staff training, telecommunication, and postal services. The goal of IT projects, IT research, and training is to promote knowledge acquisition and encourage innovation.

Knowledge is the most asset in the organization. It is a powerful resource that enables individuals and organizations to achieve several benefits, such as improved learning and decision-making (Al-Busaidi, K. A., et al., 2010). The ability to manage knowledge is becoming increasingly more crucial in the current knowledge economy. It requires the acquisition of the right technology, training people with KM skills, and putting in place core KM processes.

A technological solution that helps to manage knowledge is a knowledge management system (KMS). Knowledge management systems (KMSs) integrate technology-based systems and organizational practices that enable organizations to manage their knowledge and improve their performance (Zenouz, R. Y., et al., 2024). One of the components of KMS is the knowledge repository system. A knowledge management system (KMS) has been recognized as a knowledge repository for facilitating knowledge sharing, capturing, and institutionalization among organizational stakeholders, thereby maintaining a long-term competitive advantage and promoting sustainable development (Nupap, S., 2022). A knowledge repository system assists organizations in efficiently capturing, storing, sharing, and reusing their knowledge (Al-Busaidi, K. A., et al., 2010).

The essence of organizational knowledge resides in various aspects of an organization, including processes, products, culture, and systems. Managing this knowledge involves identifying, acquiring, developing, storing, sharing, and evaluating it (Bilal, M., et al., 2023). Knowledge is becoming the most important asset of modern organizations. The success of organizations depends on how they acquire, use, and leverage knowledge effectively (Alhawary, F. A., et al., 2011). Knowledge management is the process by which organizations create, capture, store, share, and reuse knowledge to achieve their organizational objectives (Boom, D., 2005). Additionally, knowledge management is the methods and tools for capturing, storing, organizing, and making accessible knowledge and expertise within and across organizations (Fernandez-Saez, A. M., et al., 2013). Effective knowledge management not only enhances an organization's performance but also provides it with a competitive advantage (Bilal, M., et al., 2023). The implementation of a knowledge management system has a positive relationship with knowledge innovation in the organization (Asalla, L. K., et al., 2023). In addition, Knowledge management plays a crucial role in helping companies overcome challenges and enhance their competitive strength (Putra, M. B., et al., 2024).

Nowadays, in Ethiopia, there are various governmental and private organizations with knowledgeable employees who work diligently to achieve the organization's success. They have accumulated tacit knowledge. Moreover, these organizations have accumulated explicit knowledge. The integration of explicit and tacit knowledge creates a powerful dynamic essential to the development and sustainability of organizations. This requires us to explicitly adopt KM principles and practices to systematically capture, store, and share knowledge among employees within the organization and outside the organization with clients and customers.

In Ethiopia, the knowledge management system is still in its early stages of development (Mekonnen, F., et al., 2012). MCIT is one of the governmental organizations that should have a secure web-based knowledge repository system. To solve identified problems and address its mission, as well as values such as optimizing its contribution to the country's development, enhancing citizen participation, and identifying

and implementing innovative and appropriate knowledge and work procedures. Therefore, the objective of this study was to identify the current knowledge management gap of MCIT and to develop a secure web-based knowledge repository system. It is one of the knowledge management systems that allows users both inside and outside the organization to identify, organize, store, and disseminate key explicit and tacit knowledge for quick access, use, and reuse (Fabio, F. B., et al., 2015). The implementation of a secure web-based knowledge repository system at MCIT will enable the Ministry to effectively secure and utilize its knowledge resources, helping to avoid reinvention.

LITERATURE REVIEW

Knowledge is a mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experience and information. It originates and is applied in the minds of the knower. In organizations, it often becomes embedded not only in documents and repositories but also in organizational routines, processes, practices, and norms (Sharma, A. K., 2019).

Knowledge is a powerful resource that enables individuals and organizations to achieve numerous benefits, such as improved learning and decision-making (Al-Busaidi, K. A., et al., 2010). It is a critical resource in the current competitive business environment but managing it without utilizing some technological tools is challenging (Desta, T. A., 2013). It is becoming a driving force for organizational change and wealth creation. It is also important to sustain a competitive advantage by strategically managing KM processes (Amare, M., 2014).

Knowledge can be classified into two types: explicit and tacit. Explicit knowledge is knowledge that is written, archived, and spread, and can be used as learning material by others. While tacit knowledge is knowledge that is not written and is still contained in one's mind. Typically, it is in the form of knowledge, experience, skill, and understanding (Hidayanto, A. N., & Efendy, R., 2010).

Tacit knowledge resides in the individual's mind and is deeply rooted in the values, emotions, routines, and ideals of the individual, making (Skinnarland, K. I. T., & Sharp, P., 2010). It is difficult to articulate and express in words, texts, or drawings (Amare, M., 2014). It is hard to transfer from one person to another. It must be gained by dialogue and personal experience (Ribino, P., et al., 2011). Tacit knowledge has two dimensions, namely technical and cognitive. A technical component reflects the know-how of professional activities, and a cognitive component, which reflects mental models, beliefs, and perceptions, due to the many similar actions performed. Tacit knowledge also embraces highly subjective insights, intuitions, and hunches (Bratianu, C., & Orzea, I., 2010).

Sharing tacit knowledge is a great challenge for many organizations. Tacit knowledge can be shared and communicated through various activities and mechanisms. Activities include conversations, workshops, training sessions, and similar events. Mechanisms include the use of information technology tools such as knowledge repository systems, email, groupware, intranet, and related technologies (Uriarte, F. A., 2008).

In Ethiopia, there are organizations that rely on the tacit knowledge of employees who have been working for a long time within a specific organization. In this regard, the success of the organization is directly related to the performance and the existence of those experienced employees. This is particularly challenging for organizations like these, as experienced employees may leave or retire (Al-Busaidi, K. A., et al., 2010). Capturing knowledge from experienced employees and managing it accordingly makes a significant contribution to organizational success.

Explicit knowledge exists in the form of words, sentences, documents, organized data, computer programs, and in other explicit forms than those understood by the human brain (King, W. R., et al., 2008). It can be documented and recorded in books, reports, and databases. It can be stored or embedded in facilities, products, processes, services, and systems (Uriarte, F. A., 2008). It is stored in documents, databases, websites, emails, and the like. It is knowledge that can be readily made available to others and transmitted or shared in the form of systematic and formal languages. It is anything that can be codified, documented, and achieved. These include knowledge assets such as reports, memos, business plans, drawings, patents, trademarks, customer lists, methodologies, and the like. They represent an accumulation

of the organization's experience, stored in a form that can be readily accessed by interested parties and replicated if desired. In many organizations, these knowledge assets are stored with the help of computers and information technology (Uriarte, F. A., 2008).

Explicit knowledge is not separate from tacit knowledge. On the other hand, the two are mutually complementary. Without tacit knowledge, it will be difficult, if not impossible, to understand explicit knowledge. And, unless we attempt to convert tacit knowledge into explicit knowledge, we cannot reflect upon it, study it, discuss it, and share it within the organization, as it will remain hidden and inaccessible inside the person's head who possesses it (Uriarte, F. A., 2008).

Knowledge management is the planning, organizing, motivating, and controlling of people, processes, and systems within an organization to ensure that its knowledge-related assets are enhanced and effectively utilized (King, W. R., et al., 2008). It enables individuals, teams, and entire organizations to collectively and systematically create, store, share, and apply knowledge to achieve their objectives effectively.

Knowledge creation involves developing new knowledge or replacing existing knowledge with new content (Sanchez, R., 2004). Knowledge creation originates within the individual employee and is developed through social interaction, progressing from individuals to teams and then to the entire organization (Bratianu, C., & Orzea, I., 2010). Knowledge is created through dynamic interactions with the environment, such as training, brainstorming meetings, workshops, research, and projects (Bratianu, C., & Orzea, I., 2010).

After the organization creates or captures new knowledge, knowledge management mechanisms should be placed to prepare it for storage in the organization's memory in a manner that maximizes its impact and long-term reusability (Sanchez, R., 2004). Storing knowledge is the process of inserting knowledge into an organizational knowledge repository system to later reuse (Fabio, F. B., & Veruska, S. C., 2015). The knowledge stored in a knowledge repository, such as a research project, will be captured in workshops (Fabio, F. B., & Veruska, S. C., 2015), best practices, employees' knowledge about the best way to do their jobs, knowledge that is held by teams who have been working on focused problems and knowledge that is embedded in the organization's products, processes, and relationships (Khademi, M., et al., 2011). The knowledge stored in the organizational knowledge repository system should be easily reusable, distributable, and sharable with others (Uriarte, F. A., 2008), allowing all employees to access it whenever needed and wherever they are (Lindvall, M., & Rus, I., 2003).

Knowledge sharing refers to the provision of task information and expertise to help others and to collaborate with them to solve problems, develop new ideas, or implement policies and procedures. Knowledge sharing can occur through written correspondence or face-to-face communication via knowledge management systems (Wang, S., & Noe, R. A., 2010). Knowledge management systems used for knowledge sharing include knowledge repository systems, groupware, intranet, discussion forums, expert systems, and others (Skinnarland, K. I. T., & Sharp, P., 2010). The success of knowledge management in an organization depends on knowledge sharing (Wang, S., & Noe, R. A., 2010).

Applying knowledge involves reusing and accessing existing knowledge from a knowledge repository system to solve organizational problems and benefit the organization (Lindvall, M., & Rus, I., 2003).

The ability to manage knowledge is becoming increasingly more crucial in the current knowledge economy. The creation and diffusion of knowledge have become significant factors in competitiveness (Amare, M., 2014). To manage knowledge, there are technological, people, and process-based solutions. The best approach is surely a combination of all three, within an overall knowledge management strategy that includes both personalization and codification elements (Edwards, J. S., 2003). Knowledge Management consists of techniques that utilize Information Technology tools for managing information, with the goal of improving the efficiency of work teams.

A technological solution that supports the knowledge management activities is referred to as a knowledge management system (KMS). KMS is a set of information systems designed to enhance overall organizational knowledge management activities by avoiding reinvention, reducing errors, promoting learning, and fostering innovation (Desta, T. A., 2013). It is a technology that supports Knowledge Management (KM) in organizations, specifically knowledge creation, codification, and transfer (Nevo, D.,

2003). KMS also improves individuals' performance and productivity in terms of time and speed of the knowledge sharing process (Al-Busaidi, K. A., et al., 2010).

One of the components of KMS is the knowledge repository system. A knowledge repository system assists organizations in efficiently capturing, storing, sharing, and applying their knowledge (Al-Busaidi, K. A., et al., 2010). It enables the organization to store, search, and access knowledge resources (Al-Busaidi, K. A., et al., 2010).

Knowledge sharing through a knowledge repository system involves a codification and storage process, which is the process of storing explicit knowledge for later use (Al-Busaidi, K. A., et al., 2010). Codification is used to promote knowledge sharing through a knowledge repository, such as documents and databases. The knowledge engineer is responsible for selecting and storing relevant knowledge in the knowledge repository (Desta, T. A., 2013).

The knowledge is stored in the knowledge repository, allowing employees to access it at any time they desire (Desta, T. A., 2013). A knowledge repository system also speeds up and broadens traditional knowledge sharing for socializing newcomers, that is, the transmission of cultural rituals and routines (Desta, T. A., 2013). Developing a knowledge repository system can be identified in three key dimensions: these are the identification of knowledge content, access and use of services, preservation of knowledge content, and sustainability of services (Armbruster, C., & Romary, L., 2010). A significant amount of research has been conducted in the areas of knowledge management, knowledge management systems, and knowledge repository systems.

Kernstock and Marcos (2006) developed an instructor-centered dynamic web-based knowledge management system. The aim of the system is to help the students of Computer Information Systems (CIS) at Texas University during the teaching and learning process. The authors stated that when students have a complex assignment, the proposed knowledge management system will help and provide direction for them.

The authors developed a web-based knowledge management system architectural model that helps instructors share their knowledge with students. Finally, the authors recommend that implementing a web-based knowledge management system in universities increases the interaction between students and instructors.

Meadati and Irizarry developed a knowledge repository for learning the residential construction process through Building Information Model (BIM). Building information modeling (BIM) is a process in which real-world elements of a facility are represented as objects in a three-dimensional (3D) digital model.

The authors stated that storing and integrating different construction processes: 3D drawing files, photographs, videos, structure, and unstructured files in the repository, makes it possible to help students learn the construction process. It also enables them to identify the strengths and weaknesses of their learning practices and make improvements accordingly. This knowledge repository also serves as an effective communication tool for transferring knowledge.

The research study is conducted in two phases. The first phase focuses on developing an interactive knowledge repository through BIM. The second phase focuses on utilizing the developed knowledge repository in teaching residential construction processes.

Finally, the authors state that developing a knowledge repository for construction students will enable them to identify the strengths and weaknesses of their learning practices and make improvements accordingly.

Yingong and Ismail (2012) developed a grid electronic thesis and dissertation repository system in Malaysia. It is an electronic repository system that contains information, such as concepts and outputs, of the latest research produced by scholars during their process of cognition, exploration, and analysis.

The authors proposed a Grid-Enabled E-Theses and Dissertations Repository System (GREET) to allow remote access to resources and maintain services such as scalability, accessibility, availability, and integration ability. It is proposed to provide uniform access to knowledge integration across distributed, heterogeneous platforms and repositories by utilizing data grid technology.

Another study, conducted by Muluken Amara (2014), develops a knowledge management strategy for the Documents Authentication and Registration Office (DARO). The primary objective of the research is

to develop a knowledge management strategy tailored for public organizations, specifically the Documents Authentication and Registration Office (DARO).

The author attempted to assess the existence of knowledge sharing practices in DARO, the barriers to knowledge sharing within the organization, the factors that affect the implementation of knowledge management, and the existing knowledge management technologies in the organization. Then, he recommends organizational and technological solutions to DARO.

The recommended organizational solutions are improving access to DARO's information, translating knowledge into practical use, sharing and reapplying experiential knowledge, and fostering an enabling environment. The recommended technological solutions are a document management system, a workflow management system, and an intranet. Finally, the author recommends that the organization provides a detailed strategy to manage knowledge by preparing a schedule within a specified period and replanning it continuously.

METHODOLOGY

The researchers used design science research methodology. It is a research methodology designed to build and evaluate innovative artifacts in the process of solving identified individual and organizational problems (Desta, T. A, 2013). This research project aims to develop a secure web-based knowledge repository system designed to address identified social and organizational challenges. Design science is fundamentally a problem-solving paradigm. The artifacts will be evaluated using the user acceptance evaluation method. Finally, the results of the design science research must be communicated to potential audiences (Hevner, A. R., et al., 2004).

System Modeling Tools

The architectural model of a secure web-based knowledge repository system was represented using Unified Modeling Language (UML). UML is a general-purpose notation language for specifying and visualizing complex systems (Desic, S., et al, 20011). It is the standard language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system (Brown, A. W., et al, 2005). UML is used by anyone involved in the production, deployment, and maintenance of software (Desic, S., et al, 2001). It helps to simplify communication between various project stakeholders in the development process (Gvozdanovic, D., et al, 2001).

UML has become the most widely used modeling language for software-intensive systems today (Rumpe, B., 2004). It inherits only the best features of various modeling languages, such as data modeling, business modeling, object modeling, and component modeling (Desic, S., et al, 2001). It enables the design of Class diagrams, Use case diagrams, Object diagrams, Sequence diagrams, Collaboration diagrams, State chart diagrams, Activity diagrams, Component diagrams, and Deployment diagrams (Desic, S., et al, 20011). Using UML enables a better understanding of the problem domain, improved communication, reduced software defects, improved quality, and reduced software maintenance effort (Fernandez-Saez, A. M., et al, 2013). Additionally, it can be used throughout the entire requirements capture to implementation phase (Gvozdanovic, D., et al, 2001).

Software Development Tools

The development of a secure web-based knowledge repository system was done by using Liferay content management and portal development tools. Liferay is a Java-based web content management and portal development tool. It is highly powerful, secure, flexible, easy to develop new applications, open source, extensible, and well-integrated with other tools and standards. It enables the addition of CSS style sheets, Java Server Pages (JSP) codes, and JavaScript codes.

JSP is a Java web application development technology that enables the inclusion of dynamic content. It provides a simplified and fast way to create dynamic web content. JSP technology enables rapid development of web-based applications that are server and platform-independent.

MySQL database management tools are used to develop the database of a secure web-based knowledge repository system. It is one of the popular database management systems used in most web-based applications. To implement a fully secure web-based knowledge repository System in the Ministry, we recommend ASP.NET to develop a web-based repository system and SQL to implement the database of a secure web-based Knowledge repository system.

Data Collection Methods

To understand current knowledge management practices and identify the gaps in knowledge management within MCIT, a new secure web-based knowledge repository system was proposed. Data was collected through questionnaires, interviews, and observations.

A questionnaire is structured data collection tool that respondents fill out. It is an appropriate method of data collection for large sample sizes, which can be prepared in both closed- and open-ended formats. Closed-ended questions limit respondents' answers by forcing them to choose from a pre-existing set of options, such as yes/no or a rating scale. The other format of questionnaire is the open-ended format in which respondents are encouraged to explain their answers to the question by writing sentences or paragraphs (Bera, P., & Rysiew, P., 2004). The questionnaire for this research contains 10 questions and is distributed to respondents purposefully, requesting their opinions on the issues of knowledge capturing, storing, and sharing in MCIT. A total of 40 questionnaires were distributed to the employees of MCIT in five core departments. Among these 30 questionnaires, papers were filled out and returned. To complete these questionnaires, IT Experts, senior experts, principal experts, Team leaders, web developers, and professional developers participated. The sample of the questionnaire is attached to Appendix A.

The other data collection method is observation. Observation is a purposeful, systematic, and selective way of watching and listening to an interaction or an event as it unfolds. It is used to validate data captured through interviews and other documentary sources. It is also used to capture data within its natural settings (Bera, P., & Rysiew, P., 2004). There are two types of observations: participant observation and non-participant observation. Participant observation is an activity where the observer participates in the activity of the people being observed in the same manner as their members, with or without the knowledge that they are being observed. Whereas non-participant observation occurs when the researcher does not actively participate in the group's activities but observes the respondents' behavior passively (Bera, P., & Rysiew, P., 2004). During this data collection process, we used participant observation.

An interview is one of the major data collection methods. An interview can take place face-to-face or via telephone. In some cases, an interview may be superior to other data-gathering methods because people are usually more willing to talk than to write. Once the connection is established, even confidential information may be obtained through an interview (Bera, P., & Rysiew, P., 2004). There are various types of interview formats, including structured, semi-structured, and unstructured. During the data collection process, we employed both unstructured and structured interview methods for the selected user groups.

DATA ANALYSIS

The collected raw data were analyzed using descriptive statistical methods. Microsoft Excel was used as a data processing tool. Additionally, UML modeling tools were utilized to represent various views of the system. UML is a technology-independent modeling language, allowing the system to be implemented using any technology that meets the organizational technological requirements and standards. We also used Liferay content management tools to develop the prototype into a working system for user acceptance testing.

The quantitative data collected through questionnaires was analyzed using Excel with descriptive analysis methods, including average, percentage, and frequency. Whereas the qualitative data from open-ended questions and interviews were analyzed using open coding methods to identify important themes and concepts, a final summary was then performed.

Employe Participation on Training, Research, Project and Workshop

The survey responses showed active worker involvement in knowledge-production activities. Table 1 shows the details of the participants; 43.3% and 33.3% of the respondents had very high, high, or medium levels of active participation in training, research, projects, and workshops, respectively. Conversely, only 10% and 3.3% of the participants reported low or very low participation, respectively. Employees produce significant knowledge that must be systematically captured, stored, and shared for reuse.

TABLE 1
EMPLOYEES PARTICIPATION IN TRAINGING, RESEARCH AND WORKSHOPS

Employees Participation in trainings, workshops, research and projects in MCIT					
	Very high	High	Medium	Low	Very low
Freq.	3	13	10	3	1
Per.	10%	43.3%	33.3%	10%	3.3%

Ministry Budget Allocation to Acquire Knowledge

As shown in Table 2, 73.3% of the respondents agreed or strongly agreed that the ministry provided a sufficient budget for research, training, projects, and workshops, while only 13.3% disagreed. This shows that finances are needed to fund knowledge acquisition and support the case of having a secure web-based knowledge repository system.

TABLE 2
THE MINISTRY ALLOCATES BUDGET TO ACQUIRE KNOWLEDGE

MCIT has allocated adequate budget for research, training, projects and workshops to acquire knowledge					
	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
Freq.	4	18	4	4	0
Per.	13.3%	60%	13.3%	13.3%	0%

Ministry Uses IT Tools to Manage Knowledge

According to the survey results, there are major gaps in the utilization of information technology tools to organize knowledge. Table 3 shows that 33.3% of the participants either agreed or strongly agreed that IT tools were used to capture, store, and transfer knowledge and 56.7% disagreed or strongly disagreed. These results reveal the inadequacies of existing knowledge management techniques and call for a secure web-based knowledge repository system that improve productivity and stability.

TABLE 3
THE MINISTRY USES IT TOOLS TO MANAGE KNOWLEDGE

The Ministry uses IT tools to capture, store and share knowledge of research, projects, trainings and workshops					
	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
Freq.	3	7	3	15	2
Per.	10%	23.3%	10%	50%	6.7%

The Capability of the Existing Systems to Manage the Ministry Knowledge

Table 4 indicates that 60% of the respondents disagreed or strongly disagreed that the current system properly recorded, stored, and shared knowledge, whereas only 16.7% agreed. This shows a significant deficiency in the existing functionality of the system and further justifies the need for a new, secure, web-based knowledge repository.

TABLE 4
THE CAPABILITY OF THE EXISTING SYSTEM TO MANAGE KNOWLEDGE

The capability of the existing systems to capture, store and share knowledge effectively					
	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
Freq.	0	5	7	16	2
Per.	0%	16.7%	23.3%	53.3%	6.7%

The Infrastructure of the Ministry to Implement Web-Based KRS

The responses in Table 5 indicate that 66.7% agreed or strongly agreed that the ministry had sufficient infrastructure to adopt a large web-based knowledge repository system. Only 16.6% disagreed or strongly disagreed. Observations of the Ministry's data center confirmed that it is large and well-organized, providing a strong foundation for implementing the proposed system.

TABLE 5
THE INFRASTRUCTURE OF THE MINISTRY TO IMPLEMENT LARGE KRS

The infrastructure of the Ministry to implement large web-based knowledge repository system					
	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
Freq.	3	17	5	4	1
Per.	10%	56.7%	16.7%	13.3%	3.3%

ELICITIONTION AND A PROPOSED SECURE KRS

The data collection results show the existing knowledge management practices in MCIT, identify the gaps, and propose a secure web-based knowledge repository system. The Ministry is collaborating with various training companies, research institutes, universities, and scholars to generate knowledge. To create this knowledge, the Ministry invests an adequate budget, and the employees of MCIT actively participate in this process. However, we identified gaps in capturing, storing, sharing, and reusing knowledge resources created through research, projects, training, and workshops.

The Ministry provided training on cooperation among different training institutes in various information technology areas for its employees, federal office employees, and regional office employees. However, after completing the training, a gap remains in capturing, storing, and sharing the knowledge gained from training, making them accessible in a collective, comprehensive, and efficient manner for employees and customers.

In addition, the Ministry, by cooperating with various scholars, institutions, and universities, works together to conduct research, projects, and workshops. However, after completing the research project, IT project, and workshops, a gap remains in capturing, storing, sharing, and making accessible information in a collective, comprehensive, and efficient manner for its employees and customers. Moreover, existing systems have a gap in capturing, storing, and sharing knowledge resources in a collective, comprehensive, and efficient manner to make them accessible and reusable for Ministry employees and customers.

Elicitation User Knowledge Requirements

In Ethiopia, the knowledge management system is still in its early stages of development (Mekonnen, F., et al, 2012). The Ministry of Communication and Information Technology (MCIT) is one of the governmental organizations that should have a secure web-based knowledge repository system. To understand the existing knowledge management practices in the Ministry, we gathered data through questionnaires, observations, and interviews with employees working in the Ministry.

From the collected data, we understood that the Ministry collaborates with different training companies, research institutes, universities, and scholars to create training manuals, research reports, and project studies. To create this, the Ministry invests an adequate budget, and the employees of MCIT are actively participating in these processes. However, we identified a gap in systematically capturing, storing, sharing, and reusing knowledge resources created through research, projects, training, and workshops.

The Ministry provided training by inviting various training companies to cover different information technology topic areas for its employees, federal office employees, and regional office employees. However, after completing the training, there is a gap in systematically capturing, storing, and sharing the knowledge resources that they gain from the training, and making them accessible on a shared platform for easy access by employees and customers.

Additionally, the Ministry collaborates with various scholars, institutions, and universities to undertake research projects and workshops. After completing the research projects, IT projects, and workshops, new knowledge is created, which is vital for other similar activities. However, there is no business process that handles these activities, as shown in Figure 1 below. As a result, vital knowledge resources remain underutilized or wasted due to the lack of a knowledge repository system and managerial attention.

The analysis model of a secure web-based knowledge repository system comprises a use case diagram, a class diagram, a deployment diagram, and a prototype of the proposed system. A use case diagram is used to identify the system's use cases and helps illustrate the interaction between actors and the system.

The following figure 2: shows the proposed web-based knowledge repository system class diagram. It displays the attributes and methods of the class, along with their relationships. Attributes describe the properties of the objects. A method is a procedure that implements an operation.

FIGURE 1
USE CASE DIAGRAM OF SECURE WEB – BASED KRS

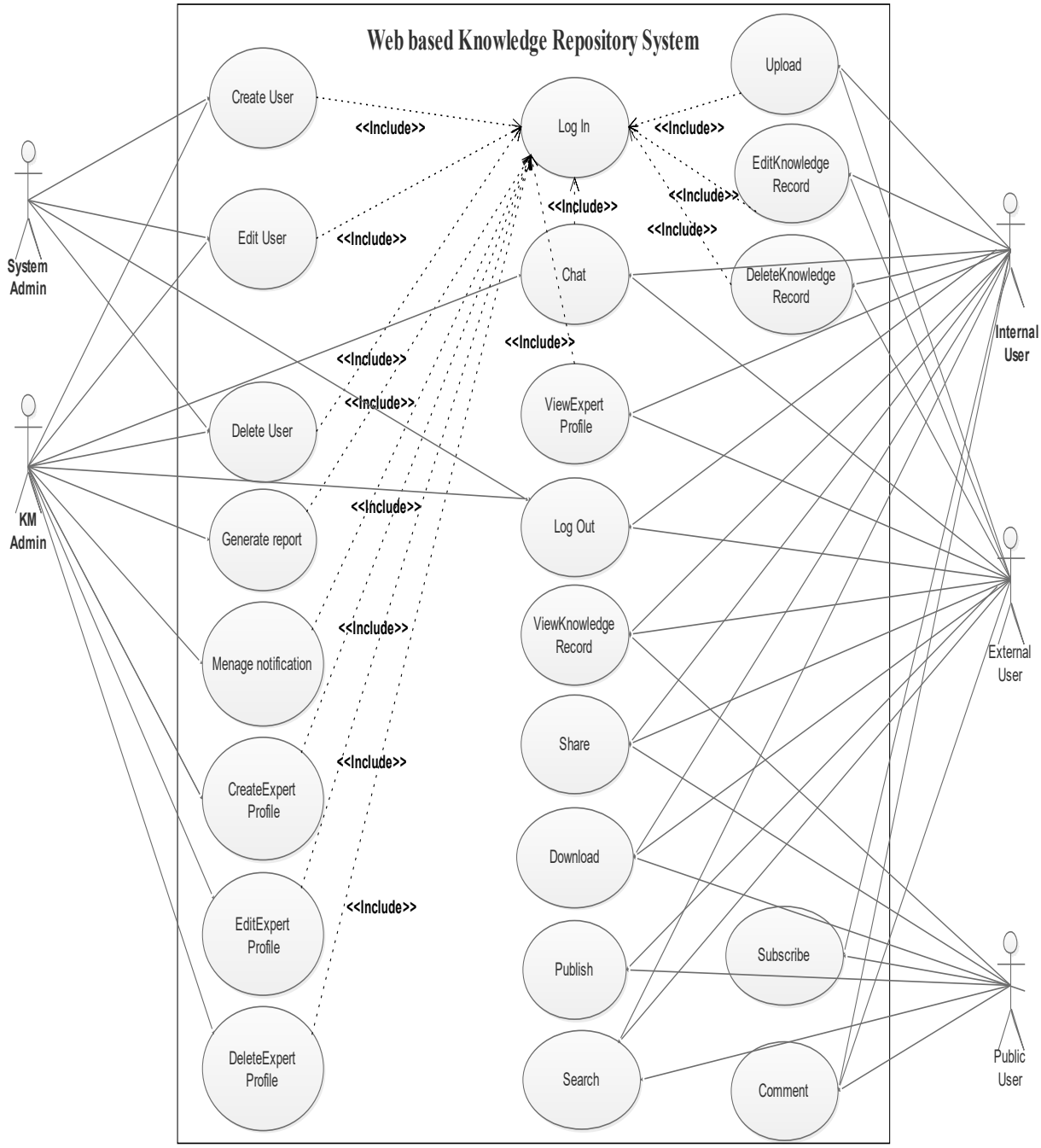
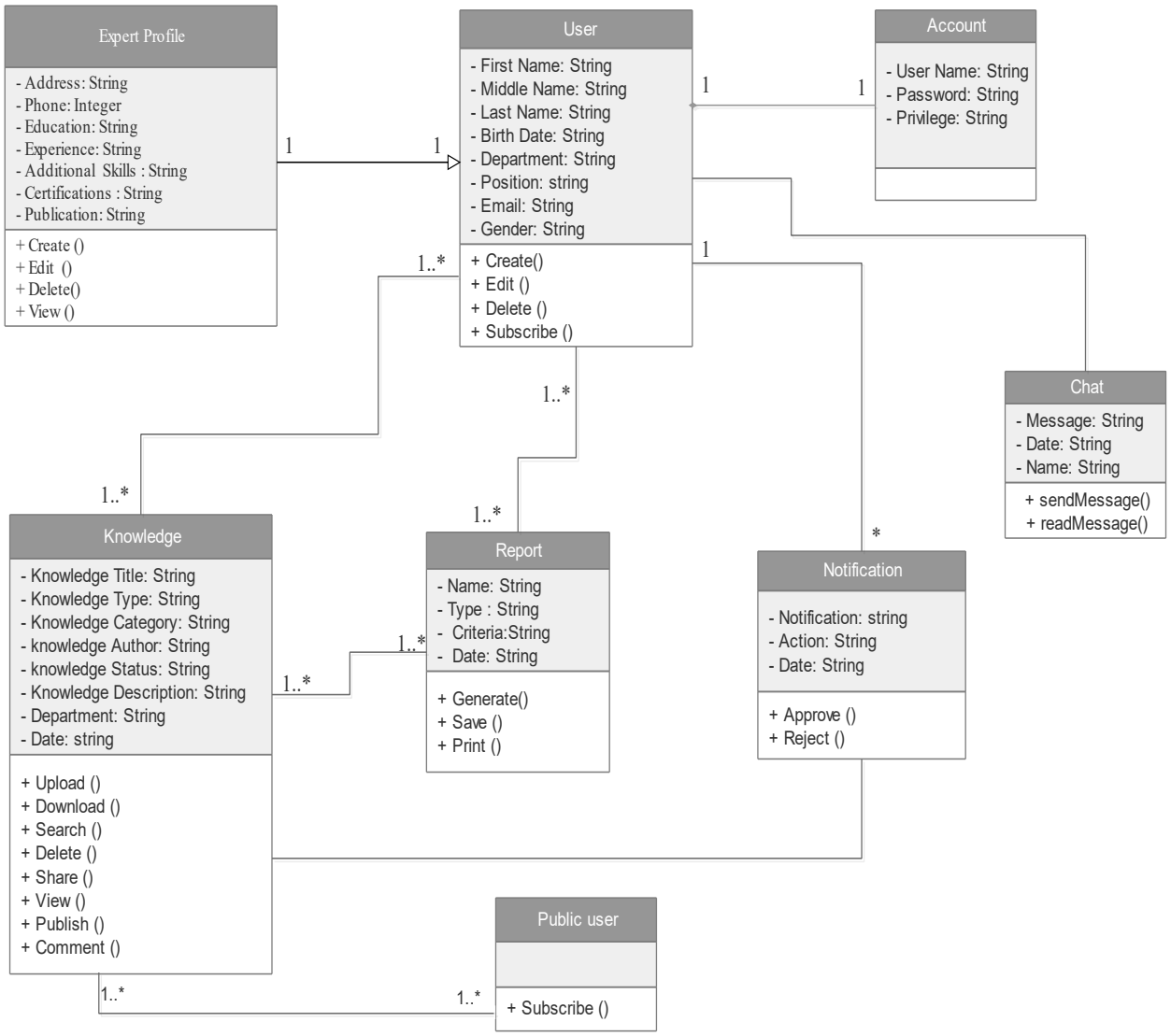


FIGURE 2
CLASS DIAGRAM OF A SECURE WEB – BASED KNOWLEDGE REPOSITORY SYSTEM



Proposed Solution

A secure Web-based Knowledge repository system is a web-based system that helps to capture, store, share, search, access, and retrieve knowledge easily. It is a system architecture that houses and manages a collection of corporate intellectual assets.

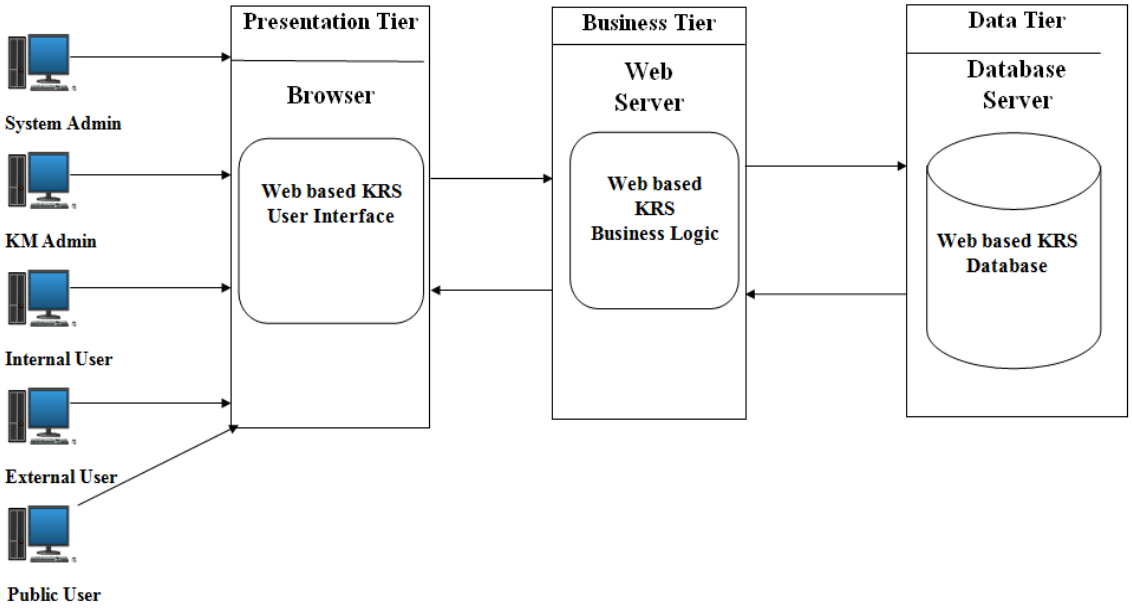
The proposed secure web-based knowledge repository system will be implemented on a three-tier client-server architecture. It is commonly used in most web-based applications. The architecture is organized into three major parts: the presentation (client) tier at the top, the business (application) tier in the middle, and the data tier at the bottom. This type of architecture offers high performance, scalability, maintainability, reusability, and security for the system.

The presentation tier provides a graphical user interface (UI) to users. It consists of different web forms that help users to input and retrieve data from the system. The web forms of the system are designed using Liferay content management and portal development tools. System Administrators, KM administrators, internal users, external users, and public users access the form using a browser.

The business logic tier runs on a separate web server and serves as an intermediary for the presentation and data tiers, facilitating faster communication between them. It is responsible for receiving queries from the presentation layer and retrieving knowledge from the data store layer to answer users' queries. It may use search engines and other knowledge processing tools.

The data tier contains the database and stores system data separately from the presentation and business logic tier. It has methods to connect and perform various tasks, such as inserting, retrieving, editing, deleting, and viewing data from the database. Figure 3 shows the proposed secure web-based knowledge repository system architectural view.

FIGURE 3
PROPOSED A SECURE WEB – BASED KNOWLEDGE REPOSITORY SYSTEM ARCHITECTURE VIEW



The proposed system has different user groups as described below.

KM Admin: has the responsibility to control the activity of each department. They approve uploading, publishing, editing, and deleting explicit knowledge by users. They can also create, edit, and delete internal and external users.

System Admin: has a responsibility to create a KM Admin for each department.

Internal Users: These are employees of MCIT who participate in coordinating training, research, projects, and workshops. Additionally, they have a responsibility to collect training manuals, research papers, projects, workshop papers, and videos. These users are registered in the system. They can upload, publish, download, edit, delete, and share explicit knowledge. However, their action needs approval from KM Admin.

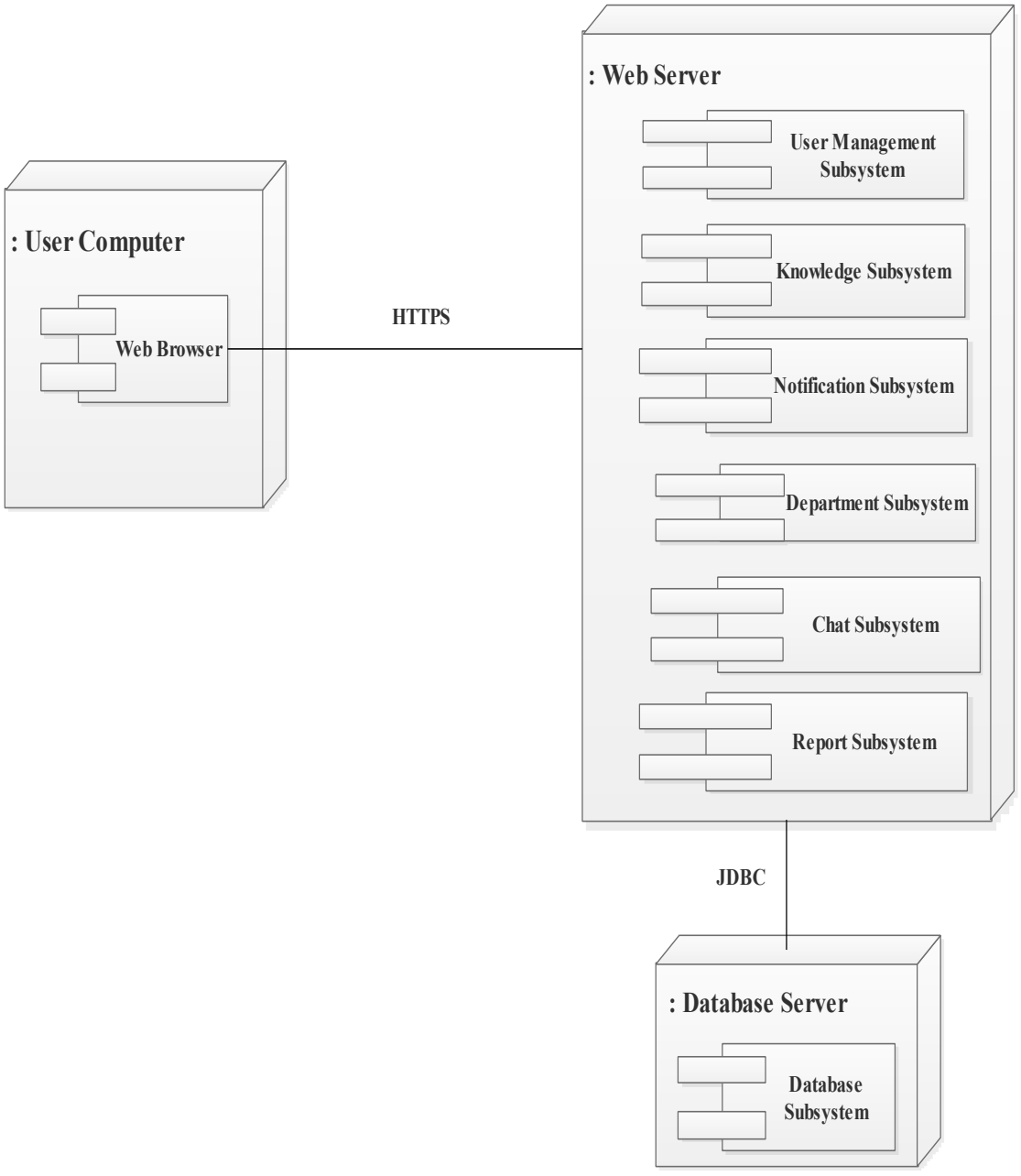
External Users: These users are professionals who are registered on the system. They collaborate with MCIT to conduct research, provide training and workshops, and develop projects. These users can upload, edit, and delete their works with the approval of KM Admin.

Public Users: These users are not registered on the system and can only access the publicly available knowledge. These users can search, view, download, and use only public explicit knowledge from the repository system.

A deployment diagram is a type of architectural model that illustrates how hardware components interact with software components. It helps to visualize the topology of hardware components and where the software components are installed.

Figure 4 below illustrates the deployment diagram of a secure web-based knowledge repository system. It shows the users' computers accessing the knowledge repository database by sending an HTTPS request through the web server. The result is displayed on the browser, which is installed on the user's computer. A secure Web-based knowledge repository system application accesses the database from the database server by using a JDBC connection.

FIGURE 4
DEPLOYMENT DIAGRAM OF A SECURE WEB – BASED KNOWLEDGE REPOSITORY SYSTEM



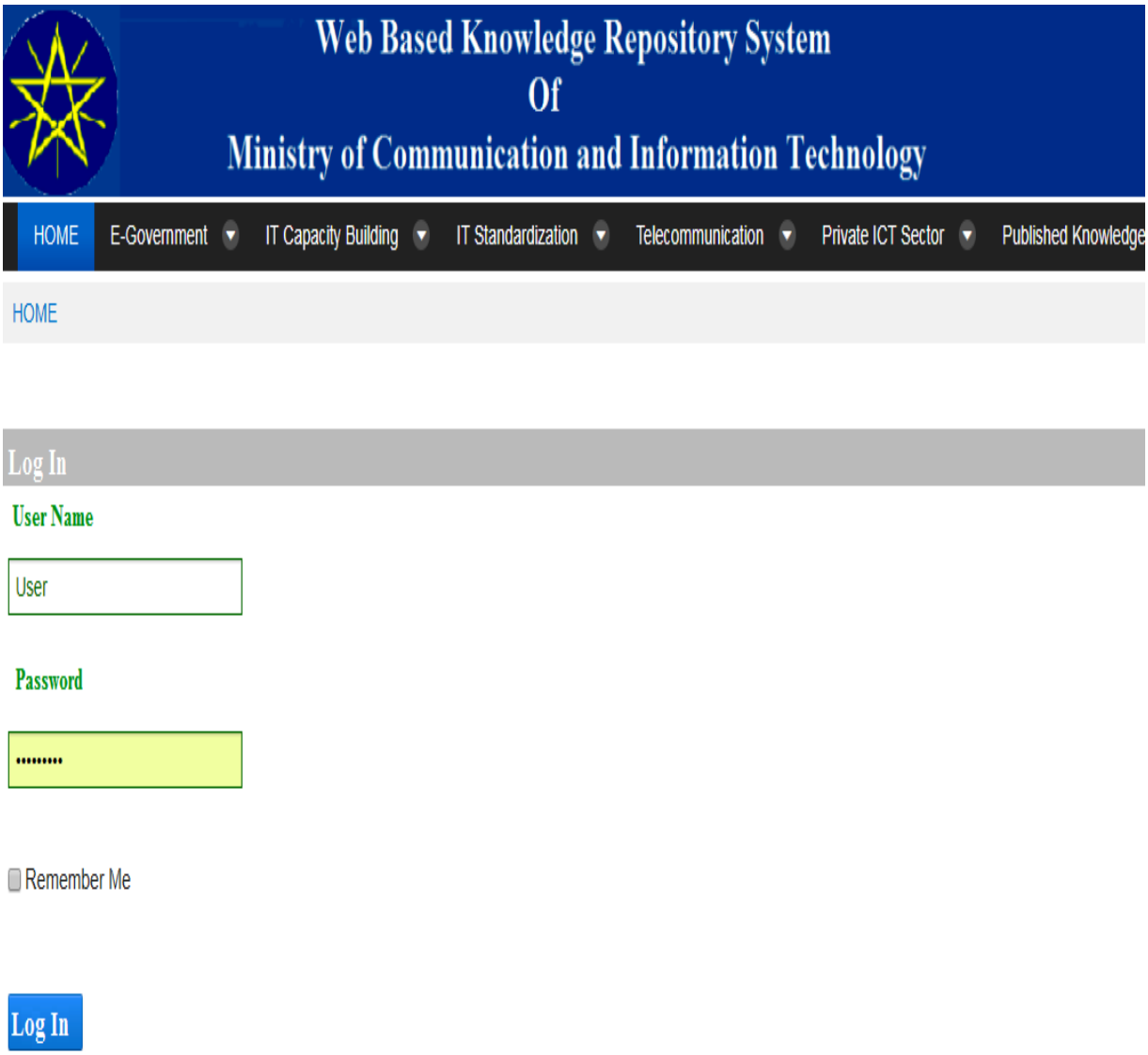
PROTYPE OF SECURE WEB BASED KRS

The prototype of the Secure Web-based knowledge repository system has two parts. The first part covers the prototype of the system, while the second part evaluates the prototype. The following section covers the prototype of a secure web-based knowledge repository system. It contains the User Log In page, KM Admin Log In page, KM Admin Main page, User Main page, User Creation page, Upload page, View page, Create Expert Profile page, and Chat page.

User Login Page

The following figure 5 displays usernames and passwords to authenticate users. After users log in to the system, they can upload, download, search, and perform other knowledge-related activities.

FIGURE 5
USER LOG IN PAGE OF THE SYSTEM



Home Page

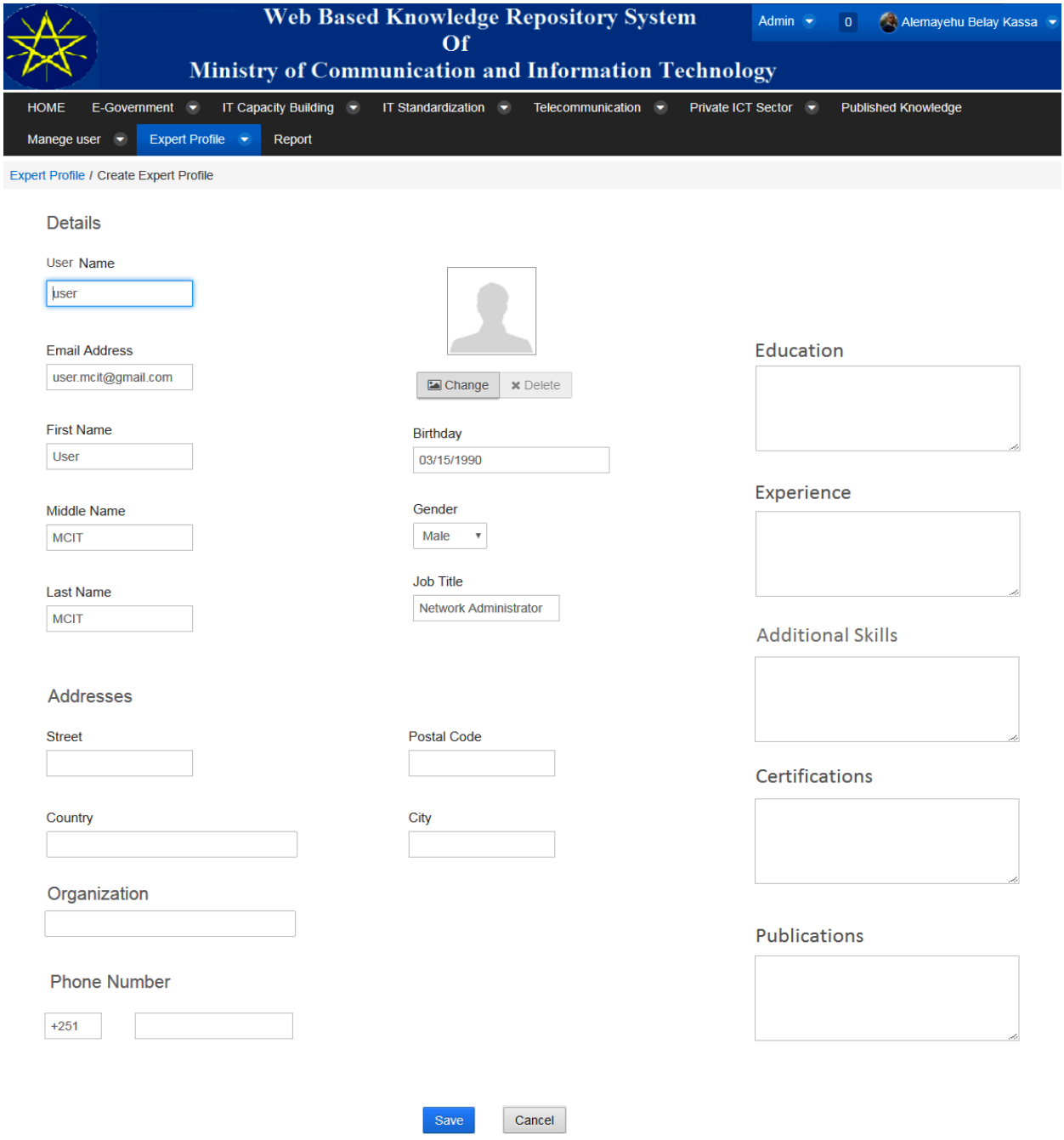
This page serves as the home page of the system, as shown in Figure 6, It has tabs and buttons, including search buttons and department buttons with a drop-down menu that includes research, projects, training, and workshops.

FIGURE 6
HOME PAGE OF THE SYSTEM

Create Expert Profile Page

This page assists the KM Admin in creating an expert profile. To create an expert profile, the page displays fields. The KM Admin fills in the necessary information and creates the expert profile. The Expert profile Page is shown in Figure 7

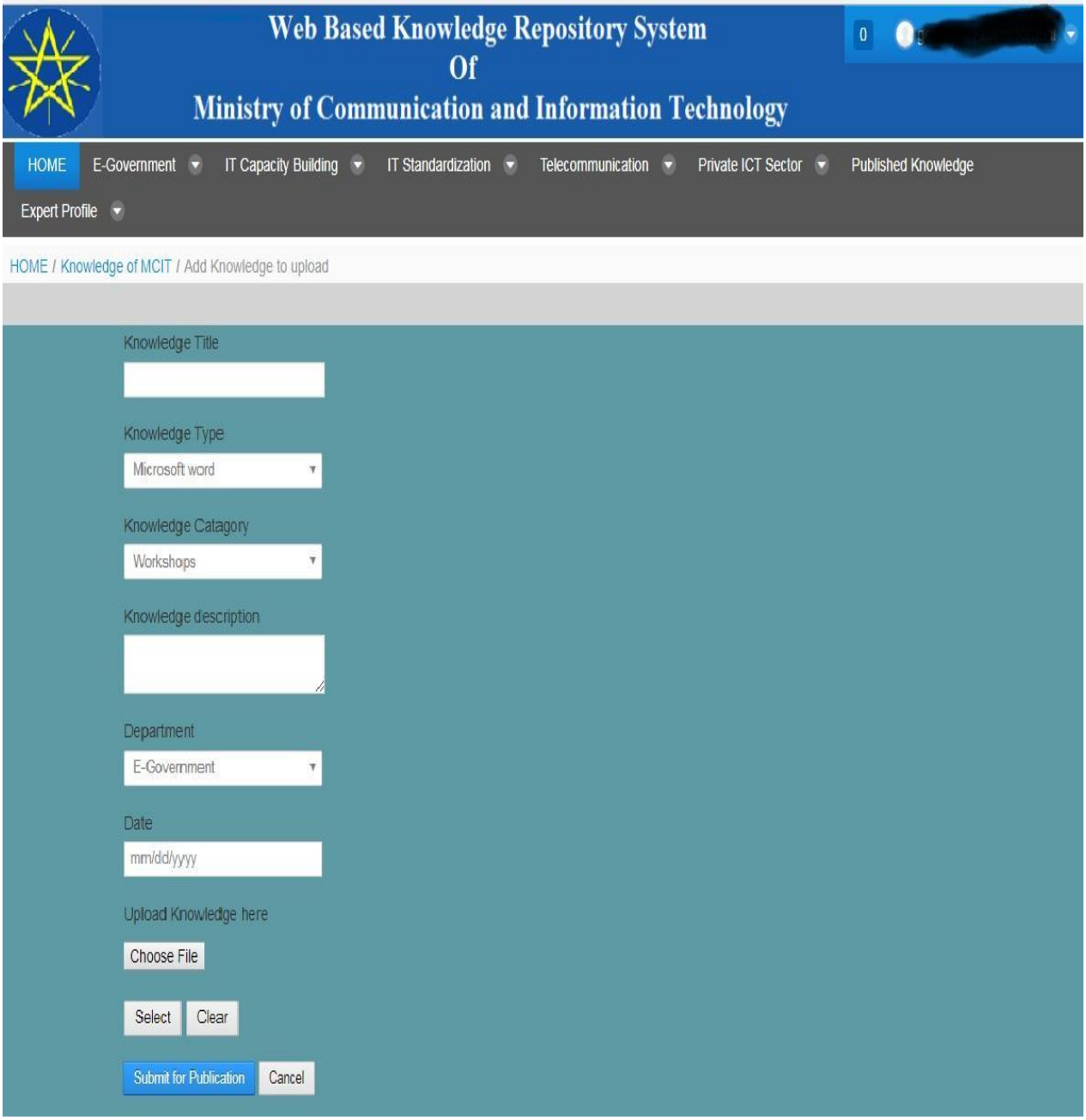
FIGURE 7
CREATE EXPERT PROFILE PAGE OF THE SYSTEM



Upload Page

This page enables users to upload explicit knowledge to the system. For that, it displays fields such as knowledge title, knowledge type, knowledge category, knowledge description, and department. Users fill in the knowledge information, choose the knowledge content, and submit it to upload. The upload page is shown in Figure 8.

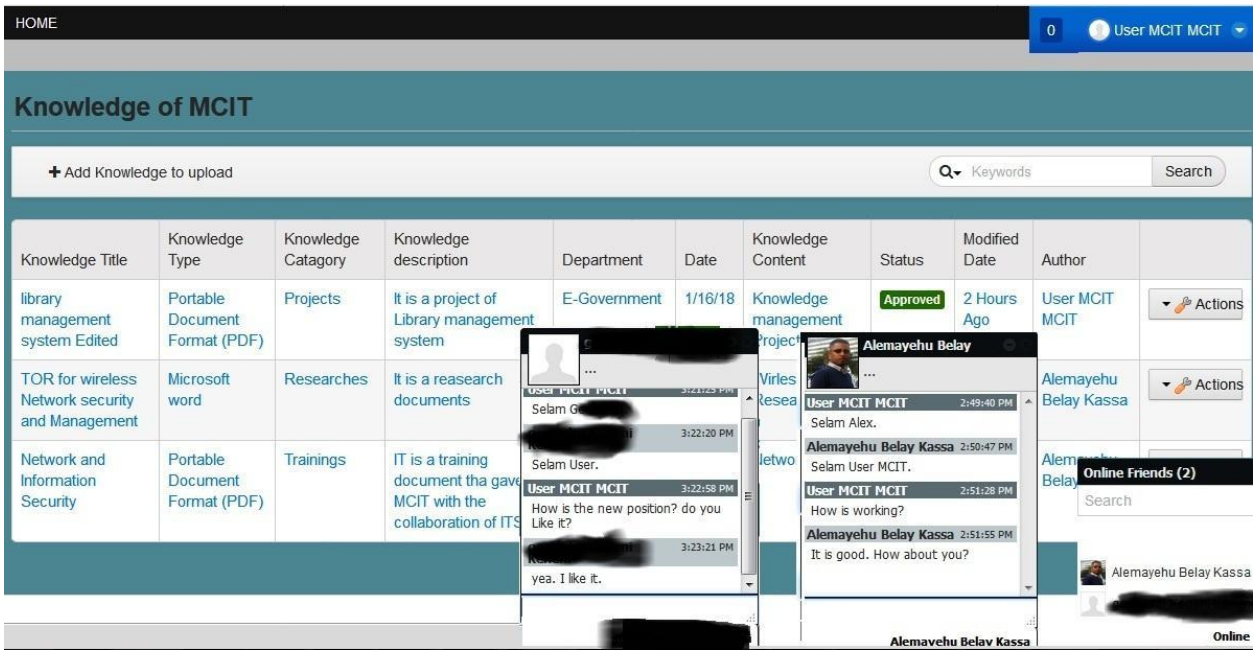
FIGURE 8
UPLOAD PAGE OF THE SYSTEM



Chat Page

This page enables users to communicate with each other and to share their tacit knowledge. The chat page is shown in Figure 9.

FIGURE 9
CHAT PAGE OF THE SYSTEM



The prototype of a secure web-based knowledge repository system was evaluated by users. To evaluate the prototype, we use functional testing and usability testing. To test the prototype, we select a user group from the MCIT departments and external users.

To evaluate the functionality of a secure web-based knowledge repository system, we test how the system's functionalities work. These functionalities are defined in the system analysis and system design phases. It covers how the system authenticates users properly, uploads knowledge, views, downloads knowledge, deletes knowledge, edits knowledge, creates a user, edits a user, deletes a user, and chats.

The usability of the system is a crucial factor in its success. To evaluate the usability of a secure web-based knowledge repository system, we test how the system is usable, learnable, and attractive for users.

We distribute questionnaires to selected user groups, and based on the responses, users evaluate the prototype of a secure web-based knowledge repository system. The questionnaire consists of 10 questions regarding the system's functionality and usability. The user's groups are selected from the departments of IT Capacity Building, E-Government, IT Standardization, and one external user.

Appendix C presents the evaluation results of the secure web-based knowledge repository system. During the evaluation of the prototype, six participants were involved. It was selected from IT Capacity building, E-government, IT standardization, and from an external training company that works in collaboration with MCIT.

As Appendix B below shows, the 10 key questions provided a framework for evaluation; therefore, a significant result was verified. Because the evaluation enables us to assess the usability and functionality of the proposed system that achieves the stated objectives. Thus, all users indicated that the system could authenticate, create, edit, and delete users, as well as upload, edit, download, and delete knowledge. And almost all users stated that the proposed secure web-based knowledge repository system prototype is a useful tool for easily managing knowledge. This is because, as indicated in Appendix C, the system is easily accessible, allowing users to quickly access knowledge from it. Accordingly, we encourage the Ministry of

Communication and Information Technology of Ethiopia to implement the proposed system by integrating it with the existing system.

CONCLUSION AND RECOMMENDATIONS

The objective of this paper is to identify the existing knowledge management gap in Ministry of Communication and Information Technology (MCIT) of Ethiopia. This paper proposes a secure web-based knowledge repository system that helps capture, store, share, and reuse knowledge from research projects, IT projects, training, and workshops within the Ministry. Additionally, the proposed system facilitates the capture of experts' profiles, experience, skills, and knowledge. Once the knowledge is captured in one central knowledge repository system, it will be easily accessible for reuse and sharing. The implementation of the proposed secure web-based knowledge repository system will enable the Ministry to provide efficient and quality services for its employees and customers.

The research has made a theoretical contribution by demonstrating how KM is designed and implemented with objected oriented system development method. It has methodological contributions for other researchers who undertake research in knowledge management.

The research also practical contribution by indicating how KMS is designed and implemented in the organization. It shows that MCIT has systematically capturing, storing, sharing, and reusing its existing knowledge resources of research, projects, training, and workshops.

To implement a comprehensive knowledge management system, the Ministry should develop an organizational knowledge management strategy. The following recommendations are forwarded to achieve organizational-level KM solutions.

- The Ministry should audit its knowledge resources every time to know which knowledge has a greater contribution to achieving its business objectives.
- The Ministry must have an explicit knowledge management strategy and policy. It should also establish a knowledge management department that is responsible for implementing its KM strategy and managing its knowledge resources just like other resources.
- The Ministry can implement the proposed secure web-based knowledge repository system to enhance its KM capability and application of knowledge in its day-to-day business activities.
- People are the core elements in any KM solution implementation. Therefore, the Ministry must create awareness among its employees about the value of KM and provide incentives to willingly share their personal knowledge.

ACKNOWLEDGMENT

This paper was submitted as part of the research project conducted by Alemayehu B. Kassa under the Graduate Program of the HiLCoE School of Computer Science and Technology, in partial fulfillment of the requirements for the Master of Software Engineering degree at Addis Ababa, Ethiopia, in 2018.

At the time of submission, the Ethiopian Ministry of Communication and Information Technology (MCIT) was an independent governmental organization. Since then, MCIT has been merged with the Ministry of Innovation and Technology, Ethiopia.

We would also like to acknowledge the Ethiopian Ministry of Communication and Information Technology (MCIT). However, MCIT is not responsible for any of the results published in this paper.

REFERENCES

Al-Busaidi, K.A., et al. (2010). *Sharing knowledge to a knowledge management system: Examining the motivators and the benefits in an Omani organization.* 2010, Article 325835.

Alhawary, F.A., et al. (2011). Building a knowledge repository: Linking Jordanian universities e-library in an integrated database system. *International Journal of Biometrics*, *6*, 129. DOI: 10.5539/ijbm.v6n4p129

Amare, M. (2014). *Formulating knowledge management strategy for public organizations: The case of the Federal Documents Authentication and Registration Office, Ethiopia.*

Armbruster, C., & Romary, L. (2010). Comparing repository types: Challenges and barriers for subject-based repositories, research repositories, national repository systems and institutional repositories in serving scholarly communication. *International Journal of Digital Library Systems*, *1*(4), 61–73. https://doi.org/10.4018/jdls.2010100104.

Asalla, L.K., Karsen, M., Bandur, A., Elidjen, Prabowo, H., & Putri, M.R. (2023). The influence of knowledge management systems in corporate university in triggering knowledge innovation in higher education: A case study approach. *2023 International Conference on Information Management and Technology (ICIMTech)*, 644–648. doi:10.1109/ICIMTech59029.2023.10277841

Bera, P., & Rysiew, P. (2004). *Analyzing knowledge management systems: A veritistic approach.* University of British Columbia, Vancouver, Canada.

Bilal, M., Ali, M. I., Rasheed, K., & Saad, S. (2023). Exploring adoption trends of knowledge management systems in the software industry's SMEs: A comprehensive investigation of enablers and barriers. *2023 4th International Conference on Data Analytics for Business and Industry (ICDABI)*, 598–604. doi: 10.1109/ICDABI60145.2023.10629373

Boom, D. (2005). The Asian Development Bank's knowledge management framework. *KM4D Journal*, *1*(2), 69–75

Bratianu, C., & Orzea, I. (2010). Organizational knowledge creation. *Management & Marketing*, *5*(3), 41–62.

Brown, A. W., Delbaere, M., Eeles, P., Johnston, S., & Weaver, R. (2005). Realizing service-oriented solutions with the IBM Rational software development platform. *IBM Systems Journal*, *44*(4), 727–752. https://doi.org/10.1147/sj.444.0727

Desic, S., Gvozdanovic, D., Kusek, M., & Huljenci, D. (2001). *Advantage of UML-based object-oriented system development.* University of Zagreb, Croatia.

Desta, T.A. (2013). *Enabling knowledge sharing in the workplace: The case of Commercial Bank of Ethiopia (CBE).* Ethiopia.

Edwards, J.S. (2003). Managing software engineers and their knowledge. In *Managing software engineering knowledge* (pp. 5–27). Springer.

Fabio, F.B., & Veruska, S.C. (2015). Ipea's knowledge repository. In *Proceedings of the 16th European Conference on Knowledge Management*, 1–11.

Fernandez-Saez, A.M., Chaudron, M.R.V., & Genero, M. (2013). Exploring costs and benefits of using UML on maintenance: Preliminary findings of a case study in a large IT department. In *Proceedings of EESSMoD'2013 within MODELS'2011* (pp. 33–42).

Gvozdanovic, D., Desic, S., & Huljenic, D. (2001). UML supported software design. *Proceedings of the 2001 International Conference on Software, Telecommunications and Computer Networks (SoftCOM 2001)*, Split–Dubrovnik.

Hevner, A.R., March, S.T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*(1), 75–105

Hidayanto, A.N., & Efendy, R. (2010). Analysis and design of knowledge management system in product development. *International Conference on Management Science and Information Engineering (ICMSIE 2010)*, Jakarta, Indonesia.

Khademi, M., Kabir, H., & Haghshenas, M. (2011). E-learning as a powerful tool for knowledge management. *5th International Conference on Distance Learning and Education*, *12*. Singapore.

King, W. R., Chung, T. R., & Haney, M. H. (2008). Knowledge management and organizational learning. *Omega*, *36*(2), 167–172. doi: 10.1016/j.omega.2006.07.004.

Lindvall, M., & Rus, I. (2003). Knowledge management for software organizations. In *Managing software engineering knowledge* (pp. 73–94). Springer.

Mekonnen, F., Sehai, E., & Hoekstra, D. (2012). *Innovative approaches of knowledge management in agriculture: The case of IPMS, Ethiopia*. Poster presented at Tropentag 2012, Göttingen, Germany. Nairobi, Kenya: ILRI.

Nevo, D. (2003). *Developing effective knowledge management systems* (Doctoral dissertation, University of British Columbia).

Nupap, S. (2022). Knowledge management system by applying knowledge creating company: Transforming tacit to explicit knowledge. *2022 Joint International Conference on Digital Arts, Media and Technology & ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI DAMT & NCON)*, 439–444. doi:10.1109/ECTIDAMTNCON53731.2022.9720388

Permadi, H., & Sensuse, D. I. (2021). Measuring knowledge management system utilization by government in various countries. *2021 International Conference on Informatics, Multimedia, Cyber and Information System (ICIMCIS)*, 226–231. doi: 10.1109/ICIMCIS53775.2021.9699129

Putra, M.B., Wiratara, M.R.B., Aliva, S.V., Rabiha, S.G., & Desak, G.F.P. (2024). Designing knowledge management system for performance efficiency based chatbot at PT. XYZ. *2024 9th International Conference on Business and Industrial Research (ICBIR)*, 1521–1526. doi:10.1109/ICBIR61386.2024.10875920

Ribino, P., Augello, A., Lo Re, G., & Gaglio, S. (2011). A knowledge management and decision support model for enterprises. *Advances in Decision Sciences*, Article 425820. doi:10.1155/2011/425820

Rumpe, B. (2004). Agile modeling with the UML. In *Radical Innovations of Software and Systems*.

Sanchez, R. (2004). Tacit knowledge versus explicit knowledge approaches to knowledge management practice. *IVS/CBS Working Papers 2004-01*. Copenhagen Business School. https://doi.org/10.4337/9781845426842.00025

Sharma, A. K. (2019). Knowledge management and new generation of libraries information services: A concept. *African Journal of Library and Information Science*, 1–7.

Skinnarland, K. I. T., & Sharp, P. (2010). *Knowledge sharing (KS), organizational learning and competitive advantage in a Scandinavian hotel company*.

Uriarte, F. A. (2008). *Introduction to knowledge management*. ASEAN Foundation.

Wang, S., & Noe, R. A. (2010). Knowledge sharing: A review and directions for future research. *Human Resource Management Review*, *20*, 115–131.

Zenouz, R. Y., Rad, F. H., Centobelli, P., & Cerchione, R. (2024). Knowledge management systems evaluation in food industry: A multicriteria decision-making approach. *IEEE Transactions on Engineering Management*, *71*, 506–516. doi: 10.1109/TEM.2021.3118667

APPENDEX A: Structure of Questionaries

1. How do you rate your participation in training, workshops, research, and projects in the MCIT?
   □Very High, □High, □Medium, □Low, □Very Low
2. How do you rate your participation in knowledge capturing, storing, and sharing in the Ministry using knowledge management system tools?
   □Very High, □High, □Medium, □Low, □Very Low
3. The ministry has a good culture of creating knowledge through research, projects, training, and workshops?
   □Strongly Agree, □Agree □Neutral □Disagree □Strongly Disagree
4. MCIT has allocated an adequate budget for research, projects, training, and workshops to acquire knowledge?
   □Strongly Agree, □Agree, □Neutral, □Disagree, □Strongly Disagree
5. Does MCIT have a culture of capturing, storing, and sharing the existing knowledge resources of research, training, and workshops?
   □Strongly Agree, □Agree, □Neutral, □Disagree, □Strongly Disagree

6. The Ministry uses IT Tools to capture, store, and share knowledge of research, projects, training, and workshops?
   □Strongly Agree, □Agree, □Neutral, □Disagree □Strongly Disagree
7. The existing systems in the ministry have the capability to capture, store, and share knowledge effectively?
   □Strongly Agree, □Agree, □Neutral, □Disagree, □Strongly Disagree
8. The ministry has good infrastructure for implementing a large web-based knowledge repository system?
   □Strongly Agree, □Agree, □Neutral, □Disagree □Strongly Disagree
9. Please mention the existing methods in the Ministry that are used to capture, store, and share the knowledge resources of research, projects, training, and workshops? ……..
10. Please give your recommendation: what kinds of systems are needed to capture, store, and share knowledge resources of research, projects, training, and workshops? ……..

APPENDEX B: Prototype evaluation questionnaire

1. The system is authenticating each user properly.
   □Yes □No
2. The system can create, edit and delete users properly.
   □Yes □No
3. The system can upload, edit, download and delete knowledge.
   □Yes □No
4. The system enables the users to search for knowledge easily.
   □Yes □No
5. The system is useful for MCIT and solve identified problems
   □Yes □No
6. The system enables the user to subscribe, share and comment.
   □Yes □No
7. The system enables the users to publish knowledge.
   □Yes □No
8. The system enables users to chat with each other.
   □Yes □No
9. The system is easy to use and easy to learn.
   □Yes □No
10. The user interface of the system is attractive
   □Yes □ No

APPENDEX C: Prototype evaluation results

	Items	Yes	No
		Freq.	*Freq.*
1	The system is authenticating each user properly	6	0
2	The system can create, edit and delete user properly	6	0
3	The system can upload, edit, download and delete knowledge	6	0
4	The system enables the users to search knowledge easily	5	1
5	The system is useful for MCIT and solve identified problem	6	0
6	The system enables the user to subscribe, share and comment	5	1
7	The system enables the users to publish knowledge	5	1
8	The system enables users to chat with each other.	6	0
9	The system is easy to use and easy to learn	5	1
10	The user interface of the system is attractive	5	1

Abbreviations

MCIT- Ministry of communication and Information Technology
KM- Knowledge Management
KM Admin- Knowledge Management Administrator
KMS- Knowledge Management System
KRS- Knowledge Repository System
HTML- Hypertext Transfer Mark Language
UML - Unified Modelling Language
JDBC - Java Data Base Connectivity
JSP- Java Server Page