Knowledge-Based Information Retrieval System for Construction Industry

Applying Knowledge Management Concept in Small and Medium Enterprise

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***Abstract*— Knowledge management (KM) is the process of making the best use of knowledge and information within an organization to achieve business objectives. It allows people to access and apply the most appropriate knowledge when it is needed and supports learning. Knowledge-Based Information Retrieval System is one of the tools built for small and medium enterprises (SMEs), especially for construction companies that need to manage information in their abundance of explicit documents that are dependent to the employees' tacit knowledge. Through this system, the employees can share their explicit and implicit knowledge in the knowledge management system, which is developed with the concept of knowledge-based information retrieval. The development of this system will ease employees' work in the company in terms of retrieving information, sharing knowledge, leveraging knowledge management, and so on. The main function of the Knowledge-Based Information Retrieval (KBIT) system is to enable users to search for files related to project or tender, or files needed at that time by project name or by location. Besides that, users can view the files and scroll the documents through the system interface. This system will bring a significant impact to the users, who consist of the administrator and employees. In addition to that, it will improve the business process and ensure efficiency in the company's business value chain. The important contribution of this system is in terms of reducing waste of time to search for files.**

Keywords—knowledge management; knowledge-based; information retrieval; web-based system

I. INTRODUCTION

Knowledge-Based Information Retrieval system (KBIR) is a system developed especially for a construction small and medium enterprise (SME). In this globalization, SMEs must follow the path of technology in order to be in competitive in business. It is expected that a positive impact on business process management can be realized with the introduction of the Knowledge-based Information Retrieval system (KBIR). In addition to that, important decision-making and action can be done faster and easier. If used correctly and to its full potential, the system platform can become an invaluable tool for an employee to meet their expectations. Through this system, the company can share their explicit knowledge and implicit knowledge, since its development is based on the concept of knowledge management. The development of this system will ease employees' work in the company in terms of retrieving information, sharing knowledge, leveraging knowledge management, and so on.

II. RELATED WORKS

This section covers the previous literature and research relating to this study. It is separated into few sections, namely knowledge management, information retrieval technique, knowledge-based system, and knowledge value chain.

Knowledge management (KM) tools are important in the construction company. The industry depends on human knowledge, with limited systems support. "Knowledge is a hidden asset, to be sustained for long term corporate sustainability, and KM is a method to exploit and transform knowledge as an asset for organizational use and improvement" [1].

In KM, the best four components of knowledge management are people, processes, information technology, and strategy. The organization needs to provide resources to store essential information as it boosts the effectiveness of the decision-making ability of an organization. By ensuring that all workers have access to the overall experience kept within the organization, a smarter workforce is created that can make decisions that support the company more easily and informedly.

A. Knowledge Management

Knowledge management (KM) is important to organizations. Researchers revealed that knowledge can help improve business performance. The benefits of knowledge management for small and medium sized enterprises (SME) defines employee development, innovation, customer satisfaction and organizational success as areas SME businesses benefit from [2]. From the author's systematic review, it is shown that small businesses face unique KM challenges that are distinct from those of their larger business counterparts. To implement approaches originally developed for larger firms in SMEs, SMEs tend to place more emphasis than larger firms on the management of tacit knowledge, and communication channels in SMEs are more likely internal to the organization

[2]. KM activities, such as knowledge sharing, are time consuming and require a certain level of trust, especially when high staff turnover is found in many SMEs.

The technologies that are used to manage knowledge and the effectiveness of these technologies, including strengths and weaknesses of particular information technology (IT) in managing knowledge in the construction industry [3]. It shows that conventional technologies, such as telephones, are used more frequently to manage knowledge than a more radical IT tool like Groupware or video-conferencing. In construction firms, the potential benefits of IT for KM are not fully exploited and many have expressed a need for greater implementation of IT appropriated by sufficient training and education of employees [3]. Nevertheless, study on IT in construction industry [4] proves that the internet and intranet have high usage and effectiveness in knowledge management. Research findings by this author showed that there are gaps in the literature on migrant knowledge workers in construction companies, as to what will happen when they go home. Importance of knowledge and its management for the construction sector is apparent and KM is immature.

The area of KM brings out the importance of organization as it proves that knowledge management is a key driver of organizational performance as well as being a critical tool for organizational survival, competitiveness and profitability [5]. In order to successfully implement KM, strategy, creation, organization, leveraging (sharing) and application of knowledge must be taken into account. There are three key components to bring the importance of KM, which are people, process and technology [5]. People is very important to organizational success but they give effect to staff turnover and are affected by company's downsizing. Researchers argued whether knowledge is always something good, and found that knowledge does not give much value for this case. Similarly, the concept of knowledge and knowledge management as nature and lifecycle of knowledge management defined into three components: the effective utilization of people, processes and systems (technologies) [6]. Both these authors found that these three components need to be effectively managed to meet the objective of any knowledge management practice.

A framework is developed for characterizing the various tools and techniques available to knowledge management practitioners, and found new tools like web-based applications as unique, because applications that are free can thrive on users' participation [7]. It is argued that knowledge intensive processes have met with less success. In supporting this, the knowledge-based view theory (KBV) and competitive value framework are combined to develop a new theoretical framework for investigation of factors that affect innovation, and has shown its contribution to firm management in formulation of policies and strategies for sustainability in innovation context [8]. Innovation assists organizations to supply product or service in a sector to operate innovatively, competitively and profitably. The study opened new perspectives into KBV theory as internal resources and indicated how the innovative of firm's internal resources in terms of organizational strategy leads to resources management in both the internal and external environments of organizations. The benefits of innovation are shown to be both comprehensive and sustainable in the long term for the whole industry.

By focusing on identifying employees' needs and issues, activities and initiatives can be recommended with the confidence that these will have a clear and measurable impact upon the organization [3]. Innovation and knowledge management provide competitive advantages for organizations when organizations fully exploit their dynamic capabilities by mobilizing knowledge, experience and technology within a supportive organizational context. In addition, effective knowledge management in construction is not just about the supply side (data and communication systems) but also involves the demand side (business goals, strategy and people issues) [3].

A web-based database framework for the knowledge management of construction projects is introduced in 2014 [9], to assist construction companies with the collection, storage, exchange and use of project and corporate knowledge. A study shows that the key benefit of this method is the development of organizational memory and the assistance of organizations in their project management activities. It is expected that this tool will improve the organizational learning abilities of construction organizations and better build organizational memory.

An approach of communities of practice (CoP) is proposed to uncover tacit knowledge in the construction industry [10], which can promote the capture and management of project knowledge. It pays special attention to tacit knowledge by objectively examining the literacy on the relationship between knowledge. It is critically important to exploit the findings of studies on useful project information that exists in the field of the construction industry, especially the tacit knowledge that resides in human minds, as it makes up a significant proportion of the intellectual commodity that is much required to achieve enhanced efficiency and sustainable competitive advantage [10].

An evidence from Malaysia on the impact of tacit knowledge management on organisational performance proves that companies apply implicit information management techniques that are likely to affect their corporate efficiency, both tangibly and intangibly [11]. It affirms the importance of tacit knowledge in knowledge development and management, especially to those who aim to succeed and boost their corporate efficiency for improved execution of company operations and return on investment (ROI) from the top management level of every enterprise.

There is a framework based on the concept of knowledge management and growth performance in construction companies [12] that looks into the growth efficiency and the goals of the system for more study on the effect of knowledge management on the growth performance of construction firms. The supporting study indicated that growing companies have long attracted the attention of policy makers worldwide as high growth enterprise, and are seen as important contributors to employment, innovation, and competitiveness, innovation, and competitiveness. Companies who experience meaningful growth would lead them to make the country more productive contributors. Development is essential to an organisational well-being, and information is a key resource that needs to be handled well to achieve the success output of the company.

B. Information Retrieval Technique

In the area of information retrieval technique, embedding knowledge into information mining algorithms and finding suitable techniques for information retrieval indicates usage of KPS (Keyword, Pattern, Sample search techniques) algorithm is probably more suitable for searching one site, than the whole Web [13]. Although it cannot mine all desired information, it is very useful for information extraction of textual Web pages. From research, information retrieval techniques cannot give precise answers about semantic content of documents, because of difficulties in automated extraction of knowledge. Therefore, more work should be done to apply semantic knowledge and natural language processing techniques.

A study on modern information retrieval provided a brief overview that are key advances in the field of information retrieval, and a description of where the state-of-the-art is at in the field proves the task of finding information. Statistical techniques have proven to yield many new technologies used by people on an everyday basis [14]. An information management, retrieval, and display system for searching through an informational resource and displays the results of the search in a collapsible/expandable format based on a user-selected display criteria or hierarchy [15]. It showed that the display hierarchy allows the end-user to obtain items of interest effectively and quickly from the search results. On top of this, effective techniques include improving document ranking using query modification via relevance feedback [15].

Information retrieval (IR) is concerned with the organization, storage, retrieval and evaluation of information relevant to the query [16]. In normal case, the user having an information needs to formulate a request in the form of query written in natural language, as the retrieval system responds by retrieving documents that seem relevant to the query. The effectiveness of the retrieval process proves the improvement of information retrieval systems through the development of intelligent techniques aimed at helping users to find relevant information [16]. The use of conceptual graphs as a knowledge representation formalism offers many advantages in IR. The general model presented by researchers for creating conceptual graph from natural languages text can be easily extended to capture more semantics if domain specific information is available.

C. Knowledge Value Chain

The concept of knowledge value chain comes from the original concept of value chain in business world. The value chain is a concept from business management that was coined and popularized in 1985 [17]. A value chain is a chain of production activities in a firm, starting from the input up to the final customer delivery. The chain of activities gives the products or services more added value than the sum of added values of all activities. On the other hand, knowledge value chain (KVC), based on the famous but fuzzy DIKW hierarchy (i.e. data, information, knowledge and wisdom), is a chain of fundamental intellectual task (cognitive activities) [18]. The management of KVC gradually brings the organizations to superior cognitive capacities, from memorization, understanding, learning and intelligence up to maturity.

A study on knowledge value chain in 2000 [19] shows that KM guides the way a corporation performs individual knowledge activities and organizes its entire knowledge value chain, indicating that competitive advantage grows out the way corporations organize and performs discrete activities in the knowledge value chain, which should be measured by the core competence of the corporation. For KM to "open the black box" of a corporation and examine its intricate details, the corporation should treat more or less as a box of tricks producing the predictable outputs of knowledge-based products and services from specific inputs of information or/and knowledge [19].

D. Knoledge-based System

Human brains have limited storage to save abundant of knowledge. Knowledge is one of the most critical success factors for many businesses. Safe store, creation, refinement and application of knowledge are some major key factors in knowledge management process [20]. The implications on development of a nation, commodity or population proves the need for knowledge-based systems (KBS), which are a step towards an intelligent system that can be justified when a few individuals have the majority of the knowledge [20]. The important factors in selecting a KBS tool its appropriateness in domain modelling are proving a new knowledge-based task must share in a domain, as well as a viewpoint, with an existing knowledge-based task [21].

Furthermore, knowledge management with a focus on the potential role of information technology in the process [22] indicates that KMS on various and flexible IT capabilities can lead to various forms of KM support, extending beyond the traditional storage and retrieval of coded knowledge.

Current trends, the intrinsic nature of systems, and the development of systems thinking and methodologies are explored. Key KM systems are detailed, with an emphasis on their component technologies and their effective implementation. From the above discussion, various facets, emerging issues, and perspectives are discovered on knowledge management in a few topics like information retrieval, knowledge-based system, and knowledge value chain. From this literature, advantages and disadvantages are drawn and discussed, and the knowledge-based system is the best tool for knowledge management, as it stores tacit knowledge and explicit knowledge. Supporting this, the information retrieval technique is suitable to be applied to the proposed system. Currently, the information retrieval technique is already in use in many areas by people on an everyday basis. Lastly, in terms of the knowledge value chain, knowledge management can make a valuable contribution to the achievement of strategic objectives in facilitating the knowledge value chain in organisations' business operations.

III. METHODOLOGY

This section presents the methodology that this research takes up in the design and development of the KBIR system. The methodology adopted is the Rapid Application Development (RAD) model, as shown in Figure 1. RAD starts off with requirements planning stage and user design stage that consists of prototype, test and refine steps, followed by construction and cutover stages.

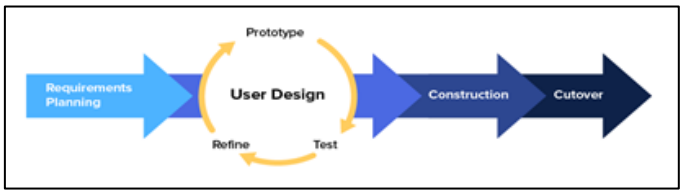

Fig. 1. Rapid Application Development (RAD).

A. Requirements Planning

In the requirements planning stage, all the important things needed and suggested by the company are defined to be incorporated in the Knowledge-Based Information Retrieval system (KBIR). Any proposals about system functionality are prepared and defined accordingly. In this project, data analysis and research review are required to reinforce the project goals and objectives. The method used in this project is an interview with the client to get the system requirements.

The interview was conducted on a case organisation (identified here as UISB) in April 2020. It was conducted virtually due to the COVID-19 pandemic crisis and Movement Control Order (MCO) during that time. The interview respondent, the Managing Director of UISB, provided the project priorities and objectives, as well as the existing and future problems that need to be resolved by developing KBIR system.

B. User Design

All the information gathered during the requirement planning is analyzed. During this stage, state changes and optimization are done, and sets of data are further defined. Any description for adding, removing, or changing the data objects are also created. All the diagrams including class diagram, use case diagram, activity diagram and sequence diagram are illustrated to provide clear process flow of the system. In addition, the diagrams allow users to understand and eventually approve a working model of the system that meets their needs.

Each module designed in the prototype is tested independently during the iteration in this phase. The tests are followed by refining step to repair and improve the system design to meet the requirements and system design objectives.

C. Construction

In construction stage, the code development of Knowledge-Based Information Retrieval system (KBIR) started according to the functions identified in the earlier stages. The development is performed using PHP programming language, hypertext markup language (HTML), cascading style sheet (CSS), JavaScript and bootstrap, based on Laravel framework. The platform used is the Sublime text editor for development. The system runs using Laragon as server and HeidiSQL for database, and it is tested on web browser using localhost. The system is then uploaded on a web hosting server. In addition to that, Amazon (S3) services is also used for file storage at server. Amazon Easy Storage Server (Amazon S3) is an Internet storage service that can be used to store and recover any volume of data from anywhere on the Internet at any time.

D. Cutover

In the cutover phase, the KBIR system is given to the case organisation to be evaluated as a whole system. If there are no bugs or defects that need to be fixed, then the system is ready for full implementation. If there are any, the project needs to be revised and reverted to the User Design phase. The KBIR system is evaluated based on usability and functionality tests and feedback from the respondents. Cutover phase is the final phase in this methodology, and all the upgrading, fixing and enhancing the prototype will be done in order to make the prototype work properly as it was planned.

IV. PROTOTYPE DEVELOPMENT

Knowledge-Based Information Retrieval system (KBIR) is designed and developed to produce the following modules: login page, dashboard page, project list and folder list. The interface of each module will be different based on the privilege given to the users who access it. This privilege is based on the permission set by the administrator. As an example, project owner can view the file access information while other employees do not get that same privilege.

Figure 2 shows the system login page interface. The control of permission or privilege is done in the background, which its interface can only be accessed by the administrator. This is one of the many security measures required for this system. In addition to that, a registration page to create new users for administration is designed, as shown in Figure 3. The purpose of this page is to ensure that only the office administrator can create new users.

Fig. 2. System interface – login page.

Fig. 3. System interface – login page.

Figure 4 shows the system interface of a dashboard, accessible by the administrator. In order to have control of the system and for security reasons, this dashboard is allowed to be accessed by the administrator, to monitor and manage the records of projects and folders stored in the system. The display of this information is in the form of graphs.

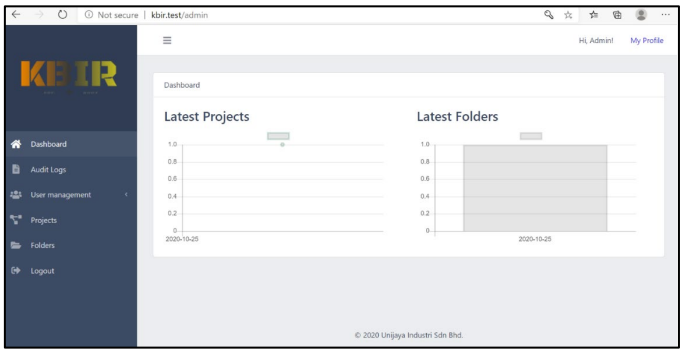

Fig. 4. System interface – administrator's dashboard.

Figure 5 shows the project information management, which covers the list of projects created in the system, as well as the details of the project information once a selection is made on a project in the list. Users can view the full list and details of the projects, but only can create new project and edit project information if they have further privilege, such as being a project owner or having a role of assistant project manager. The project information management module is the parent director for folder management. This means that there would be many folders created under one project. All files saved in the folders created under a project will have information related to the project.

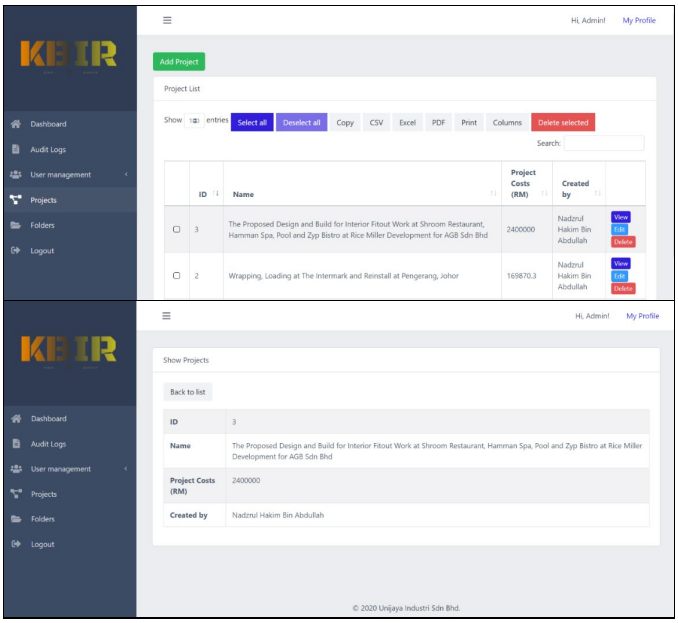

Fig. 5. System interface – project information management.

Figure 6 shows the folder management interface. As mentioned above, each folder management view is related to a project. For a project owner, he or she can go straight to the folder that is created for the project owned. In this module, there are features of folder list, create folder, show folders and edit folder. Since the main directory for folder management is the project information management, creating a new folder must be based a project listed in the project information management or project main parent directory.

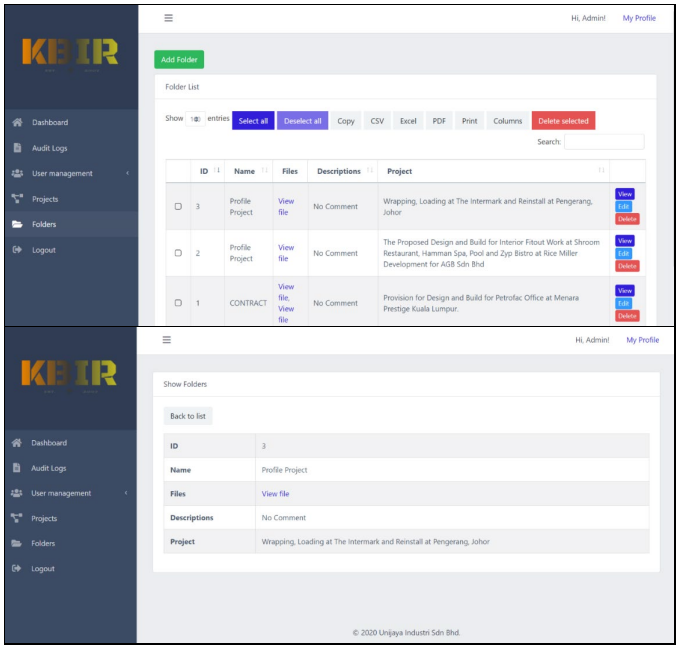

Fig. 6. System interface – folder management.

For a normal user, or any employees in the company, a simple view of project list can be accessed, as shown in Figure 7. This is the basis of the whole Knowledge-Based Information Retrieval (KBIR) system, in which the main purpose is for efficient search and access to knowledge within the project information management and folder management modules. Despite the access rights given to search and view the projects, the in-depth view of folders and files within the projects is still controlled by the privilege or permission given to the users. The number of buttons shown on the right most column of the list in the interface indicates the access rights that the users have for each project. Compared to the interface shown in Figure 5, an administrator has more rights than a normal user.

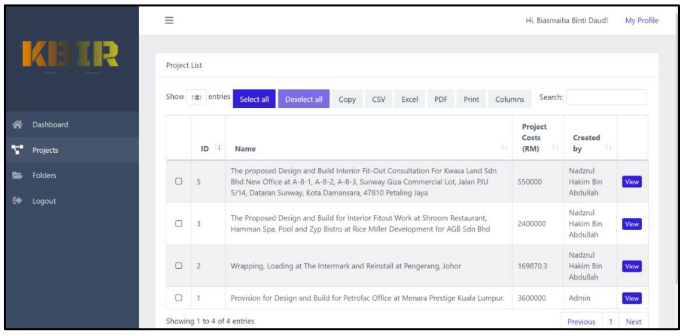

Fig. 7. System interface – users' view of project list.

V. Evaluation Results and Findings

Figure 8 show the demographic information of the respondents who evaluated the KBIR system in October 2020. There are 9 respondents who responded to the questionnaire

survey and testing. Based on this figure, the respondents came from various background and have many years of experience in career. Most respondents are accountants (33.3%), followed by clerks (22.2%), interior designer (11.1%), system security (11.1%), site supervisor (11.1%) and cashier (11.1%). Since the case organisation is a small company under the category of SME, the number of respondents here basically covers almost all the roles in the company who will use the system, and their responses can be generalized for the whole case organisation.

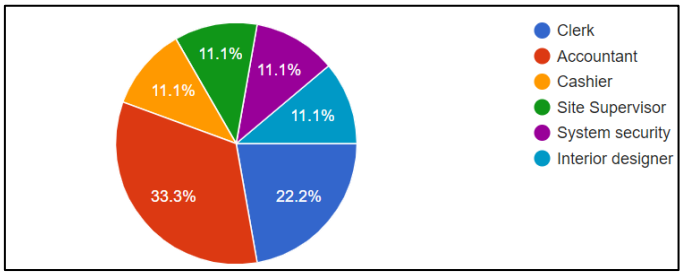

Fig. 8. Respondents' role in company.

Figure 9 shows the user acceptance towards KBIR system. A Likert-scale of 1 to 5 was used in the questionnaire, given 1 to indicate "strongly agree" and 5 to indicate "strongly agree". Respondents were asked to rate their agreement level for each question given in the survey.

Based on the feedback shown in Figure 9, majority of the respondents accepts this system for use as it has all the expected functions and capabilities as stated in the system requirements. Only 33.3 percent (33.3%) are unsure (i.e. neutral) if all functions we made available in the system, mainly because they were not part of the interviewees during the requirements analysis stage to know what was initially discussed during the session.

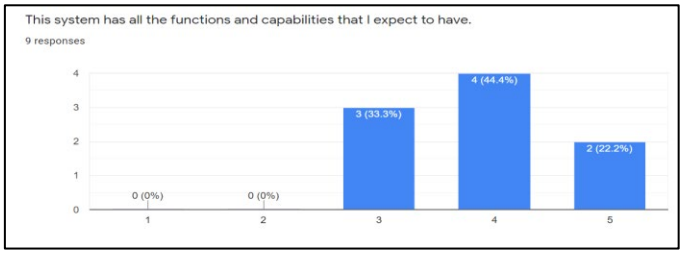

Fig. 9. Response on system functionality.

Figure 10 shows the agreement of the respondents in terms of user-friendliness of the KBIR system. Most of the respondents voted "agree" (Liker-scale 4) and 33.3 percent (33.3%) of them voted "strongly agree". However, one respondent (11.1%) coveted "disagree", with possibility of not understanding how to navigate the system accordingly.

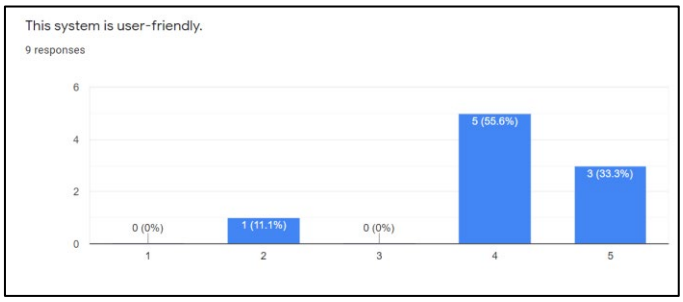

Fig. 10. Response on system interface.

Figure 11 shows the users' acceptance towards KBIR system in terms of overall satisfaction. All respondents agreed (44.4%) with majority strongly agreed (55.6%) that KBIR system is needed by SME companies in the construction industry.

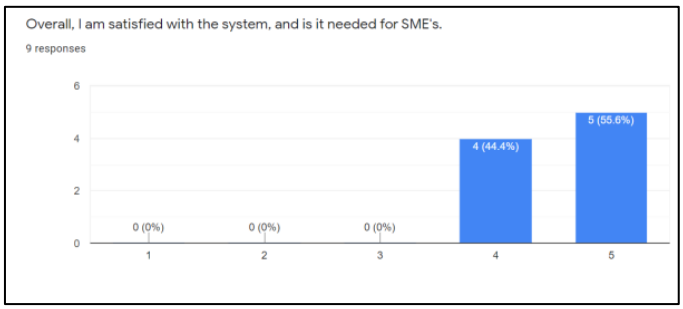

Fig. 11. Response on system interface.

VI. Discussion

Knowledge management (KM) systems are primarily driven by an organisation's desire to improve quality management processes and knowledge sharing. A simple share of knowledge can be done by accommodating the needs to find the right information in an efficient manner, as how this Knowledge-Based Information Retrieval system (KBIR) is designed to provide. Since finding the right information (which resides in explicit documents and files) is crucial in understand knowledge in a construction firm, a simple system like KBIR is highly needed and appreciated, as proven in the survey result shown in Figure 11.

As presented in this paper, all projects and folders with documents will be stored in the Knowledge-Based Information Retrieval system (KBIR). This project has successfully develop a simple system suitable to increase efficiency in SMEs in construction industry, as the demand is still there despite the many available software and applications in the market. The usability and acceptance tests are successfully conducted, despite the challenges in performing them during the COVID-19 pandemic. Even though the number of respondents may seem insufficient, it still reflects the objectives of the evaluation with various roles of respondents'.

Knowledge-Based Information Retrieval System (KBIR) is one of the tools technologies build to construction companies. This system can be the best solution for the problem statement. Through this system, the company can share their explicit knowledge and implicit knowledge in the knowledge management system. A combination of knowledge

management in a few topics like information retrieval technique, knowledge-based system and knowledge value chain makes it more complex. The development of this system eases employees' work in the company in terms of retrieving information, sharing knowledge, leveraging knowledge management and so on. The main function of the Knowledge-Based Information Retrieval system (KBIR) is to enable users to search for files by project or tender, or files needed at that time by project name or by location, and this objective is successfully achieved.

VII. CONCLUSION

This project brings significant impact to the users, namely the administrator and employees. Besides that, it will improve the business process and ensure the efficiency in the company's business value chain with added-value project knowledge. This project will help the construction sector to manage their business much more efficiently and effectively and help them to optimize their business process. Lastly, it also can reduce the waste of time to search for files.

Future work on the expansion of this research can be in terms of: statistical visualization of total project earnings by year; statistical graph on total number of users registered for access in the system; better security measures like only project members can see the project folders (i.e. with the authority only given by the project owner); and categorization of projects so that users can search for information by project categories.

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