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Research paper

Modelling and implementing a bilingual improved management system for research grants

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Abstract

Research is a vital process in academic and industrial communities requiring a lengthy process involving activities from different parties, including principal investigators, research teams, funding agencies, reviewers, and administrators. Moreover, successful research requires efficient management of several resources, including human and financial resources, which can be a challenging task to ensure positive out-comes of resulting research projects. Therefore, many funding agencies around the world that attempt to regulate this process through one or more information systems. However, according to existing literature, there is a gap between the existing systems and required functionalities. This paper describes a new design and implementation of a management system at UQU to encompass all research activities from Saudi funding agencies. The developed system was tested through two rounds of proposal submissions during two academic years. The results demonstrate improvements in the proposed system over existing products regarding functionality and integration.

Keywords: *Grant Management System; Research Grants; Systems; Saudi Funding.*

1. Introduction

Research can be defined as a systematic investigation process that aims to increase or advance knowledge. The produced knowledge can take many forms, such as data, applications, theory, equipment, or methods etc. and research is a vital process in academic and industrial institutions. In academia, research is the process through which postgraduate students graduate, and in industrial institutions, research is the process by which products and services are improved. Regardless of the type and field, research requires resources. For instance, qualitative research requires collecting data from people and analysing the data. Similarly, quantitative research requires collecting samples and conducting experiments. The need for these resources creates what is called research funding agencies, which provide funds to cover the expenses involved in the research activities. Examples of funding agencies include the NIH in the USA, EPSRC in the UK, and KACST in SA. The expenses involved in the research activities mainly include remuneration, tools and equipment, consumables, travel and accommodation, publication, and training.

Each funding agency has important research priorities. Once these priorities are determined, the funding process begins with a call for proposals. All received proposals are inspected against the rules and regulations of the funding agency, and only a team to check the feasibility and usefulness of the proposals scientifically reviews those that are verified. If the reviewers recommend funding the proposals and the agency accepts, then the Principle Investigator (PI) is allocated the budget that was requested in the proposal. Afterwards, the agency manages the research activities from two perspectives. The first is administrative where the agency performs activities, such as issuing purchase orders and paying remunerations. The second is scientific where they direct the research activities and explore the outcomes. At the end of the project, the agency signs it off.

2. Contributions

Managing the activities involved in the research process is not an easy task, especially when additional issues, such as ethical considerations, copyrights, or intellectual property may be incorporated. The task also becomes more difficult in Umm Al-Qura University (UQU) due to its size. UQU has more than six thousand professors teaching across forty colleges, which are established throughout thirty-two campuses. This research aims to:

- Achieve the objectives of the Saudi National Information Technology Plan focused on developing e-government.
- Support e-government concepts in the academic sector via improving e-service systems for researchers and grants.
- Provide a high-productivity environment for working in research areas.
- Benefit from the developed electronic systems to support decision-making at institutions.
- Reduce consumption of human, financial, and temporal resources related to managing research.
- Develop an electronic portal for managing research grants with optimal use of communication and information technologies.

These goals are targeted through the modelling and implementation of a web-based management system for research grants, which is described in this research. The system is designed according to the rules and regulations of the top-most funding agencies in Saudi Arabia including ministries, public universities, King Abdulaziz City for Science and Technology (KACST), and Saudi Arabia Basic Industries Corporation (SABIC). The system is called the Grants Management System (GMS) and has been tested during the previous two years in UQU, which is a top Saudi university. This proposed system is distinguished from other by

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providing bilingual user interfaces and integrating with other systems.

The organisation of this paper includes the following sections. Section 4 introduces the background about the research focus, and Section 5 describes the architecture of the developed grants management system and its components. The structure of supporting databases is outlined in Section 6 and the empirical platform is selected in Section 7. Section 8 discusses the results of this work as well as a conclusion to summarise the key points for the developed system.

3. Background

Due to the importance of research, a variety of efforts has been undertaken to develop research management processes and provide financial support. Research includes various processes and related subtasks that lead to complex management requirements. Previous efforts have improved research management through automation and modelling systems.

One well-established related topic is the management of research conferences. A conference management system (CMS) is a web-based platform for organising scientific events and includes tasks such as creating agendas and announcements as well as managing paper submissions, reviews, notifications, and registrations [1]. Existing CMSs include EasyChair, ePapers, HotCRP, CoCon, and ConfSys. Established in 2002, Easy Chair is one of the first conference management systems made available, and has hosted approximately 54,000 conferences and served more than 2 million users. Different user categories can interact with this system, including organisers, programme committees, authors, reviewers, members, and attendees. It offers many services such as monitoring programmes and activities, automation of the submission and review processes, and connecting users [1, 2]. ePapers is another commonly-used system for electronically managing conferences as it is used in many IEEE technology and engineering conferences. In addition to providing basic services related to submission, reviewing, and registration, it offers archiving data and various levels of technical support [3]. HotCRP was developed in 2006 to provide similar services and adds extra features such as smart search and tagging for papers [4]. CoCon is a conference management system that handles information flow securely. It was repeatedly improved as the result of information leaks, and it now controls users' access to certain data according to the user's role in the system [5, 6]. ConfSys is a research-based academic conference management system that supports technical work by publishing research papers [1, 7, 8]. It handles general tasks as well as improving session management and programme publication. Kanav et al. argue that the processes in existing conference management systems are complicated, which lead to systems errors, such as when the system needs to include further security improvements to protect information integrity and reduce other concerns about leaks of confidential information [5].

A related area in the system developed in this paper includes managing research grants. A research grant is a process through which researchers obtain financial support to accomplish their projects and studies [9, 10]. Although acquiring research grants is important, the process is complex and involves proposals, reviewers, and payments [11]. Researchers in Australia [12-14] highlight that the application process for research grants requires intensive efforts and consumes lengthy periods. Also, after all of the invested time, researchers still have a low chance of being awarded a grant due to extensive competition. Developing a flexible grant management system may facilitate and accelerate these application processes. Grants Management Systems (GMS) are information systems that handle the full life cycle of applying for grants from preparation and submission to supporting and final tasks. These systems are built to service and deal with thousands of research users and proposal applications. The existing literature includes limited scientific research discussing the development and technical aspects of research grant management systems as an information system. At the same time, the range of products for grants management systems in the marketplace has grown markedly concerning their variety in functionality and price.

Some developed grants management systems are filed as patents [15-17]. The multi-channel grants management system dynamically integrates between a grants management system and a financial management system and supports the application process through different forms available via the web, fax, telephone, or in person [15]. The invented grant management system by Kobeh et al. [16] focuses on financial concerns by receiving supporting information from different sponsors and dealing with many organisational transactions synchronously. Shulman [17] invented system that tracks proposals and predicts the success of grants and future funding based on past successes and an existing research portfolio. These systems are primarily focused on the financial side of the process and may not customise well with the academic research grant proposal sections.

The Consumers report [11] thoroughly reviews 29 grants management systems and compares them from a variety of perspectives, including cost, flexibility, complexity, outcomes, and functionalities. Approximately 20 features are evaluated, including tracking, online applications, emails, payments, data access, usability, and supporting features. This report demonstrated that the compared systems had various levels of quality considered as basic, intermediate, or advanced. Table 1 lists a summary of the ten grants management systems reviewed with the advanced level. This comparison suggests that all selected grants management systems suffer from limitations in some features that are reported as basic levels. Most require further development in features related to design, payments, requirements, email, reporting, customisation, and ease of use.

Table 1: Comparison of the Top Grants Management Systems [11].

	first Akoya.net	fluxx	foundation Connect	GIfTS online	Smart Simple GMS360°	Zengine Grants Management	Good done Great Grant MS	Granted Ge Spectrum	versaic Grants	fluidReview
Internal Tracking	●	●	●	●	●	●	●	⊙	●	●
Grant Maker Experience	●	●	●	⊙	●	○	●	●	●	●
Grant Seeker Experience	●	●	●	●	●	○	●	●	●	○
Form Design & Flexibility	⊙	⊙	⊙	⊙	●	⊙	●	⊙	●	⊙
Application Review	●	●	●	●	●	⊙	●	●	●	●
Email	●	●	●	⊙	●	⊙	●	●	⊙	⊙
Relationship Management	●	●	●	●	●	●	⊙	○	⊙	⊙
Requirements & Outcomes	●	●	⊙	●	⊙	○	⊙	⊙	⊙	⊙
Payments	●	●	●	⊙	⊙	⊙	⊙	⊙	●	⊙
Budgeting	●	●	●	●	●	●	●	⊙	●	⊙
System Querying	●	●	●	⊙	●	⊙	●	⊙	⊙	⊙

& Reporting										
Permissions & Workflow	●	●	●	●	●	⊙	●	○	●	⊙
Data Access	●	●	●	⊙	●	●	●	●	●	●
Customization	●	●	●	⊙	●	●	●	⊙	⊙	●
Ease of Use	⊙	⊙	●	●	●	●	●	⊙	●	●
Support	●	●	⊙	●	●	●	⊙	●	●	●

○ Basic ⊙ intermediate ●Advanced

Additional common grants management systems are produced as commercial software products, including Streamlyne Research, Microsoft Grants Manager Plus, and Grant Manager. Streamlyne Research [18, 19] is considered one of the recommended software tools that deal with the grant management lifecycle efficiently. The system is a cloud-based platform that handles different system users and provides many services, such as the creation of proposals, maintenance of funded projects, and financial entities submissions. Microsoft Grants Manager Plus is a customer relationship management (CRM) application that deals dynamically with grant processes, including initial stages, reviewing, and reporting, and provides a platform tailored to the specific needs of the customer [20]. Grant Manager is an online system that attempts to make the administration processes easier and faster by supporting many general tasks, including applying, tracking, evaluating, and grant awarding [21]. Although several commercial products are available, they do not consider these processes from research-based perspectives. These commercially-developed systems require further investigation for a thorough evaluation. Moreover, there is insufficient published information about analysing, designing, and developing processes in all these commercial systems.

The majority of the GMSs developed for customised regulation follow the provider's environment and language. Perbangsa et al. [22] mention that some products still manually run many functional processes and face obstacles to determine statuses. From this point, this research paper explains the structure of the newly developed grant management system. It contains different modules that are responsible for subtasks that adhere to the general Saudi regulations for grants. The proposed GMS also handles financial processes for the grant application in an appropriate manner as well as providing significant new features, including checking the originality of proposals and following-up on supported grants until their termination.

4. Grant management system

This section describes the developed grant management system for an academic university. This new system features an online portal for serving thousands of users, including researchers, administrators, reviewers, and scientific committees. It is also designed to be updated and responsive through the verification of data entries using a dynamic wizard.

Understanding the system processes is essential to designing an appropriate system architecture. Figure 1 shows the flow chart for the key processes and procedures utilised in the developed system. The sequential processes begin with submitting a research proposal and determining if its completeness. The proposal then moves to the subsequent process to provide an assessment by external reviewers. Next, the scientific committee evaluates the reviewed proposal, and after the approval process, the researcher signs the contract and starts working on the project. Finally, the researcher must submit all required reports after all work is complete and terminate the research grant.

The system architecture consists of five main modules: applying module, Verification module, reviewing module, approving module, and follow-up module. The first handles the submission processes of the research proposals from the researchers. The second allows the programme administrators to be confident that the submitted application forms match the initial requirements. The third is responsible for the reviewing processes performed by external reviewers. The fourth allows the evaluation of the entire research proposal project by the scientific committee and the selection of the approved proposals. The final module in the system is performed after the researchers sign contracts representing the completion of their research projects.

The system architecture is diagrammed in Figure 2 where all modules are illustrated separately, and the integrations between them are described in the following sections. Different user categories utilise the GMS to accomplish several tasks and enter related data. Each user is assigned an appropriate access control panel to the system according to their job roles at the university. All users work with the system through user interfaces designed specifically to the related modules.

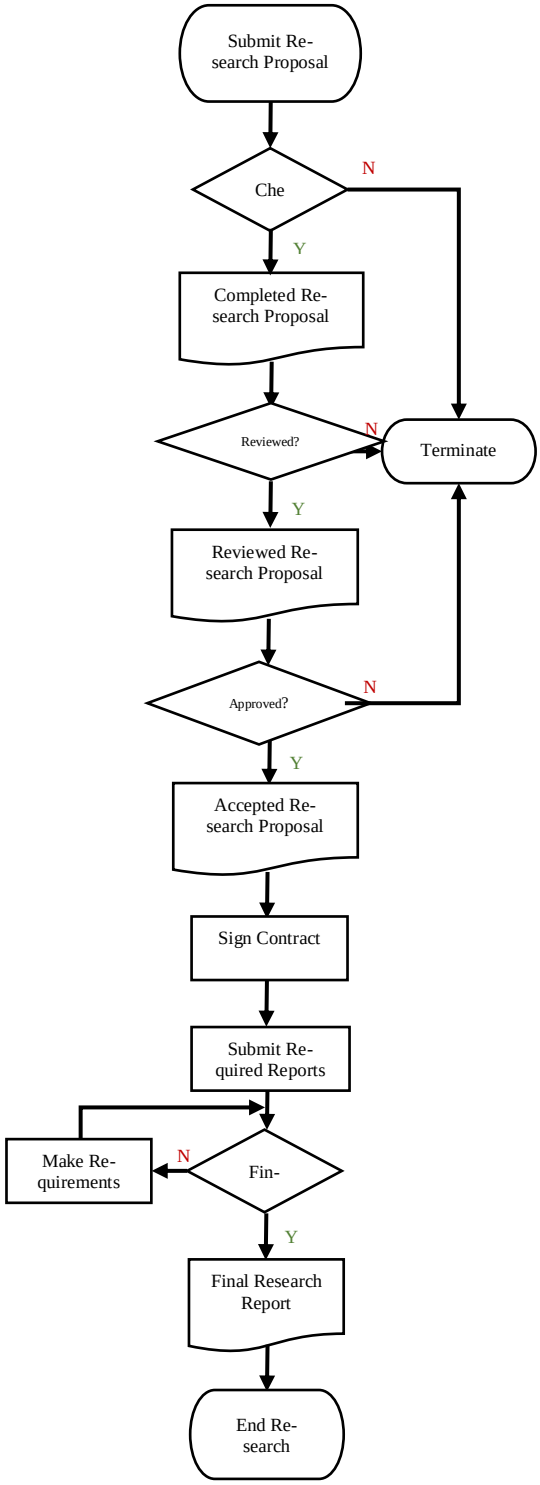


Fig. 1: Flow Chart of the Proposed GMS.

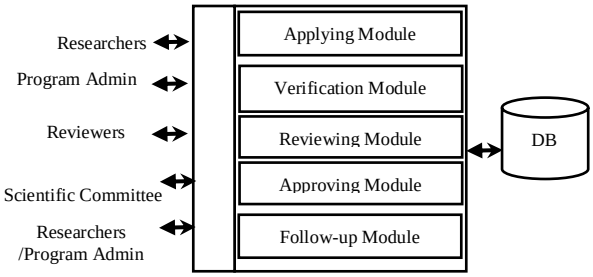


Fig. 2: GMS Architecture.

4.1. Applying module

The first module processes the proposal submission for applying for research grants. The procedures in this module align with the information requirements defined by the scientific committee. To complete the submission, the researcher must perform the following steps:

1) Log in to the personal control panel.
2) Accept the initial agreement.
3) Input general information regarding the research proposal, including title, keywords, research area, track, and duration.
4) Upload research files containing all parts of the proposal: abstract, introduction, literature review, methodology, value to the country, reference, and resume files.
5) Insert information about the research team and receive electronic agreement to participate in the proposed research from co-researchers, consultants, and research assistants.
6) Separate the proposed research project into phases and tasks.
7) Map phases and tasks to related research objectives.
8) Assign tasks to the research team and estimate the required time.
9) Relate research outcomes to the specific research grant programme.
10) Calculate the research budget, including personnel compensation, materials, equipment, and travel.
11) Recommend reviewers who are then used to populate the review database maintained by the system.
12) Accept the final agreement.
13) Submit the completed research proposal.

The applying module is flexible because it automatically saves entered information at each step into the database and allows users to modify their information as needed before the final submission. At the end of the process, this module produces a complete PDF file as a reference copy for the researcher.

4.2. Verification module

This module focuses on verifying the initial requirements in the submitted research proposals and evaluates each according to specific rules as defined by the scientific committee. The policy rules consider the following perspectives:

- Complete: Check if the research proposal has provided all required sections and attachments.
- Original: Generate plagiarism reports using developed algorithms and determine a plagiarism percentage to identify the originality of research.
- Appropriate: Ensure the number of research team members does not exceed the maximum limits and measure the budget plan to determine if it is suitable.

After the programme administrator processes the verification rules, the module classifies all proposals into two groups: Group 1 contains all completed proposals, and Group 2 includes incomplete proposals. The proposals in Group 2 are then either completed or rejected, depending on any limitations. The module classifies the processes by colour to represent each proposal's status. All proposals in all situations may be easily sorted according to different attributes. At the end of the process, the module moves the completed proposals to the next module to begin the reviewing process and informs users of rejected proposals including the reasons for rejection.

4.3. Reviewing module

The reviewing module deals with both the proposals and the external reviewer. The programme administrator selects reviewers from different countries and inputs their information, including basic and research field data. Next, each research proposal is simultaneously assigned to one or more reviewers, according to the research area and research specialisation.

The external reviewers have access privileges to the proposal through the GMS to complete the reviewing forms, which include several rules for reviewing and are measured by marks and comments. The external reviewers evaluate the proposal from different perspectives, including the scientific, team management, and financial viewpoints. The scientific view covers basic points about

the evaluation of the content of the proposal, depending on the originality and creativity of the research. The team management evaluation focuses on if the research team is applicable for working on the suggested proposal based on their experience and speciality. Next, the required budget is validated as suitable for the research proposal.
This module allows the programme administrator to follow up on the status of all the proposals under review, notify external reviewers, and manage the entire reviewing process. The control panel for this module also offers different services for external reviewers to control their accounts and handle their payment contracts. All data related to the reviewing process are stored in the system database to be used by other modules.

4.4. Approving module

The approving module functions based on the outputs of the previous reviewing module. The scientific committee inspects the reviewing results and checks if the external reviewer followed the defined policy rules. Next, they evaluate the required budget and highlight if it matches the grant requirements and does not exceed the maximum limits. Also, this allows for the study of the effects of the research proposal on the economy of the country. All these points are considered when identifying preferred proposals.
The control panel in this module provides all data related to the proposal to the scientific committee for a final decision. Intensive evaluations and studies guide the scientific committee to approve proposals. The research teams of these accepted proposals are informed through internal system messages. The final step is for the research teams to sign the contract and begin working on their proposal.

4.5. Follow-up module

All four previous modules handle the research proposal's submission, initial check, review, and approval. This module focuses on the resulting project and follows-up on the completeness of the processes. The control panel gives the principal investigator access to submit annual reports, modify the research team, and manage financial requirements. It includes submitting invoices and receiving funds. The programme administrators have full access to follow up on the funded research and notify the principal investigators before the deadline for submission of reports and request financial details. Moreover, the administrators check receipts and offer funds to the researchers. The follow-up module is available throughout the entire process until the project's close. Researchers must submit the final reports and close all financial requirements to terminate the grant.

5. Database structure

The backend database structure of the proposed system contains 82 relational database tables, and Figure 3 shows the ERD of the structure. The front end system along with the backend database are bilingual.



Fig. 3: ERD of the Database.

6. Experimental Work

This section describes tools, software, and datasets used in the experimental evaluation. The grant management system is developed using PHP and MySQL. PHP was selected because it is open source and widely used to develop dynamic websites and systems. MySQL is considered the second-most popular database management system and it adequately handles the designed relational database in our GMS.
The system was deployed at Umm Al Qura University for more than 6,000 academic staff in 40 different colleges across 32 locations. The GMS includes three main programs with distinct regulations: Baheth, Waedah, and Raeed. Baheth is a fast- track for male researchers to apply for grants. Waedah is a special programme to encourage females to work in research. Raeed is a fast-track for new academic staff to engage them in the research environment quickly.
The GMS was tested from the perspectives of functionality, flexibility, and performance. It is evaluated through two rounds of applications and submissions, and the application process for grants is open for one month each year. The results of using the system for applying for grants are explained in the following sections.

7. Results of evaluations

The GMS was deployed into a production environment and officially tested as previously described. This section explains the evaluation for the sub modules as well as the entire application. The system received applications for proposals in both rounds 1 and 2 and included transactions involving 284 proposals in round 1 and 229 proposals in round 2 covering the three grant programmes, Baheth, Waedah, and Raeed. The majority of applications were submitted for the Baheth programme, and the results of the three programmes are shown in Figure 4.

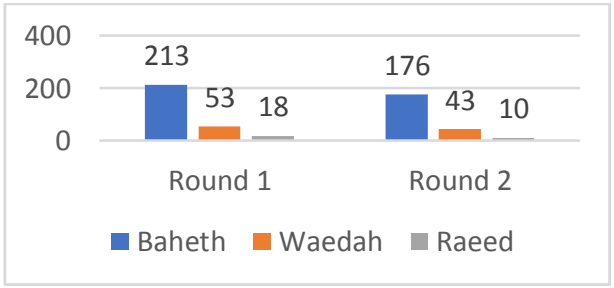


Fig. 4: The Quantity of Proposals Submitted in Round [1] and Round [2].

Hundreds of users from different colleges submitted these proposals. Figure 5 lists the participating colleges in round 1, and Figure 6 lists those in round 2. In both figures, the greatest number of proposal applications came from the College of Applied Sciences, as represented by approximately 80 proposals in round 1 and 42 proposals in round 2. The total number of submissions varies between colleges in both rounds.

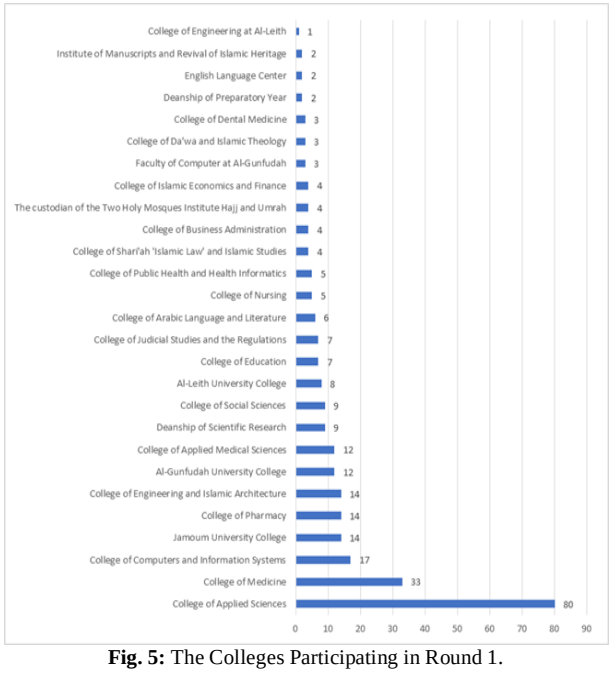


Fig. 5: The Colleges Participating in Round 1.

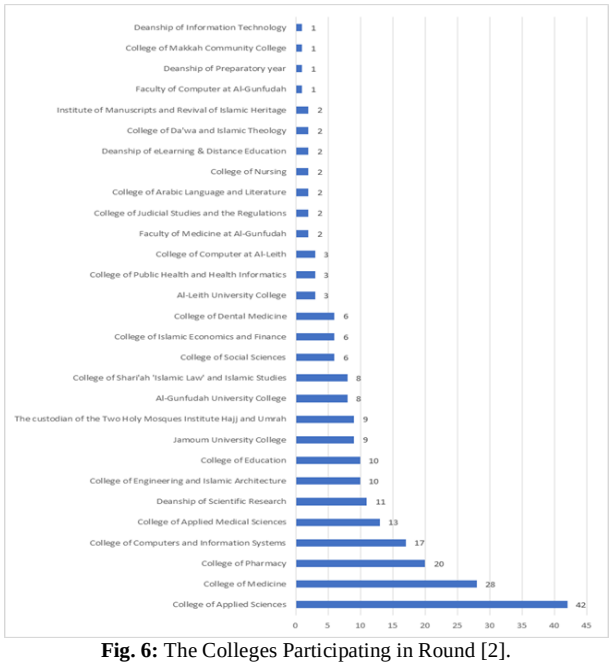


Fig. 6: The Colleges Participating in Round [2].

In round 1, the system received 284 proposal applications that were processed by the applying module. The Verification module next applied the initial requirements for these proposals, and the number of proposals reduced to 167. After the reviewing module completed the review process, the number of proposal decreased to 134. The scientific committee used the approving module to recommended 49 proposals for grants, and the researchers ultimately signed 47 contracts. The process stages in round 1 are illustrated in Figure 7. These users also controlled their grants and documentation for their supported projects using the follow-up module.

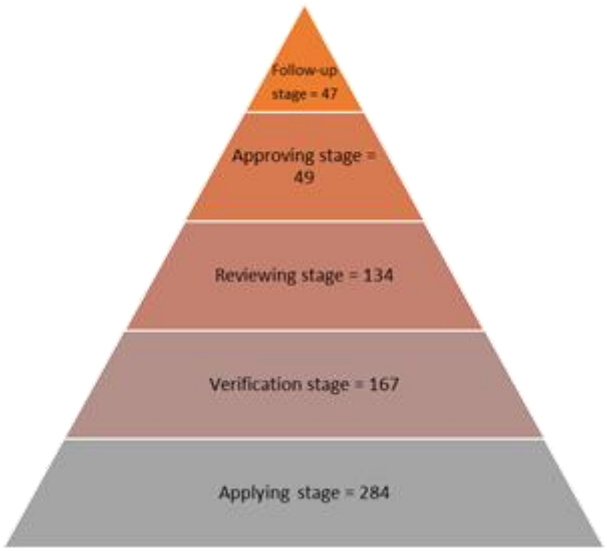


Fig. 7: Process Stages in Round [1].

The researchers using the system originate from different backgrounds and specialities, which led to several types of interaction experiences with the user interfaces. For practicality, the system provides users with step-by-step instructions using videos and screenshots. It also offers technical support for users through three channels: telephone, email, and in-person consultations. Figure 8 shows the requested channels of help from the researchers in round 1, and Figure 9 describes round 2. Considering the obstacles that users faced in round 1, the user interface was further developed further before launching round 2 so that it would be more usable and flexible. This effort was successful as the number of requested help cases decreased from 141 in round 1 to only 57 cases in round 2, presumably due to the improved processes in the system. It is apparent that the system is usable and flexible according to the history of users' interactions and feedback.

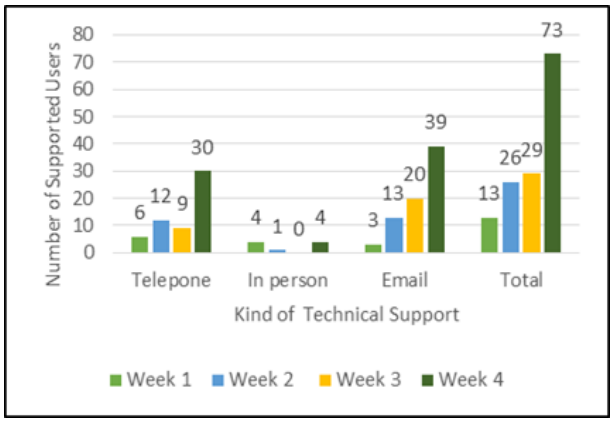


Fig. 8: Technical Support During Round [1].

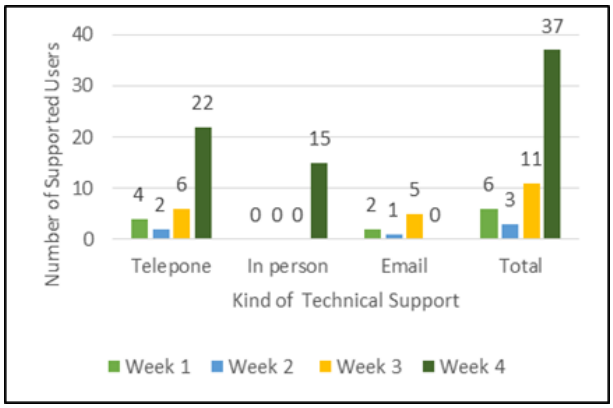


Fig. 9: Technical Support during Round [2].

8. Conclusion and future work

This paper proposes a design and implementation for a web-based bilingual (Arabic + English) Grants Management System (GMS), which targets Saudi funding agencies by accommodating all rules and regulations of the funding process. However, the system was designed in a parametric way such that it also allows accommodating rules and regulations from other funding agencies. The system was tested in two proposal rounds during two years at the Saudi university, UQU, which has more than 6,000 academic staff and 100,000 students. The results obtained from the testing period shows that the proposed system outperforms the existing ones.
Future work from this research will integrate this GMS with other systems, including human resource management, financial, and graduate student information systems.

Acknowledgement

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