SYSTEM UTILIZING USER-CENTERED DESIGN APPROACH

Paul Joseph M. Estrera [1], Jomar C. Llevado[1], Jocelyn L. Garrido*[,1]

[1]Department of Information Technology, University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines

*For Correspondence; Tel. +639656510866, Email: *jocelyn.garrido@ustp.edu.ph*

ABSTRACT: *Research-based Academic Institutions (AIs) need to adopt a Research Management system (RMS) to keep abreast with the growing demands of research workloads and to systematically keep track of the research files and monitor research activities to deliver on-time research outputs. This study aimed to develop a web-based RMS that includes monitoring research activities to keep track of research deliverables. The development approach used User-Centered Design (UCD) by getting informative user feedback through a series of interviews and system design presentations. Rapid prototyping was used to produce several prototypes that were revised through user feedback. As a result, the system was used with minimum effort without much concern on the "how-to-use" system. The study concludes that one of the success indicators of the system can be based on the volume of users using the system. In terms of system functionality, it provided seamless research management with reliable monitoring of research deliverables. It is recommended though that a case study be conducted to determine the effectiveness of the system in terms of the number of on-time research output delivery.*

Keywords: Research Management and Monitoring System, User-Centered Design, Rapid Prototyping, Monitoring System

1. INTRODUCTION

The involvement of Higher Education Institutions (HEIs) in research is one of the core determinants of the contribution they make to economic and social development [1]. At the University of Science and Technology of Southern Philippines (USTP), research is one of the core elements of its mission. Adhering to its mandate, USTP established its Research and Development Office (RDO) to create a seamless environment for research and teaching [2]. The provision of Research Centers is perceived as a necessity in its academic eco-system to boost research-driven educators and learners [3, 4, and 5]. As USTP gained its credibility in doing research, opportunities opened to forge a partnership from external entities to fund research projects. Gradually, the USTP-RDO develops a critical mass of researchers in the university. The urge of doing research become evident as more and more students and faculty were engaged. Consequently, the number of research outputs from various disciplines has increased significantly making its way to being a research-centric university.

Despite its ability to keep abreast with the needs of the research office, the increased growth of research endeavors brings new challenges. The operations within the research office is challenging in terms of research management and monitoring. Currently, the USTP-RDO uses the manual system in carrying out research workloads. The manual system used can be time-consuming and affect the productivity of the research office [6-7]. Also, the absence of an electronic database file repository can be prone to misplace, damage, and lost documents detrimental to the research office performance [5, 8, 9]. The manual monitoring of different research progress with different timelines can be tedious and time-consuming particularly when short of research staff. Moreover, poorly monitored research progress often results in delayed delivery of research outputs bringing doubts on the competence of both researchers and the university.

Nowadays many are turning to technology to systematically manage research activities [5]. This gives birth to the development of multiple Research Management Systems (RMS) for a fast, systematic, and organized research management that will keep track of all research activities in the university or organization[2, 5, 6, 7]. Adopting RMS can be done by making use of available RMS or through in-house development. Readily available RMS can be acquired by subscription (proprietary software) or by implementing open-source RMS software. However literary review reveals that the idea of subscribing to commercially available RMS like Elsevier, CONVERTS (Thomson Reuters) and Symplectic Elements to name a few with proofs of its efficiency and effectivity to manage research workload just as what most universities abroad have implemented is undoubted which makes it expensive to acquire and requires higher monetary budget allocation for its subscription [10, 11, 12, 21]. For university research offices with ample budget allocation on their operation, this option is not a sound choice to make. Furthermore, most proprietary RMS was not designed to adapt to the dynamic needs of the institution [13]. Unfortunately, there was no literature found on the usage of open-source RMS in academic institutions. On the other hand, some universities and institutions opted to develop their RMS to directly address arising problems related to research management and at the same time gain all the benefits of having a research management system [1, 7, 14, 15]. This study considered developing an in-house web-based research management system (RMS) that will address the problems of the manual system currently used in the USTP research office. The main objective of the study was to provide fast, systematic, and organized research management and monitor research milestones and deliverables. The RMS design was tailored-fit to the needs specific to the procedures and processes followed during the conduct of research in the university. To realize and meet the intended system requirements and functionality a User-Centered Design (UCD) approach was used throughout the development process. Moreover, the study also focus not only on the development of RMS that is functional and efficient but the goal was also to design the system in a way that the users can use it as a tool rather than learning how to use the tool [16]. With UCD, the system design was from the user perspective instead of the technical/developer perspective to increase the use, success and performance of the designed system [18, 19, 20]. Based on an existing study, the success goal of using UCD was evident in a reduced number of user errors, increased ease of use, increase user satisfaction, reduced development cost and time, reduce redesign cost and reduce training needed [21, 22].

3. SYSTEM FRAMEWORK

The development of the Research Management System (RMS) is anchored in the framework shown in Figure 1. The RMS runs in a web platform with a dedicated local database server that can be accessed using Wifi connectivity within the university area. User registration will be required to gain access to the system. The framework consisted of six modules as reflected in the figure. Handling of modules depends on the user rights set by the system administrator.

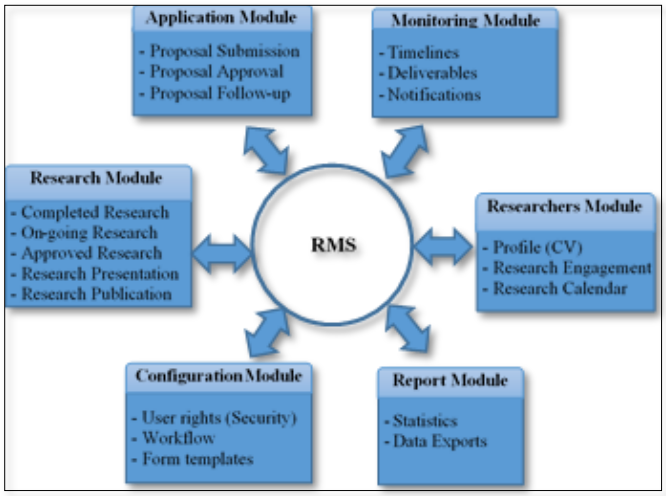

Figure 1: RMS System Framework

The application module handles the entire research application process, from posting research calls to submission of proposals, forwarding proposals for blind review towards acceptance or rejection of the research proposal. Here, all registered users are notified by the system when a call for research is posted in the system. Interested users can directly create proposals within the system by completing all proposal sections with the information needed as well as uploading all necessary files required in the proposal stage. The user has also the option to either submit a finalized proposal or withdraw/delete the proposal. When the user submits the proposal, the system automatically notifies the research director (RD) and research program officer (RPO) assigned for that area for the final review and selection process. All selected proposals are automatically forwarded to each pre-assigned reviewer based on a specialized field for blind review and reviewers are notified by the system. Reviewers can directly write comments and suggestions on each section of the proposal as well as the overall comments and verdict. The verdict can be accepted, not accepted, or for revision. This module also includes monitoring of the proposed paper which is reflected on the status of the submitted proposal. Status indicators are pending, selection stage, blind review stage, approved, disapproved, for revision. Apart from the tasks mentioned, some important aspect for final approval was also considered in this module such as budget, accounting and University heads approval which is beyond the system scope. Once these things are in place, the research director approves the proposal and the user is notified of the proposal acceptance and acknowledges the notification.

The monitoring module was intended for accepted research proposals only. This module is anchored on the timeline and deliverable (Gantt chart) section indicated in the proposal application module. Included in this module are notifications for nearly due research deliverables as a means to follow-up researchers on the needed document for timely submission. All notifications are also sent to the RD user account and the assigned RPO user account for awareness and overall monitoring of research conduct. A graphical progress report for each ongoing researches is also included in this module.

The Researcher's module was intended for individual researcher portfolios. This module keeps a dataset of researchers' profiles, research engagements and outputs and an activity calendar. Data on this module is essential for suggesting expert researchers from resilient research teams handle specialized research projects.

The research module serves as the RMS databank. It provides listings of research files such as completed, ongoing and approved research papers, research publications and presentations. This module can be used for literary reviews, possible areas for research conduct based on recommendation and a means to check the novelty of future research proposals.

The report module provides necessary information for a specific purpose like academic accreditation. This module generates information-based, statistical-based and graphics-based reports. Reports include time-based (yearly, quarterly, etc.) research outputs, externally funded research, on-time research, delayed research, extended research and other related reports relevant to the research office.

Configuration module handles the security of the entire system and adaptability of the system based on the dynamic needs of the research office. Security in this module adopted the concept of Authentication, Authorization and Accounting (AAA) principle. With AAA, the system filters who are allowed to access the system using assigned user login credentials (authentication). Authorization determines what type of activities, resources (files), or services a user is permitted. Using authorization, users are given a different types of access and activities in the system. Accounting logs all user activities such as what resources (files) were accessed, at what time and date, and what actions were performed as usage information. This is very essential to mitigate software security issues on user and data breaches. For adaptability and flexibility, the authorized user can either create or update the research forms and/or workflows and set the effectivity date of the new or updated forms and/or workflow. The system will implement the updates based on the effectivity date set.

4. METHODOLOGY

This study was an in-house development with the foremost participation of the Research Office during the design process. To keep the users as the focal point of the system, the development process incorporated three principles. First, the approach was user-centered because the participation of the users is given high priority. Second, the approach used rapid prototyping in the design phase producing several prototypes that were revised through user feedback. Finally, the approach was incremental throughout the whole process, because some modifications were necessary to improve the quality of the system through continuous and gradual refinement based on the user feedback. The development approach was the incorporation of UCD and the standard SDLC-Rapid Prototyping consisting of four basic phases:

requirement analysis, design, implementation and testing and evaluation as shown in Figure 2.

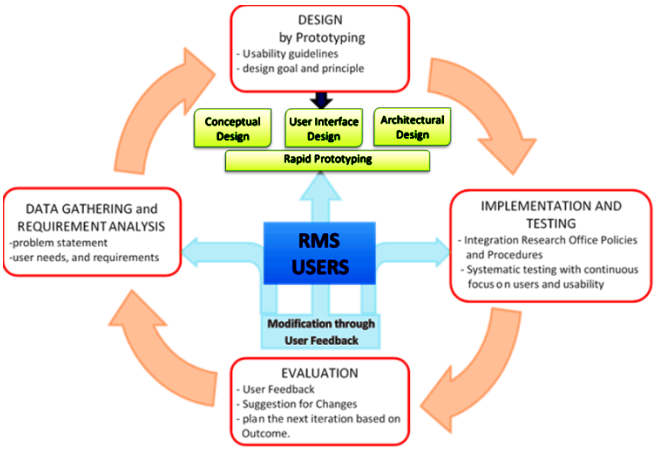

Figure 2: SDLC-UCD Approach

Phase I. Data Gathering and Requirement Analysis

The initial gathering of data used a focus group discussion with the proponents, the Research Office Director, Research Program Officer and the research staff of the university who were identified as the system users. Discussion included issues and requirements that need to be addressed by the system. Initial presentation of the system prototype was done to get feedback and suggestion for data collection related to the needs and expectations of the users as well as the expected sequence of works to be performed by the system. The main objective of this phase was to specify user and system-related requirements while developing a full understanding of the target user group and its tasks. This process is used in the development of the requirements specification document to identify key features and corresponding components that constitute the system environment.

Phase II. System Design Phase

The design phase of RMS consisted of three stages: Conceptual Design, User-Interface Design and Architectural Design.

Stage 1: Conceptual Design

The conceptual design focuses on the explicit construction of the system functionality based on the requirement analysis. This is to set a clear description of the proposed system in terms of integrated ideas and concepts about what the system should do, behave and look like that will be understandable by the user in the manner intended. A system context diagram was designed to present the birds-eye view of the proposed system.

Stage 2: User-Interface Design

This stage captured the user interface associated with the tasks and functionality each user intends to perform. Key features of the interface will be based on the users' points of view. A combination of three approaches will be used to express the functionality of RMS. The first approach used scenarios based on natural language statements. Scenarios will be associated with the operations the user performs. The second approach was to create an activity flowchart that will be used to organize the verbs that are extracted from the scenarios. The third approach was to create a prototype of the user's main pages based on the activity flow created on the second approach. The prototype was to show the functionality of the system of the users in a graphical interface. User feedback was collected during the presentation as the basis for the revision of the system page appearance and structure. From the formative evaluation by user feedback, the design continued for revision using rapid prototyping. Every prototype was presented to the user for evaluation and was revised based on user feedback from both the Research Office and the Researchers. User feedbacks at this stage was essential to guide and ensure that the user's needs were kept in mind and that the decisions made throughout the phase of analysis and the design were achieved. The process was iterative to ensure that user needs were met before proceeding to final system implementation.

Stage 3: Architectural Design

This stage was used as the basis for the system implementation. It used the architectural design for web-based applications using the three-tier architecture. The Client-tier (HTML, CSS, JavaScript): the Application-tier(Laravel Framework, Angular JS): and the Database-Tier(MySQL).

Phase III. Implementation and Testing Phase

The implementation of the RMS was based on the architectural design in the previous phase. Since the study is a web-based application, the Client-Tier runs on a web browser implemented using Laravel Framework, CSS and Java Scripts. The Application Tier was an Apache web server running on a Linux platform. For data access, PHP and Angular JS were used. Lastly, MySQL Database was considered on the Database Tier.

Phase IV. Evaluation.

Usability evaluation on user satisfaction was done using a survey questionnaire. The evaluation questionnaire made use of the ISO/IEC 9126-4 Computer System Usability Questionnaire (CSUQ). It used a five-point Likert scale from 1 to 5 where 1 was coded as the lowest and 5 as the highest (5=Strongly agree, 4=Agree, 3= neutral, 2=Disagree, 1 = Strongly disagree). The questionnaire was focused on the satisfaction on the use of the system considering the main themes namely: Ease of Navigation, Consistency, Ease of Learning the system, Adoptability, Support/Help and acceptability of the system. In addition, the users were asked to write their comments regarding the use of RMS and suggestions on what they think can improve the use of RMS. A quantitative method was used to evaluate RMS that mainly focuses on the usability of the system particularly user-satisfaction on the perception of the user.

5. RESULTS AND DISCUSSIONS

The result of the data-gathering phase based on the series of interviews and consultations from the intended system users provided the researchers a clear view of the user's group/account type, the user's system role, and the tasks associated with them. There were five identified system user account types namely Research Director (RD) also serves as the superuser of the system, research program officer (RPO) assigned for specific research niche, research office staff (RS), researchers and research reviewers (RR).

Table 1 shows a sample of one of the user groups identified and the tasks associated with the users.

The identified users group and their associated tasks were then mapped with the RMS framework indicated in this study to establish the overall design of the entire system.

Table 1: The Research Program Officer (RPO) System Tasks.

Tasks	*Functionality*
Manage Account	- Update Own Account
Manage Profile	- Create and update own personal portfolio
Manage Research Proposal	- View status of Research Proposal
Review Research Proposal	- View and write comments on submitted research proposal within assigned niche area. - Endorse research proposal to RD. - View all research papers (proposals, ongoing and concluded).
Monitor Research Progress	- View on-going research timelines within an assigned niche area - Recommends extension of timelines.

Table 2: Excerpt of RMS System Framework Mapping.

RMS System Framework	*System Task*	*User Accounts Involved*
Research Module	- Manage Research	RD, Researchers
Application Module	- Manage Research Proposal - Manage proposal submission/follow-ups - Manage proposal approval	RD, RPO RD, RPO, Researchers RD, RR
Researcher's Module	- Manage Profile - Manage research outputs - Manage timelines	All Researcher Researcher
Monitoring Module	- Manage research progrress - Manage notifications	RPO, Researchers System
Configuration Module	-Manage System Updates - Manage User Rights	RD, RPO RD
Report Module	-Manage Data Export -Manage Data Statistics	RD, RPO System

Based on the identified user requirements, the researchers were able to design graphical user interfaces (GUIs) or system prototypes which were shown to the users for feedback and suggestions. This phase was iterative and used the rapid prototyping technique in creating several prototypes that were presented to the users reflecting their suggestions then confirming with the users and getting feedbacks again until a finalized prototype was recognized. Shown in Figure 3 was a draft prototype design for the user Research Director (RD) Landing Page. This was shown to the user for feedback and Figure 4 was a rapid prototype design integrating the user feedback for an RD landing page. It included a communication section where RD can post announcements such as a call for proposal, send notification and message to specific user groups.

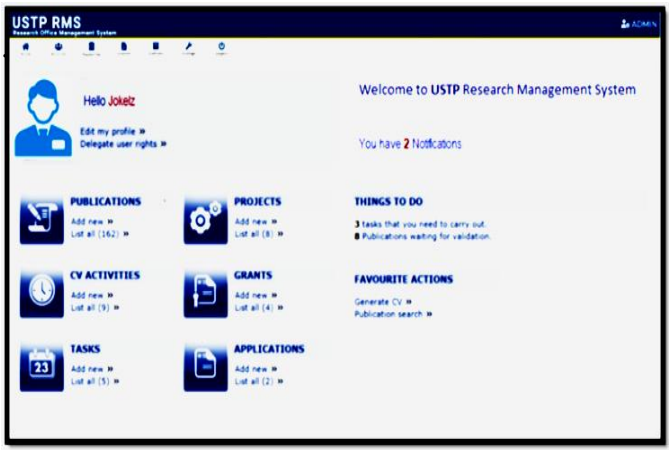

Figure 3: Research Director Landing Page Draft Prototype

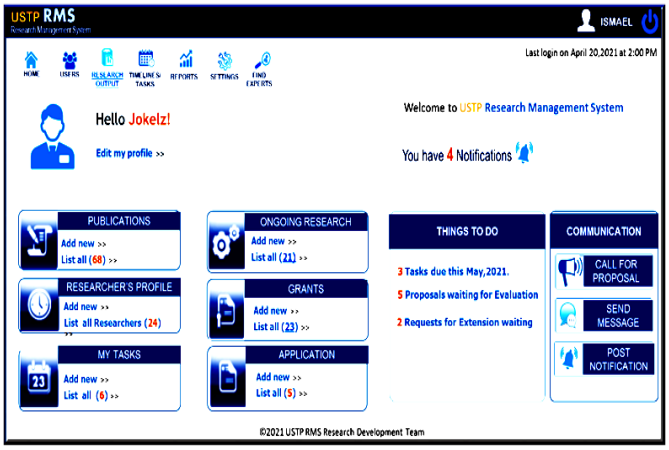

Figure 4: Research Director Landing Page Prototype Reflecting User Feedback.

The system was then developed and implemented after the final prototype was confirmed by the users. The system was developed using web-based technology which can be accessed online using authorized login credentials.

During the implementation, the system underwent alpha testing to check the accuracy of the system's functionality. This was done by asking six users from different user groups to use the system. The users were given several tasks to be performed in the system based on their respective roles. This was to verify the system functionality and accuracy to perform the given tasks under each user role.

User feedback was also collected during the alpha test to address identified system issues and perform system enhancement.

A user usability survey form was also given to the users doing the system alpha testing. Table 3 shows the descriptive statistics of the distribution of data across the range of values of the five-point scale and the mean. The usability survey reveals a high degree of satisfaction from the users in terms of system overall design. The mean response of 4.0 and above indicates that the users agreed in terms of all user satisfaction criteria. This was an indicator that RMS was successfully designed and implemented.

Table 3: Descriptive Statistics for User Satisfaction Criteria.

User Satisfaction Criteria	*Min*	*Max*	*Mean*
Ease of Navigation	4	5	4.50
Consistency	3	5	4.33
Ease of Learning the system	4	5	4.66
Adoptability.	3	5	4.17
Support/Help	3	5	4.00
Acceptability.	4	5	4.50

6. CONCLUSION

RMS was effectively developed and implemented to address the need presented in this study and suggest a UCD approach for system development. The high degree of user satisfaction from the usability evaluation implies that user involvement through formative evaluation by user feedback during the design stage of the system contributed much to overall user satisfaction with the degree of implementation provided by RMS. It can also be concluded that one of the success indicators of the system can be based on the volume

of users using the system with ease and comfortability. In terms of system functionality, the study concludes that RMS provided fast and seamless research management with reliable monitoring of research deliverables. However, the result of this study cannot be generalized due limited nature of the study. Thus this study provides a few recommendations as follows: an in-depth usability evaluation of the system considering an ample number of users after the system deployment should be conducted to generalize the user satisfaction result. A case study is conducted to check the effectiveness of the system in terms of the quantity of on-time research output delivery of the researchers. Augment the research expert recommendation of the system using more sophisticated technology like data mining instead of a filtered search algorithm used in this study.

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