Gathering Project Requirements: A Collaborative and Interdisciplinary Experience.

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Abstract

Milwaukee School of Engineering has one of the first ABET-accredited undergraduate software engineering (SE) programs in the United States. As part of the curriculum, SE students are exposed to Requirements Engineering (RE) in their junior year. These concepts are reinforced through a quarter-long project in which the SE student teams work with clients who have product domain knowledge but often no formal experience in RE. Working in unfamiliar domains, being cognizant of ethical issues, and having to deal with ambiguous and conflicting customer requirements are some of the challenges that students face in a course like this.

The authors have been working on a collaborative experiment where the clients for the junior SE student teams are biomedical engineering (BE) student design teams. This allows interdisciplinary collaboration, exposes the SE students to eliciting requirements in an unfamiliar domain, and exposes the BE students to a formal requirements process. The authors discuss how this collaboration has evolved and what they learned from it. The challenges encountered while using this approach are also discussed.

1. Introduction

The two major (and unfortunately fairly common) roadblocks that projects both in the industry and academia alike face are

(i) A significant amount of time and effort is spent on rework because the delivered product does not meet the user's needs and

(ii) The project takes longer (and is over budget) because the functionality that needs to be delivered is not properly understood and estimated.

The chances of a product being developed on time and within budget are dependant on thorough and precise analysis of the client's current situation and needs. Informally, the client's needs are also called "requirements". A "requirement" is a specification of what should be implemented by a product. The IEEE standard defines a requirement as "a condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification or other formally imposed document. The set of all requirements forms the basis for subsequent development of the system or system component" [2] [3]. Requirements are primarily of two types: functional and non-functional. Functional requirements relate to the actions that the product must carry out in order to satisfy the fundamental reasons of its existence. Non-functional requirements are the desirable properties/qualities that the product must have [4] [7]. These are the characteristics that make the product fast, usable, portable, reliable, attractive, etc.

Requirements Engineering (RE) is the process of determining, analyzing, documenting, validating and maintaining the services and constraints (i.e. the functional and non-functional requirements) of the systems that need to be designed for the client. The use of the term "engineering" implies that systematic and repeatable techniques are used to ensure that the requirements are complete, consistent and relevant. One early intermediate product of RE is the Software Requirements Specification (SRS) document [1] that describes all the externally observable behaviors and characteristics expected of a software system. A quality SRS is one that contributes to successful and cost-effective creation of software that solves real-user needs and usually incorporates the viewpoints of all the stakeholders who have an interest in the product.

2. Curricular context

Because of the high importance of RE in the design of software systems, RE is a required junior level course (SE-3821[1]) in the undergraduate Software Engineering (SE) curriculum at the Milwaukee School of Engineering (MSOE). The students are first introduced to the importance of requirements as sophomores in SE-2831 (Introduction to Software Verification), and SE-280 (Software Engineering Process). The concepts learned in SE-3821 are reinforced in SE-380 (Principles of Software Architecture) and the process is scaled up for the students in their three-quarter experience of "Software Development Laboratory" [5], where the students work on large-scale projects in a "real-world" setting.

The unique thing about the Biomedical Engineering (BE) program at MSOE is that the students start working on their design capstone project as freshman. The freshman and sophomore years are typically devoted to market and technology research phase. The various project groups are supposed to have their design presentations sometime in the winter quarter of their junior year; with their senior year typically devoted to prototyping and finishing up their project.

The academic schedule at MSOE is based on a quarter system with three quarters in an academic year. Each quarter involves ten weeks of instruction with the eleventh week devoted to final exams.

3. Background Information on the "Requirements Course (SE-3821)"

As mentioned earlier, a course on Software Requirements and Specification was first developed and during the 2000-2001 winter quarter [8]. Since then the course has continued to evolve [9]. Even though the course has evolved, the basic pedagogical philosophy on which it is based has not. The philosophy that the course has tried to incorporate is:

(i) **Learning by doing** – This philosophy has been incorporated by providing students the opportunities to work on "real projects" and produce "real deliverables" for them. As the course progresses, the students go through the elicitation, analysis and specification phases of the requirements process. The final deliverable that is produced by them is a SRS document with documented characteristics of the project.

(ii) **Working in unfamiliar domains** - We believe that for such a course, the students should be exposed to a domain with which they are not familiar, so that they do not have any preconceived notions about the project. The hardest part of eliciting requirements is to be able to understand the terminology and the language of the stakeholders. We believe that students do not appreciate the difficulty of eliciting requirements if they are placed in a domain with which they are already familiar.

[1] Based on Version 2.1 of the curriculum.

(iii) **Interaction with external stakeholders** – Interaction with people from diverse backgrounds, diverse needs and diverse skills is a very important learning experience. As we have sought out projects in unfamiliar domains, we have had an opportunity to interact with people outside of the SE curriculum context who have acted as stakeholders to SE student groups. This has been a very positive, yet challenging experience for our students.

From 2000-2003, students typically worked on external "industry-sponsored" projects. Although these external collaborations were largely positive experiences, they had some drawbacks, including great difficulty scheduling and traveling to meet with the external stakeholders. In the 2003-2004 academic year, other students were used as stakeholders for the first time. Specifically, biomedical engineering (BE) students in the third year of a four year research, development, and design project acted as domain experts with SE students acting as requirements experts. We believed that we could try this approach of using other student projects as stakeholders to avoid some of the scheduling difficulties that we were running into and yet remain true to our original philosophy of the course.

The BE students provided all of their project documentation to the SE student teams. In some cases, the SE students had to sign Non-Disclosure Agreements with the BE teams, because of the unique project ideas that the BE students were working on. The SE student teams were expected to sort through the information and then schedule subsequent meeting with the stakeholders to gather additional information about the project. E-mails and Instant Messaging was regularly used between students as communication vehicles.

During the course of the quarter, the SE students worked on four assignments (detailed later in this section) based on the Volere process described in [4], which were sent to the BE student for review as soon as they were submitted to the SE-3821 instructor. The assignments were reviewed by the instructors of the course and feedback was provided to the students. The requirements were graded on the criteria of completeness, lack of ambiguity, testability, and readability. A lot of emphasis was placed on the fact that all assumptions and constraints were listed, the glossary was up-to-date, and all alternate and exception flows were considered when enumerating a use case.

The four assignments were:

Assignment 1	Project Blastoff (i.e. enumerate goals, identify stakeholders, enumerate constraints & risks, contextual diagram)
Assignment 2	Specify the major use cases for the system.
Assignment 3	SRS for the project.
Assignment 4	Complete and finalize the SRS. Final project presentations.

More details regarding the details of these assignments can be provided by the authors if the readers are interested.

4. Evolution of the Collaborative Experience

As mentioned earlier, the first collaborative experience between the SE and BE students was coordinated in the winter quarter of 2003-2004 academic year. This collaboration was planned before the quarter began by the two faculty members teaching the requirements course (one of them is the first author) and the faculty member advising the third year BE students. The BE faculty member and one of the authors had worked together on a requirements projects earlier,

though in a different context. Both of them believed that such an experience would be beneficial to all the students and that is how the collaboration got started. The SE students were to benefit by practicing the requirements process in an unfamiliar domain. The BE students were to benefit through exposure to a formal requirements process that greatly increased the chances of ending up with a product that meets the goals of the work while minimizing wasted effort.

There were certain problems that were discovered via the assessment process after the first offering of such an experience. Some of the major ones are enumerated below.

- **Wrong timing:** Even though the BE project course sequence has an extended market and technology research phase, many aspects of the design have already been drafted by the time the SE students begin working with the BE students. The BE students have to give their design presentations in the winter quarter (which was the same quarter that SE-3821 was being offered). This meant that the SE students were working with the BE students on requirements after the BE students had already made some important design decisions.

- **Communication:** In the early offerings of SE-3821, there was no associated lab with the course. The SE student groups had to arrange meeting times outside the classroom to work on their projects. The fact that they now had to arrange meeting times with the BE students also made things complicated for them. Inability to find common times to meet, having productive team meetings with 10 members (5 BE and 5SE) and avoiding "group think" were some of the challenges that the students faced in this area.

- **Inappropriate expectation management:** At the end of the course we found out that the BE students were not sure as to what to expect from this experience and what was at stake for them. On the other hand, this course had been a source of anxiety for the SE students because they believed that their grades for the course were at stake, whether or not the BE students cooperated/interacted with them.

- **Instructor Involvement:** The BE instructor was giving feedback to the BE student group whereas the SE instructors were in constant touch with the SE students. The fact that the instructors never met the other teams and interacted with them, demonstrated a lack of commitment by the instructors to the students. The students had a feeling that "they were on their own" in this experience. Even though the various instructors were in touch with each other, the students were mostly unaware of such communication.

Although not ideal, the collaboration worked well and certainly demonstrated potential. The problems that were discovered via the assessment process could certainly be taken care of in the future offerings of the course and we attempted to do so in the next offering of the course.

In the following year (2004-2005), SE-3821 was offered in the fall quarter. We believed that the timing was appropriate for documenting requirements that are unambiguous and measurable, since the BE students have developed the appropriate domain knowledge by the third year but had not made any design decisions yet. If we could help the BE students document good requirements, they would be better equipped to make good design decisions. We made the changes in the following areas, this time around.

- **Expectation Management:** The instructor for the BE design sequence (the second author of this paper), believed that a lot of issues that were discussed earlier could be taken care of if the expectations of the BE and SE students regarding their deliverables, time spent in class,

time spent in collaboration etc. were clearly managed. The second time around the SE faculty went ahead and made a presentation to the BE students in Week 1 of the quarter and explained to them the requirements process that the SE students will be using. The deliverables that the BE students should expect, our philosophy of how we believed the BE students would benefit was also explained. That seemed to work well. The students appreciated the fact that the SE and BE instructors were all familiar with the process and were committed to making it a positive and productive experience for all students. This was not just another academic exercise!!

- **Communication:** SE-3821 was restructured to accommodate a lab period. This made it easier for the SE groups to schedule meeting times amongst themselves. We also scheduled two common meetings for all the students (BE as well as SE) and their instructors. The students could ask questions of anybody if needed. These common meetings provided other opportunity to take care of any periodic communication problems that arose.

Our preliminary assessment seems to suggest that things went much better the second time around. Certain challenges still remain and are detailed later.

5. Assessment

This collaboration between SE and BE programs started because BE instructors were finding that a significant number of their students were experiencing difficulty with their design projects towards the end (i.e. in their senior year). The students in the senior year would realize that either their scope was too wide or two narrow or the requirements were not well understood. I lot of effort was wasted to produce a product that did not meet the goals of the project. The hope is that with some intervention early on with the SE students, who would help them scope their project out and help them understand the requirements on their project better, the BE students would be able to finish their design projects with relative ease.

Since the BE students who have had this collaborative experience, will be finishing up their design projects at the end of the current academic year (2004-2005), we do not have much data on whether this intervention has improved the quality of their design project in any way. We believe that it will be a couple of years (as this collaborative experience matures), before we can get any statistically reliable data.

We have been collecting some assessment information at the course level for SE-3821. The course level assessment is currently only measuring the students' understanding of the various course objectives. It is not doing any specific assessment of the collaborative experience as such. We plan to develop some assessment techniques in the near future.

6. Challenges

As mentioned earlier, we believe that significant improvements have been made as the collaborative experience between the BE and SE students has evolved and matured. We believe that such an experience is unique both to the students in both programs and provides them with a critical understanding of how things may be in the "real-world". Yet, some major challenges remain. Some of them are:

- **Disparate Expectations:** SE students take a 4 credit course during this collaborative experience where as the BE students take only a 1 credit senior design course. The time commitment that the BE students have towards this experience is very different that the SE students. Similarly, since the SE students are graded on their assignments, which are

primarily based on their project with the BE students, the SE students also perceive (especially if the experience is not very pleasant) as the course structure being unfairly stacked against them.

- **Common Meeting Times:** It seems like more than two common meetings should be arranged for the entire group, where open and candid discussion goes on between the instructors and students. To facilitate communication between the BE and SE students, we have also requested that there is some overlap as to when SE-3821 and BE design course is scheduled. This would make it much easier for the students to meet and would take away some of the scheduling issues discussed earlier.

- **Feedback from the BE instructors and teams:** All the assignments that the SE students submit are graded by their instructors. They send the same assignments to the BE peers and BE instructor but are a little disappointed when they do not receive any feedback from them. The instructors need to continue to work on this issue and see how to tackle this problem.

7. Summary and Future Directions

In summary, requirements in general, and the authors' project approach in particular, emphasize different skills than those with which most engineers have the greatest comfort. The emphasis on understanding a new domain and finding requirements before doing design enables provides skills to our students which we believe will really help them in the workplace.

We are very excited about the collaboration and see great potential. If this collaboration continues to work, they may be future opportunities in the BE and SE curriculum to collaborate on other areas (like Verification and Validation, Design Reviews) that can be pursued.

8. References

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Biography

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