University of Sindh Journal of Information and Communication Technology (USJICT)
Volume 2, Issue 2, April 2018

ISSN-E: 2523-1235, ISSN-P: 2521-5582
Website: http://sujo.usindh.edu.pk/index.php/USJICT/

Requirement Modeling & Simulation: A Case of UOGIS

Hafsa Shareef Dar, Almas Abbasi

Department of Computer Science and Software Engineering, International Islamic University Islamabad
hafsa_darr@yahoo.com, dralmas.iiurm@gmail.com

Abstract: Software Development Life Cycle (SDLC) gives guidelines to software development process and Requirement Engineering (RE) is the initial step in development which lays base for an efficient and successful software system. The current trend in RE is to identify problems, specify and validate the requirements. Although, RE naturally fills the communication gap between client and developer, the immaturity of both knowledge implementation and human perspectives in RE creates new challenges of decision making in requirements. This paper focused on the need of clearly gathered, specified and modeled requirements that will surely help the developers to obtain and understand stakeholder's needs by using a suitable requirement technique. In particular, this paper proposed University of Gujrat Information System - UOGIS redesigning using Requirement Modeling and Simulation technique. The methodology revealed best results for current scenario in which developers will get benefits along with SRS document to completely understand user requirements. The proposed work will contribute towards broader scope in redesigning UOGIS and other educational information systems to help developers in understanding requirements through interactive visualized simulations which complies with requirement specifications and user's needs.

Keywords: Requirement Engineering, Requirement Modeling, Business Process Modeling, Requirement Simulation, Stakeholders

I. INTRODUCTION

The software industry is progressing in systems development, yet there are still serious problems with systems engineering in today's world. Some of the problems are inherited from business domain and others are due to complex nature of software projects, including longer development cycles, unrealistic schedules, cost inflation, bugs, ambiguous user needs and failure to meet user requirements, integration of off-the-shelf components, upgradation and maintenance of systems [1]. Although these problems are by product of software and hardware products but they fall under systems engineering and can happen in any system and with any type of engineering not necessarily software or system engineering only.

An Enterprise Resource Planning (ERP) system is defined as a highly integrated and reliable network of all business units as described in [2]. There are different types of enterprises ranges from small, medium and large enterprises. Small to medium enterprises (SME) have implemented ERP systems and vendors have introduced less complex, medium-sized ERP systems such as Sage, SYSPRO to suit the requirements of these organizations. Large ERP systems are often too mature and complex for smaller organizations, although vendors such as SAP and Microsoft have introduced new or scaled down versions aimed specifically at the SME market. This raises many questions to usability of the system. These ERPs also plays an important role as Learning Management Systems (LMS) and education information systems. The usability remains important factor because it decides the level of usage by the user [3]. The usability factor has been discussed by the authors and according to them five components are encapsulated in usability definition, these are: learnability, efficiency, memorability, accuracy and user satisfaction. In this paper, an educational information system UOGIS, which is also being used as LMS has been redesigned for usability enhancements.

The paper structure is quite simple yet organized according to sequence. In background, past studies on Requirement Modeling and simulation, Usability and Redesigning has been covered. In research methodology, our methodology has been explained with case study and research design. Next section has covered data gathering, extraction and analysis. Then we have presented requirement modeling based on the data analysis. This model is further visualized by using simulation tool named Bizagi [4]. To validate our research, a prototype was developed against the simulation to compare the results and prove research hypothesis. So far there is no such study present in literature to accommodate any developer in understanding requirement specifications through modeling and visualization. The research question of this study was:

RQ1: Does requirement modeling and simulation helps the developer to perceive requirements without understanding ambiguous textual requirement?

In this question, requirement modeling and simulation is focused. Along with SRS document, requirement simulation of each process and activity is done so that a developer can easily understand 'what' is required to be developed. We haven't included textual requirement here because scope of this study is limited to modeling and simulation only.

II. BACKGROUND

This study is concerned with requirements modeling which is fundamental systems engineering problem, for all kinds of systems. Requirements models will be the input to many new and enhanced design automation tools and processes. Requirements related issues are the most common source of systems engineering problems and they impact all aspects of product development as mentioned in [5].

Requirement modeling is a part of system analysis phase aiming to understand the proposed project, to support business requirements and build a sound basis for software development, as discussed by authors in [6]. Requirement modeling includes input, output and process, just like any process definition is. A requirements model helps to: Focus on the system's external behavior, separately from its internal design, describe the users' and stakeholders' needs, defines a consistent glossary of terms that can be used by users, developers, and testers, reduce gaps and inconsistencies in the requirements, plans the order in which features will be developed, use the models as a basis for system tests, making a clear relationship between the tests and the requirements. When the requirements change, this relationship helps to update the tests correctly. This makes sure that the system meets the new requirements [7].

Requirements modeling makes easier to gather, elicit, communicate, analyze, track, validate, view, and prioritize the requirements provided by users for complex systems. It will reduce the cost of systems, schedule overruns by enabling the description of human readable and friendly, specifications of a system's engineering requirements. The design is an important step in Software Development Life Cycle. It helps in modeling the system and architecture of software. A large part of a requirements model is not simulatable. Requirements modeling is not a completely new or foreign concept [8]. Designers have used various forms of requirements modeling for years and these have improved the design process. Some examples are usecase models, state diagrams, behavioral diagrams etc. Business process modeling is another example of such models.

The designer must be able to understand the abstract needs of the client and transform these needs into an implementation. The requirements model should act as a contract between the client and the developer [9]. It should also be possible to verify that an implementation is correct with respect to the customer's requirements. This is the role of the designer. According to [10], the analyst must help the customer to construct and validate their requirements. Furthermore, it is the responsibility of the analyst to verify that the operational requirements are consistent with the logical requirements. After validation, it is the analyst who acts as the principle interface between the designers and the requirements models.

It was discussed in [11] there are certain benefits of simulation that are really helpful in requirement management. Some of the discussed benefits are: Validation of a concrete object, no need to write code, no need to create application-specific, white-box visualization and better understanding of the system.

Based on these benefits several tools were developed and used so far. Not only these tools but requirement management specific [12] [13] including UML visualization techniques, customer specific requirement management suites and tools. In previous works, UML class diagram and sequence diagram was combined with simulations but it required translations to convert it into different language like XML [14] . The comparative analysis of requirement management modeling and simulation tools is presented in table I:

TABLE I: COMPARATIVE ANALYSIS OF MODELLING & SIMULATION TOOLS

Tool	Reference
COREsim 2.1	[15]
QuickCRC 1.2	
Rhapsody for C++ 2.1	
SDT/ORCA 3.3	
ReqViz3D	[13]
SPIDER Hydra Theseus	
RNSMA	
TopTeam Analyst	[12]
Blueprint	

The hypothesis is based on the assumption that the requirement modeling and simulation helps developer to visualize and understand the requirements in better way as compared to understand textual requirements in SRS document. The comparative analysis presented above is an evident of the fact that (i) developers find it difficult to understand user requirements in descriptive form and (ii) software development process becomes more smooth if requirements are shared with developers in visualized form i-e., model or simulation.

III. METHODOLOGY

The major motivation behind conducting this study is to explore various dimensions of Modeling and Simulation within the Software Engineering domain. This study will also serve as a guideline for fresh researchers in this domain. The sequence of data is according to general research structure and the research is based on qualitative method. Following figure will elaborate precisely about out method:

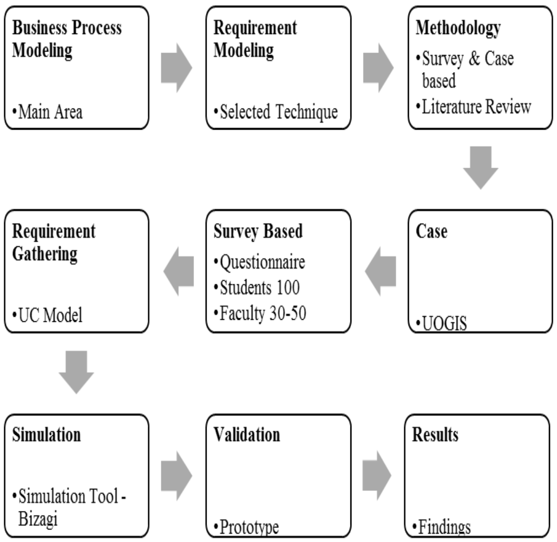


Figure 1: Methodology

The step-wise details of research methodology presented in figure 1 is as follows:

First step was to identify main area in Modeling and simulation which could also fall or merge in Software Engineering. We selected Business Process Modeling because of its wide application in different areas and then it was narrowed to Requirement Modeling. Requirement Modeling is a technique selected for conducting this study.

Second main step was to select an appropriate research method to conduct this study. The data gathering was required at huge but single location, selected qualitative method – survey based study as our research method. Under this section literature was also reviewed from authentic sources to get equipped with domain knowledge of requirement modeling.

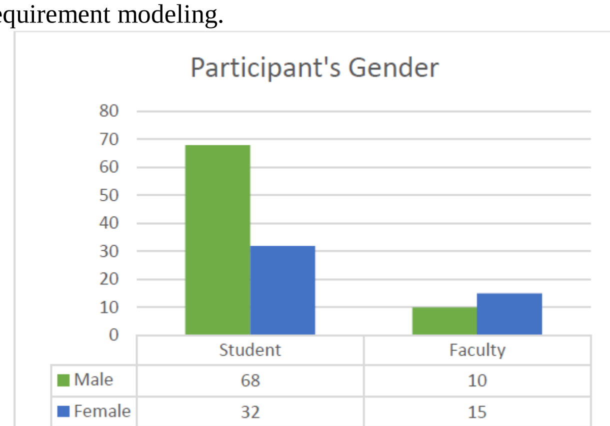


Figure 2: Participants in Survey

To keep the novelty in research, a case was taken as a real time scenario aiming to study its aspects and implement our findings on it. UOGIS – an educational information system or learning management system that is also serving as ERP solution of University of Gujrat (UOG) Pakistan. As far as the usability and design application in education sector is concerned, we are lagging behind. To analyze the design loopholes in education information systems, we are conducting this study. Our case study is limited to University of Gujrat Information System, which has its own design discrepancies due to which it is not efficiently working and considered as ineffective. Some of the common problems we identified are: Location checks, irrelevant information, unnecessary semester's time table, inefficient way of uploading/checking attendance and no proper order of course history.

On the basis of literature and problems this case study will be refined further in later stages.

Similarly, survey questionnaire was designed to get data from users. Questionnaire with 90% close ended questions and 10% open ended questions were grouped into two sections including GUI and UOGIS functionality. This research instrument was filled by two groups of participants – 100 students and 25 faculty members in total.

Following figure 2 shows the number of participants from both groups. It can be clearly observed that among students, 68% of males and in faculty 15% of female participants were involved. Due to unavailability of space some of the graphs have been removed from this article but could be provided to reader on demand.

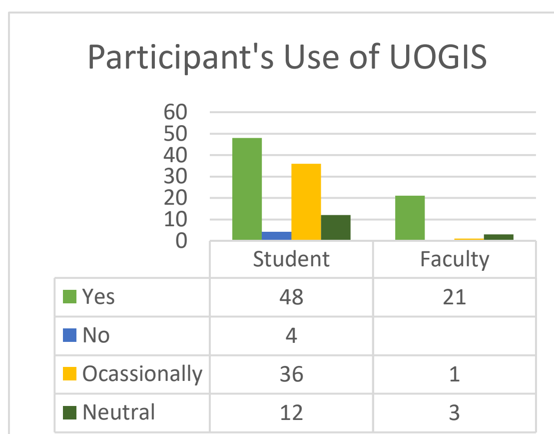


Figure 3: Use of UOGIS

In above mentioned figure 3, participants were asked about their use of UOGIS. Almost 48 participants said yes to use it regularly. 21 from faculty use it on regular basis.

University of Sindh Journal of Information and Communication Technology (USJICT), Vol.2(2), pg.: 115-124

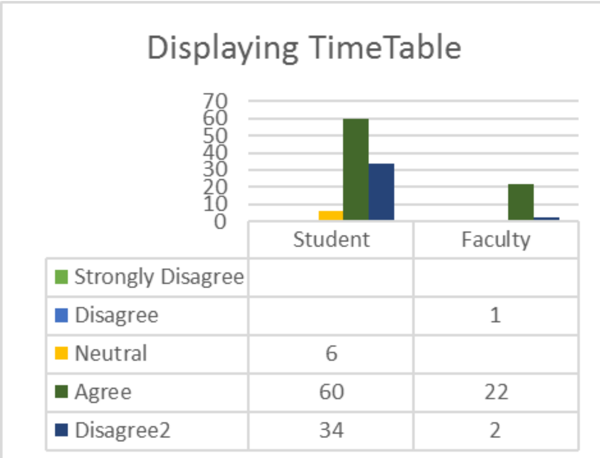


Figure 4: Displaying Time Table

Displaying the time table is an important feature which should be present at proper format. 22 faculty members agree to this while 60 of the students agreed that displaying time table has issues and need to be changed.

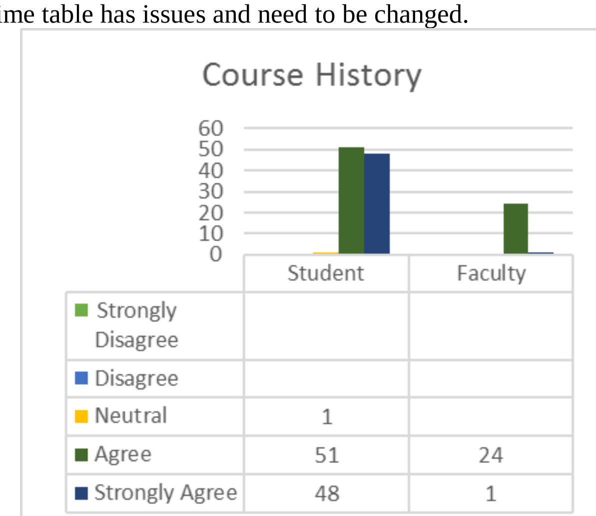


Figure 5: Course History

In figure 5 course history was surveyed for any discrepancies to which 51 students agreed and 24 from faculty agreed to this.

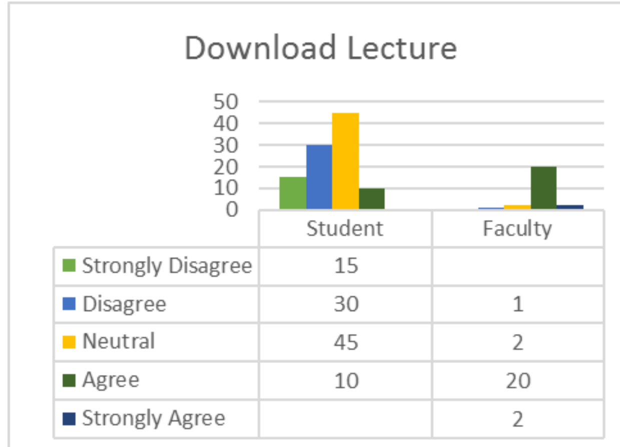


Figure 6: Download Lecture

In figure 6, lecture management was surveyed in which download lecture was depicted as an issue to which 45 students remained neutral and 20 faculty members agreed to it.

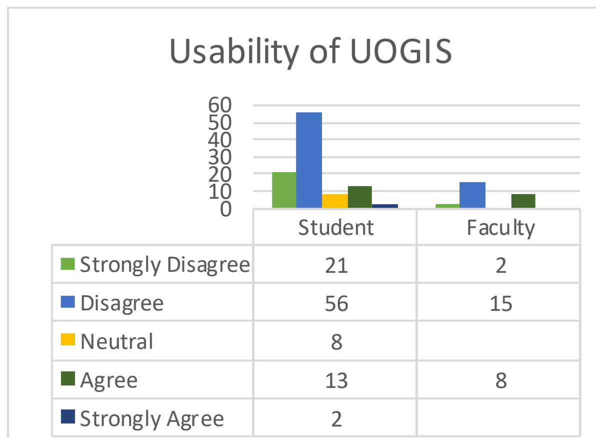
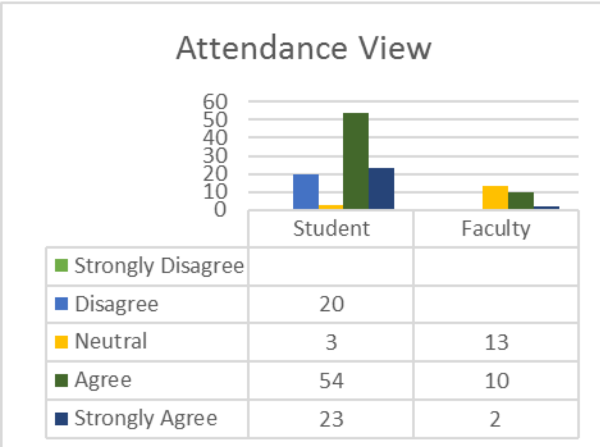


Figure 7: Usability of UOGIS

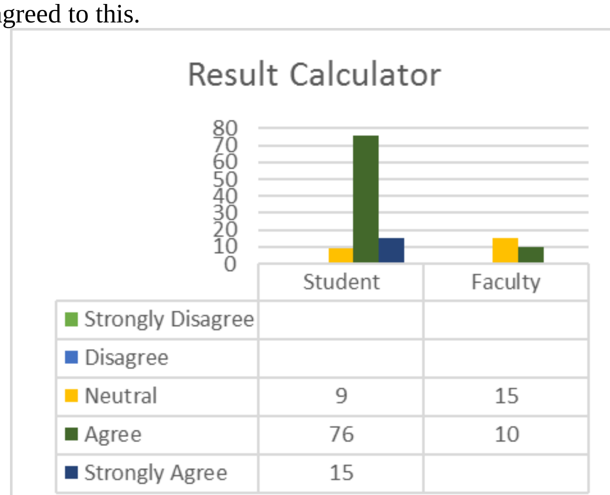
Usability of UOGIS is main concern. When inquired about the current usability of UOGIS, 56 students disagreed that it is usable while 15 of the faculty members' response was same as those of students.



	Student	Faculty
Strongly Disagree		
Disagree	20	
Neutral	3	13
Agree	54	10
Strongly Agree	23	2

Figure 8: Attendance View

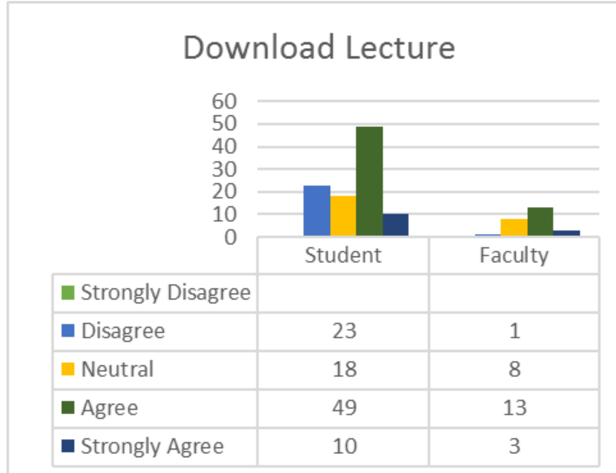
Attendance view was an issue for the UOGIS users figure 8 is an evidence of these 54 students and 10 faculty members agreed to this.



	Student	Faculty
Strongly Disagree		
Disagree		
Neutral	9	15
Agree	76	10
Strongly Agree	15	

Figure 9: Result Calculator

In this question, participants were asked whether they want to calculate their results upon which 76 of students and 10 among faculty members agreed that this feature should be integrated in UOGIS.



	Student	Faculty
Strongly Disagree		
Disagree	23	1
Neutral	18	8
Agree	49	13
Strongly Agree	10	3

Figure 10: Download Lecture

Like upload lecture, download lecture was also improperly designed in UOGIS. 49 students and 13 faculty members agreed to this.

The survey data was gathered, extracted and analyzed to refine into requirements according to user needs. The useful information was analyzed and given the form of requirement model – Use Case Model. The detailed modeling process is covered in Requirement Modeling section.

A. REQUIREMENT MODELING

Modeling is again an important milestone of this study. We tried to facilitate our developers by providing them with requirement visualization along with SRS document. For requirement modeling we followed literature to map functional requirements to model and best fit model found is use case model. In this step, we model data extracted from survey into Use Case model. As the scope of this study is limited to few modules only, use case model covered few use cases. Following use case model was created by using Microsoft Visio drawing tool:

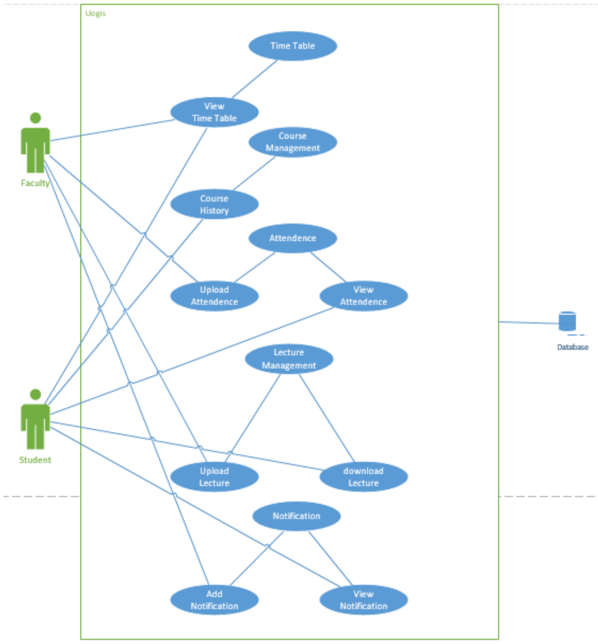


Figure 11: Use Case Model

This model has covered time table, course management, attendance, lecture management and notifications as use cases. View time table, course history, upload attendance, download attendance, upload lecture, download lecture, add notification and view notification are sub use cases respectively.

B. CONTRIBUTION OF WORK

Simulation was major focus of our research and used to visualize the requirement modeling. In literature review various simulation tools for requirements were covered having strengths and weaknesses. The tool we selected for our study was Bizagi Modeler. The reason to select this tool is 'drag n drop' feature which makes it easy to use. Another reason is detailed analysis of model in terms of process validation, time analysis, resource analysis and calendar analysis. For our study and its scope, we considered only process validation and time analysis in order to validate the process within specified time. This could help us to advocate our point of how requirement visualization of software development process is time saving. The results in detailed form are also presented later on this paper [Appendix A]. Simulation of requirement model and analysis is presented below:

In figure 12 process I is shown which is about Time Table. It represents the simulation time of whole process. And the result shown in figure 25 shows process validation of 'Time Table'. These figures are showing that the instances in each activity are covered by the simulation and thus 100% coverage has been done.

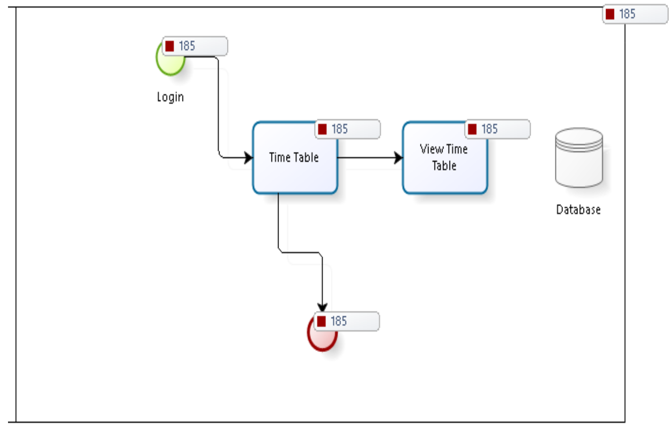


Figure 12: Simulation of Time Table

Figure 12 is showing process of covering all instances of time table on time whereas figure 13 is about time analysis of 'time table' process.

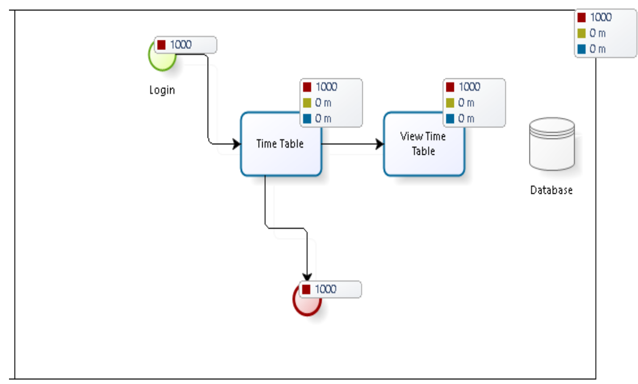


Figure 13: Analysis of TT

In figure 14, time analysis is presented for time table which can easily be seen at the top of interface with average time and total time:

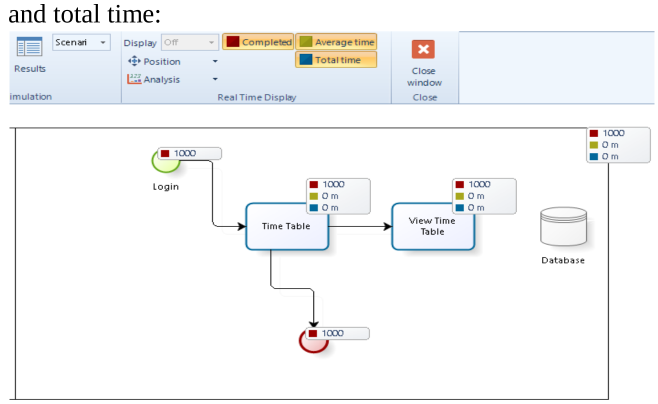


Figure 14 Time Analysis of time table

Figure 15 shows the simulation of this process. The results generated here are showing 100% coverage of each instance covered in this part.

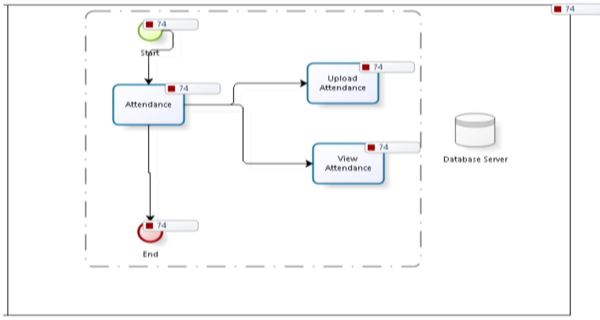


Figure 15: Attendance process

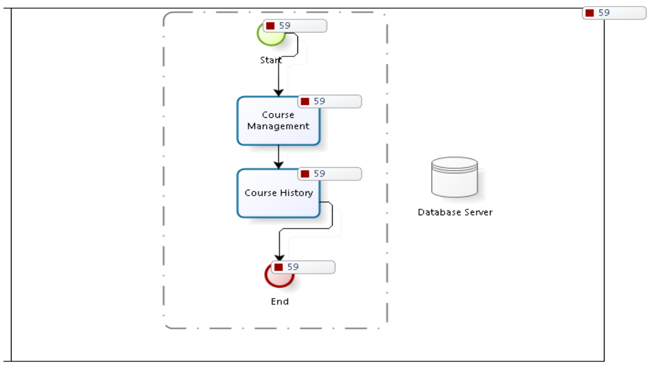


Figure 16: Simulation of Course Management

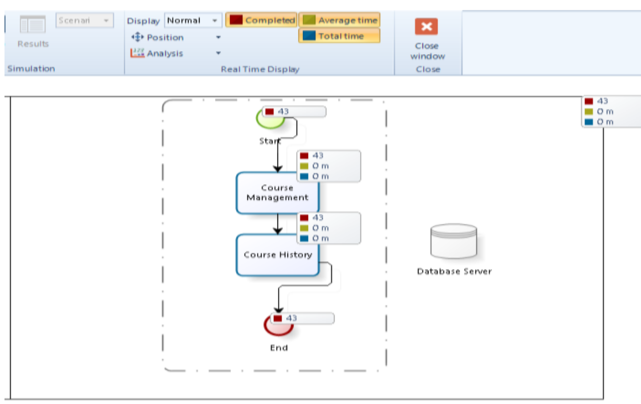


Figure 17: Time analysis of course management

In process III attendance is covered as part of simulation. Attendance will be uploaded and downloaded. Results and time analysis of attendance in Bizagi Modeler [4]. The results are showing that simulation has covered each instance 100% in activities.

Process IV is about lecture management in which lecture will be uploaded or downloaded. The interpretation of the After simulation, these visualized requirements were shown to developer to build the prototype of proposed system. The details of these simulations are provided in Microsoft Excel tables under results section.

simulation is shown in results covering 100% instances of each activity in lecture management process.

Due to unavailability of space, some of the models are shown here.

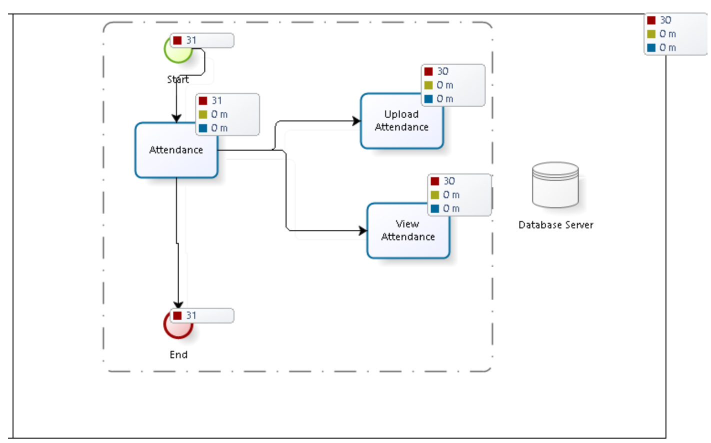


Figure 18: Time analysis of attendance

IV. RESULT AND VALIDATION

We have validated our study with the help of prototype. This prototype was developed by the developer after going through SRS and requirement modeling and simulation – visualization. The visualization made it very simple and easy for the developer to understand the requirements, some of the constraints were given in notes and SRS was also provided as an extended help. Following are the

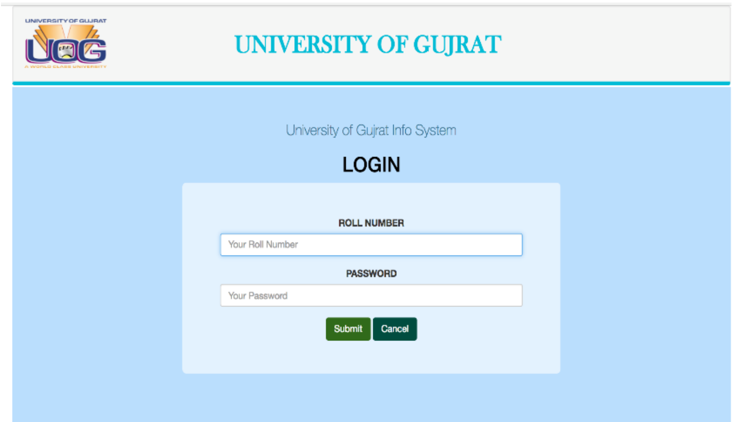


Figure 19: Login Page

The login interface displayed in figure 19 is an outcome of the developer's perception after simulation. This interface is different from the previous one and prototype has been developed according to the simulation.

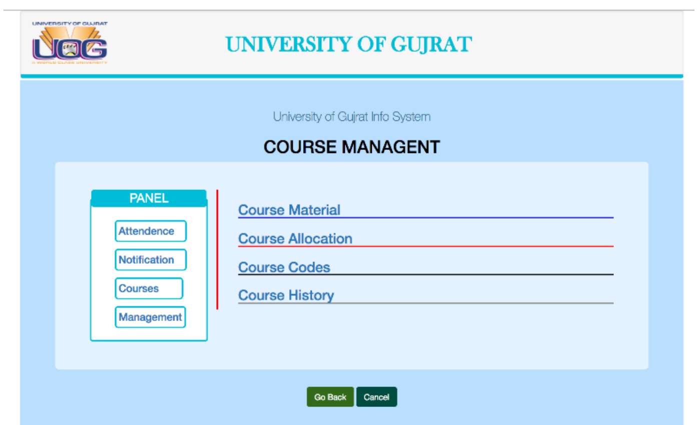


Figure 20: Course Management

This interface is different from the previous one and prototype has been developed according to the simulation. Its usability has been improved.

images of prototype developed to enhance the usability of UOGIS:

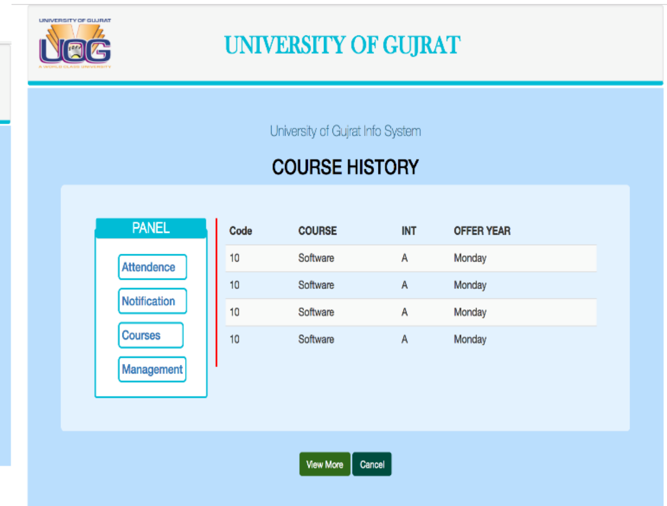


Figure 21: Course History

The course history interface displayed in figure is comes under course management. This interface is different from the previous one and prototype has been developed according to the simulation. Its usability has been improved. And courses are grouped categorically.

Figure 22: Time Table.

The Time table interface displayed in figure 22 is an outcome of the developer's perception after simulation. The previous time table was in improper format.

Due to unavailability of space only few interfaces have been displayed.

This study has been validated by providing requirement modeling and simulations of UOGIS to the developer. This prototype was designed by one of the developers in Software Development Cell of UOG. He was shown requirement simulation, discussed in section 5. Based on the requirement visualization, developer designed the prototype, given in section 6. The interfaces are provided here as a part of prototype to give solution to the problems users were facing in UOGIS. Although these are not complete set of interfaces according to gathered data but due to paper limitations only few of prototype are presented here. This shows clear perception of a developer after getting requirement visualization along with SRS document.

V. DISCUSSION

The discussion includes summary of our findings in form of results. Before requirement modeling and simulation the process of software development was not only slow but ineffective because of the technological and knowledge gap between users and developers. The system – UOGIS was developed without following proper guidelines of developing LMS and ERP that resulted in ambiguous design, low usability and inefficient system. Whereas, this study was carried on small scope in order to validate our findings. We worked on redesigning of UOGIS - usability and functionality. The whole process was done by applying requirement modeling technique in which MS Visio tool was used to model the scenario and Bizagi tool was used to simulate the model to get visual representation for the developer to develop the 'perfectly-designed' UOGIS. The prototype given in above section is made after visually analyzing the requirements. The important point to mention here is requirement simulation helped the developer to understand process input and output along with operations. We intend to make development of LMS easy by strengthening the developer's perception of requirement visualization. With the help of modeling and simulation, developer designed a prototype that accurately implements main activities of the processes involved in the system. We have found that requirement modeling and simulation helps the developer to perceive requirements in better way.

VI. CONCLUSION

In this paper, we tried to apply our findings on limited scope of learning management system called UOGIS which is operational in UOG. By following research methodology, it can be concluded that by applying proper requirement engineering and modeling techniques, software development can efficiently and effectively be completed. The coding holds 5% of the software cost but it operates 80% of the project so it is required for the developer to easily understand user needs, requirements and specifications before starting development. In this regard, requirement visualization can help to reduce the time to understand the process work flow in form of requirements. This could not only validate the process but also analyses other factors like time and resources. In future, there are multiple dimensions of this study that can be interesting to work on. This approach could be further applied on broader scope to validate this technique. Furthermore, requirement visualization can be integrated with machine learning techniques in future to overcome the machine-human barriers.

REFERENCES

[1] M. Ali. B., H. Zhong., , "Systematic Literature Reviews in Software Engineering: Preliminary Results from Interviews with Researchers," *Third International Symposium on Empirical Software Engineering and Measurement*, 2009.

[2] Brenda Scholtz, André Calitz and Charmain Cilliers et al., "Usability Evaluation of a Medium-sized ERP System in Higher Education," *The Electronic Journal Information Systems Evaluation*, vol. 16, no. 2, pp. 148-161, 2013.

[3] Maha M. Althobaiti and Pam Mayhew, "Assessing the Usability of Learning Management System: User Experience Study," *Social Informatics and Telecommunications Engineering*, p. 9–18, 2016.

[4] [Online]. Available: http://download.bizagi.com/docs/modeler/2511/en/Modeler_user_Guide.pdf. [Accessed 2016].

[5] Darrell Barker, "Requirements modeling Technology: A vision for Better, Faster and Cheaper Systems," Air Force Research Laboratory, Ohio, 2011.

[6] RM, "Requirement Modeling," SlideShare, [Online]. Available: https://www.slideshare.net/fallonbrewington/chapter-04-14085194. [Accessed 2016].

[7] MS, "Microsoft MSDN," Microsoft , [Online]. Available: https://msdn.microsoft.com/en-us/library/dd409376.aspx. [Accessed 2016].

[8] M.H. Jansen-Vullers and M. Netjes, "Business Process Simulation - A Tool Survey," NWO , Dutch, 2009.

[9] J. Paul Gibson, "Formal requirements models:simulation, validation and verification," Department of Computer Science, Maynooth, 2001.

[10] Brenda Scholtz, André Calitz and Charmain Cilliers et al.,, "Usability Evaluation of a Medium-sized ERP System in Higher Education," *The Electronic Journal Information Systems Evaluation*, vol. 16, no. 2, pp. 148-161, 2013.

[11] Nurul N., Khairuddin H.,, "Requirements Visualization Techniques: A Comparative Analysis," in *Proceedings of the 8th WSEAS International Conference on APPLIED COMPUTER SCIENCE (ACS'08)*, Malaysia, 2008.

[12] Joe B., Megan J., et al.,, "Requirements Management Tool Evaluation Report," Seilevel, 2016.

[13] Simoneta B., Moreno M.,, "SIimulation Modeling of UML software Architechtures," MURST, 2005.

[14] Reto S., Johannes R., et. al, , "A Survey of Simulation Tools for Requirements Engineering," German Informatics society, Germany, 2000.

VII. APPENDIX A

Table 2: Result of Process Login

Name	Type	Instances completed
Process 2	Process	1000
Login	Start event	1000
Time Table	Task	1000
View Time Table	Task	1000
NoneEnd	End event	1000

Table 3: Result of Process Attendance

Name	Type	Instances completed
Process 3	Process	1000
Start	Start event	1000
Attendance	Task	1000
View Attendance	Task	1000
Upload Attendance	Task	1000
End	End event	1000

Table 4: Result of Process Lecture Management

Name	Type	Instances completed
Process 4	Process	1000
Start	Start event	1000
Lecture Management	Task	1000
Upload Lecture	Task	1000
Download Lecture	Task	1000
End	End event	2000

Table 5: Result of Process Notifications

Name	Type	Instances completed
Process 5	Process	1000
Start	Start event	1000
Notifications	Task	1000
Add Notifications	Task	1000
End	End event	2000
View Notifications	Task	1000