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INFORMATION SYSTEMS ANALYSIS AND DESIGN COURSE WITH PROJECTS BASED ON REAL CUSTOMERS REQUIREMENTS

Kalinka Kaloyanova
University of Sofia, Bulgaria, kkaloyanova@fmi.uni-sofia.bg

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Complete Research

Kaloyanova, Kalinka, Faculty of Mathematics and Informatics, University of Sofia/Institute of Mathematics and Informatics, BAS, Sofia, Bulgaria, kkaloyanova@fmi.uni-sofia.bg

Abstract

Establishing a learning process that reflects various specifics of Information systems area is a challenge for every Information Systems educational program. Creating practical skills at student education requires significant efforts universities cannot afford using only traditional forms of education. This is particularly true when it comes to information systems development, where the expectation of the users play significant role in defining systems requirements. To address this challenge for an important issue – information systems analysis and design, we apply a specific approach of involving real user's requirements for student projects as a part of students' education.

The study contributes to the pedagogical and theoretical aspects of education in Information systems area by adapting methods and models for successful information systems analysis and design process. To practitioners, this paper presents directions for using effective requirements engineering activities.

Keywords: Information Systems Analysis and Design, Software Requirements, Requirement Elicitation, Project Management.

1 Introduction

Today Information systems (IS) area is facing many challenges - the growth of data, the emergency of technologies, the impact of digitalization, etc. The role of IS users in system interaction is constantly increasing and clients and users become more and more demanding. Starting from requirements elicitation every team developing a specific information system constantly try to satisfy users expectations for modern, effective and secure software product.

These open questions call for more systematic focus on requirements elicitation stage which has deep influence on the overall development process. And knowledge and skills in this area have to be obtained starting from university programs where students meet for the first time the issues of information system development.

This paper addresses the challenge of meeting real customers' needs for information systems development during the educational process. We describe our experience in teaching students in the area of IS requirements elicitation, analysis and design, based on strong theoretical knowledge and working on projects, using a specific framework and involving real users in these projects.

The paper is organized as follows. Section 2 introduces the basic theoretical courses of IS curriculum that concern the development of information systems. Section 3 describes the main steps of the approach. Section 4 offers some results and discuses them. In Section 5 conclusions and direction for the future work are presented.

2 Basics of Education for Information Systems Development

2.1 Basic courses in IS curriculum

The IS curriculum (Topi, 2010) establishes a set of courses for students education in IS area. These courses concern different aspects of information systems development – IS technologies, IS management, etc. The new guidelines focus on business process management, emerging technologies, globalization. Just as important are the human-computer interaction issues.

Several curriculum courses establish the basement of information systems development.

The main concepts of database theory are presented in *Database Systems* course – data models, operations on data, queries (Molina, 2009). *Information System Analysis and Design* course focuses on the design and the development of information systems (Shelly, 2009). It requires considering the system in its entirety – goals, functionality, constrains that meet customer requirements. The *Project Management* (PM) course introduces some basic topics from Software Engineering area to help the students in developing realistic and pragmatic understanding of modern software systems realization (Kanabar, 2008). It is common practice here to be followed the recommendations of Project Management Institute - PMI (PMBOK, 2013) and PRINCE 2 (Cadle, 2008) frameworks.

Among these three courses, the *IS System Analysis and Design* course is the one, which discusses most deeply different aspects of the systems development, starting from user requirements elicitation and presenting methods, frameworks and models for designing new solutions.

It is also this course from IS curriculum where students for the first time meet concepts from Requirements Engineering (RE) (Sommerville, 2010) - a significant subfield of both Software Engineering and Information Systems areas. Understanding customer and user requirements is an important part of every software project, specifically for IS development where users play crucial role of using system functionality.

2.2 Projects

In addition to the theoretical backgrounds, provided by classical lectures, labs, learning materials, etc., modern university education need to provide many supplementary activities that help students to obtain some practical skills. It is essential for IT professionals education (Gutas, 2013) and should be an integral part of every IS educational program.

Working on projects is an established educational method for students to gain practical experience in the area (Lazar, 2011). The projects are particularly important for graduate and undergraduate IS programs, where the knowledge and skills for the development of different information systems should be presented on appropriate level during the process of education.

3 Developing a Structured Process for Working on Projects for IS Analysis and Design Course

Faculty of Mathematics and Informatics (University of Sofia) is facing the challenge of increasing expectations in front of education at IS undergraduate program. From the very beginning we use here the project approach for better understanding theoretical fundaments of IS development.

The most educational programs use separate projects for different courses (Todorova, 2010), but we implement one project as an integral part of the three courses, mentioned above – *Database Systems*, *IS Analysis and Design*, and *Project management*. The result of the integrated project is the design of an information system.

In this study we focus only on IS Analysis and Design course at Faculty of Mathematics and Informatics (FMI) and consider the other two courses as supporting.

The course is teaching during the 6-th semester within eight semesters IS undergraduate program. It covers the basics of Information Systems design, as well some elements of data and business process modelling.

The course consists of lectures, labs and working on projects – designing small information system applying all theoretical concepts, discussed in the course. The learning materials and information are offered through the university's learning management system (Moodle). Additional e-learning modules can support the education. These modules are generally optional since they provide some supporting information about tools and techniques for collaborative work.

The students, organized in teams of five to ten people work on projects at several stages, preparing specific artefacts and present their work on projects according predefined schedule. Also, every student prepares a set of own artefacts. In this way he contributes to the project, and also presents his individual work.

The object-oriented (OO) approach was chosen for this *IS Analysis and Design* course as we consider object-oriented programming and Unified Modelling Language (UML) (Fowler, 2004) are essential for IS designers (Dimitrov, 2009). We apply Unified Process (UP) (Kruchten, 2004), because it is not only closely related to the OO development, but as an iterative approach it is very suitable for the learning process during the course education.

Considering the importance of requirements elicitation and analysis (Avison, 2006) we also take several Contextual Design (CD) techniques (Beyer, 1999) - contextual inquiry and work modelling and since 2012 we apply for our course a specific approach that integrates main principles of Contextual Design and Use Case Modelling. (Kaloyanova, 2012).

Team working during the projects also helps students to understand and apply principles and concepts of the project management area and enhance *Project Management* course outcomes. Finally, some soft skills like good communication, effective team work, etc., are accomplished during the project work.

The following sections present more details about the approach.

3.1 Stakeholders involvement

The first projects, we implemented in our undergraduate IS program, were discussed only by students and their lecturers. Every team chose the topic of its own project – information systems for university, school, restaurant, etc. The students constructed requirements for modelling these systems based on their knowledge and practical experiences and on information obtained from books, papers, internet resources, etc.

However, analyzing the results of the students projects after IS undergraduate program started in 2006, we observed weak use case models, short lists of proposed use cases, incomplete scenarios. The students thought the work on projects is only added work with no measurable benefit. They gave decisions without big appropriateness for the specific projects. As a result the projects were schematic, with weak functionality. We realized the main reason for these shortcomings is the lack of experience of undergraduate students who cannot produce a persuasive version of their systems.

Recognizing also the importance and social nature of requirements for IS functionality we decided to find other sources for software requirements and to search ways to improve their quality.

In 2012 we introduced for the first time real stakeholders involvement as a part of requirements engineering process at students projects. The students attended the course *IS Analysis and Design* were asked to choose area for their project where potential users can be found – clients, users, practitioners, etc., in order to make interviews with them and use the information from these interviews as a basement for the functionality of project systems (Kaloyanova, 2013).

Following our goal to obtain high level requirements, we also added some extra models, techniques and learning activities to support communication with the stakeholders. Contextual inquiry and several specific models that support interviews processing were integrated at the beginning of the course to give the students good start point for requirements elicitation.

3.2 Theoretical background of IS Analysis and Design course

The main theoretical concepts of the course concern both Information Systems and Database Life Cycles (Elmasri, 2007).

As Database fundamentals are covered by *Database Systems* course, provided in previous semester, here the focus is on the domain modelling and it's further detailing with UML class diagrams for the design model.

During the course different aspects of RE are discussed, classifications of software requirements are presented (Sommervile, 2010). Use Case modelling is established as a methodology for presenting functional requirements of information systems for the projects. The methodology is explained in detail, involving all elements of the model – actors, roles, and system boundary (Larman, 2004). Many examples, templates, etc. are provided to illustrate the theory (Cockburn, 2001).

Considering that Use Case modelling as a UP discipline doesn't explain in details how to obtain the needed information from user data and understanding that this area too complicated to undergraduate students without any experiences in the field we use some Contextual Design elements (Kaloyanova, 2013).

Contextual Design (Beyer, 1993) provides specific techniques and models that help analysts to find information from the domain. Its work models are understandable from the both sides – clients and developers/analysts and they also are very appropriate for the learning process. We use three work models – Flow Model, Sequence Model and Artifact model that are most proper for our approach:

- Flow models - represent the information about roles and individuals and their activities and how they are related each to other;
- Sequence models - describe how specific intends of the users are achieved in several steps; possible breakdowns, alternative steps;
- Artefact models - explain important for the system documents and other artefacts.

The models are used to capture the information from interviews in more natural way. They also are very useful in the next step - use case modeling and very suitable for the students that haven't practical experience.

Furthermore, for every project a set of UML diagrams detail requirements and illustrate the design model of the system. Here mostly sequence, activity, statechart diagrams are used. In addition, class diagrams are considered to precise the domain model.

3.3 The process

For the course and its projects for information systems development the Unified Process is followed. The theoretical framework of UP is explained in details, particularly the first two phases – Inception and Elaboration are strongly addressed during the course, because they are closely related to analysis and design disciplines.

As UP not only applies Use Case modelling and OO paradigm but it is also iterative process it is very suitable for the educational process. And we use this iterative approach to present theory and practical assignment incrementally, adding more information in every new step.

3.4 The steps

In this section the main steps of the project work are presented following all elements of work on the projects and the corresponding deliverables.

Contextual interviews and models

The project work starts with interviews with users or potentional clients. At least two interviews should be provided by every team and every student must participate in at least one interview. We recommend the students to provide the interviews in real work environment of the stakeholders.

The teams prepare questions for the interview in advance. Some questionnaires can be sent before the interview, too. During the interview students take notes and after each interview they prepare:

- An Flow model with main roles and individuals and their activities;
- Several Sequence models for reaching specific intends, mention by interviewed;
- Several models of artefacts, discussed during the interview.

The first two kinds of models present a basement for capturing the user's behaviour, the third one concern the information side of the systems.

Next, the particular models from the different interviews are consolidated, showing the common work patterns and strategies across all users - the real work processes. All Flow models are merged into a

completed one. The Sequence models are supplemented and unified and the Artefact models become complete and coherent.

Having the full picture from the interviews, all teams analyse the complete requirements exploring for breaks, contradictions, missing elements. Based on this analysis and the ambition to develop a better software product every team re-designs the initial vision and establishes its own vision for the new system to be designed.

Use case model, functional and non-functional requirements

The core element of the *IS Analysis and Design* project is Use Case modelling. The use case model presents functionality of the system in terms of use cases and actors that interact with the system. It also draws the boundary of the system.

Describing use cases directly from users' interviews and other requirements document is a laborious task, especially when it comes to undergraduate students without practical experience. Including the three mentioned above CD models as a first step in our approach we give the student good start point to use case modelling.

As the CD Flow models describe roles and their activities they are good source for defining different actors/roles that operate with the system. So the teams can define the first group of actors for their system. The Flow models also show users activities, their goals and some important artefacts. As a result the use case model with the most actors, goals, and an initial list of use cases could be named at this moment.

The activities described in the Sequence models as well the activities from CD Flow models present the ways that users can use to work with the system at different levels. The Sequence models are good source for the use cases steps; the breakdowns can be used for separation of activities or alternative scenarios, the intents and the triggers could be successfully incorporated into full use cases descriptions.

Here a template for complete use case description also is established for every project and the descriptions of several most important or risky use cases are made.

At this step also non-functional requirements are presented for the first time. Following the recommendation of UP we rely on (F)URPS+ model, where Usability, Reliability, Performance and Supportability are presented in details, pointing specific constraints for the developing system.

IS Design – domain modelling, UML diagrams

Further, the work on the projects focuses on the information models of the systems. Every team works on a Domain model, which present real world artefacts and concepts as parts of the problem area that is specific for the project. Here students also have support from the previous developed models.

A lot of important object and concepts can be found on the Flow models. The Artefact models also provide good source for many domain elements. And the text descriptions of the use cases are very useful for discovering the domain elements, too. As a result not only the dynamic side of the system is modelled, but also the static one.

Further, a set of UML diagrams are prepared to detail the behaviour of the system, for example, sequence, activity and state diagrams. Class diagrams are drawn to detail the information part of the system.

Every team also prepares storyboards to present not only user activities on the system but also some manual practices, initial UI concepts, business rules, etc.

Following the proposed steps, finally every students' team obtains a complete, correct and detailed description of the system to be developed.

3.5 Documents and other artefacts

A lot of documents and artefacts (models, diagrams, etc.) are prepared by students during the projects (Table 1). For every element a detail description is provided by specific assignment. The documents are delivered following a predefined schedule. All assignments are given at least two week before the deadline.

Project parts	Text Documents	Models and Diagrams
Step 1	Interviews – questions Notes/memos on interviews: - questions and answers Letters of communication Questionnaires	Flow models Artefact models Sequence models
Step 2	Use cases text descriptions FURPS+	Use case model
Step 3	Final vision All use cases text descriptions	UML diagrams: Class, Sequence, Communication, Activity, Statechart

Table 1. Project Documents and Models.

4 Results Evaluation

It has been three years since we started to apply the above described approach to the course *IS Analysis and Design* and to use real customer requirements as a part of the educational process. Fifteen projects were developed; one hundred and fifty students took part in them.

4.1 Measurement of learning outcomes

To measure learning outcomes of this course and its particular implementation we should take into consideration the specific of the course field.

For *IS Analysis and Design* course we first focus on the cognitive outcomes (Biggs, 1999) - basic knowledge (concerning concepts in the area of software requirements, IS functionality, specific design principle for information systems, object-oriented design) and understanding basic elements the software development processes.

Working on specific information systems during the project, students go beyond factual knowledge, because they need not only to understand and remember the concepts of information systems design theory, but to apply them to identify particular functions and users of the designed system.

The abilities to create meaningful summary from huge amount of data, to recognize patterns in systems behaviour and human activities, to formalize them and model real situation are crucial for analytics and designers and many assignments from this approach assists students in obtaining initial skills in this area.

While doing re-design of the system, every team reaches higher levels of cognitive dimensions during the analysis of the existing system (discussed during the interviews) and evaluation of its effectiveness (Anderson, 2002).

4.2 Measurement of projects outcomes

As it is mentioned above, for these projects we focus on the use case modelling and on customer requirements presented as use cases. So, the number of use cases for the project, based on preliminary work models and interviews is a good indicator to measure the project success.

A possible way to measure project outcomes is also to correlate the number of interviews and work models with elements of the UC modeling.

Project topic	Inter-views	Flow models	Sequence models	Artefact models	Use cases	Actors
Social Network	2	2	3	3	30	6
Publishing House	3	3	7	6	23	8
Kinder Garden	4	4	4	7	29	6
Metrological System	4	4	3	8	21	7
Internet Auction	2	2	4	5	26	3
Movie System	3	3	2	5	17	7
Project Management system	2	2	3	6	30	6
Zoo Store System	2	2	4	7	23	7
Library System	2	2	5	6	21	5
Online Catering	2	2	6	5	22	5
Online insurance	2	2	8	13	17	7
Furniture Store	2	2	10	4	26	5
Hotel Management	4	4	5	6	25	6
Internet Banking	3	3	3	4	27	5
Transport System	2	2	4	5	21	5

Table 2. Projects and their elements.

Table 2 presents results from 15 projects, developed during the period 2012-2014. As we can see the teams usually define more than 10 use cases form each interview, which is a good start point for the projects. Also the level of use cases descriptions is much better and the visions and overall system definitions are more realistic.

As about the time spent working on projects, the time for interviews, CD work modelling and use case modelling is almost the same as the time for preparing use case models for the projects when no real customers were involved.

4.3 Students benefits

There is no doubt working on projects help students to better understanding of theoretical concepts. But working on projects with elements of real world contributes even more to the connection between theory and practice.

The involvement of real client requirements help students to understand more deeply the specific of the system and they soon saw the need to modify these initial requirements as they had to measure their proposal's effectiveness.

The students, attended to our *IS Analysis and Design* courses gain solid practical experience via authentic customer interactions. This interaction assists them not only to understand the details of the specific domain area but also foster them to look for non-standard, creative solutions and to relate theoretical concepts with real domain objects. They learn how to handle changing requirements, to resolve the problems that usually have no straightforward solutions.

Working as a team on the projects force the students to use a set of practices, which improve their soft skills. They have to deal with different issues concerning team work, communications with stakeholders, meetings organization.

Students also learn how to follow a strong schedule, how to share responsibilities, how to communicate with others and with clients.

All these issues are actual challenges of every real-world projects. Having encountered them in a project at academic environment gives the students opportunity to overcome obstacles with their lecturers in more structured and disciplined way, using a lot of useful practices, presented in the courses.

5 Conclusion

In this paper we present our approach of teaching *IS Analysis and design* course as a part of undergraduate IS programme at Faculty of Mathematics and Informatics (University of Sofia). The core elements of the applied approach concern involving real customer requirements for students' projects.

Theoretical backgrounds of the course are presented and the steps of projects work are explained. Examples of our three years of experience are shown and the main results from them are discussed.

The paper contributes to finding a solution for an important question, related to insuring practical skills in IS education. It also aims to make some theoretical and practical contribution to developing a framework of analysis and design activities in the field of IS analysis and design education. For the practitioners it could be useful via the set of modern approaches and technologies applied in more systematic way in university environment that can also be used for industrial projects, as well as for training junior developers.

The approach we implemented is continually improved. We are creating new assignments, supporting materials, documents and templates for different activities. We also make many efforts to attract industrial partners to take part at these projects.

Considering the increasing role of stakeholders (indicated as the newest PMBOK knowledge area - Stakeholder management in (PMBOK, 2013) we have the confidence that we have chosen the right direction.

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