Teaching Requirements Engineering with Virtual Stakeholders without Software Engineering Knowledge

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Abstract—Teaching requirements engineering (RE) is a difficult endeavor since it must reflect the reality as close as possible. Also, a sense of risk for the students should be included, while the supervisors need to be in control all the time. Related literature agrees on the importance of stakeholders for RE education.

While different potential groups of people were considered as stakeholders already, we propose a novel approach of using students of non-software engineering disciplines to introduce a semantic gap between software engineering students and these virtual stakeholders.

In this paper, we describe our results and experiences in embedding RE education within a software engineering lecture for undergraduate students. Also, we report on our efforts in setting up and conducting requirements engineering sessions with virtual stakeholders without software engineering knowledge.

Keywords—Requirements Engineering Education, Virtual Stakeholders, Role Playing, Software Engineering

I. INTRODUCTION

The importance of requirements engineering is usually not reflected in today’s software engineering curriculum and the availability of corresponding lectures and seminars. Thus, graduating students are lacking essential skills necessary to create successful software systems, as the skills required by requirements engineers differ significantly from those of a software engineer (cf. [1], [2]).

To create a realistic learning experience, the environment should not be overly controlled, since this may create a false sense of security [3]. Thus, the related literature focuses on creating such a realistic learning experience, mainly through the usage of different role playing approaches [4] to simulate stakeholders (referred to as virtual stakeholders [3]) or by explicitly exposing the students to the unknowable to foster an attitude of acceptance [5].

This lack of education is not a lack of motivation. Rather the effort necessary for setting up and supervising a successful and stable requirements engineering course is usually quite time consuming and costly. To obtain requirements, the needs and desires of stakeholders need to be elicited [6]. Thus, one of the most commonly discussed issues in requirements engineering education is the availability of stakeholders. The presence of a stakeholder provides the students with the possibility to develop for somebody who, e.g., has a real need and is not a member of the faculty or a fellow student. To experience the whole requirements engineering phase, at least one iteration of elicitation, specification, and validation is necessary, which needs to be supervised and evaluated to be able to comment on the students’ results. Also, to emphasize and enforce the effect of feedback during iteration cycles, surprising results might help. Alas, shocking results are not recommended [7].

As argued by Polajnar et al. [3], a realistic software engineering experience is not only a prerequisite for grasping the intent of software engineering methods, but also a prerequisite for proper understanding of why the discipline exists. Thus, our intent was to enable students to experience the need for requirements engineering methods by experiencing the problems these methods try to solve first hand. For one iteration cycle, the goals of our efforts were the following:

- $G_1$ the students should experience a semantic gap during elicitation;
- $G_2$ the students should experience consistency issues when synthesizing information gathered during an interview;
- $G_3$ the students should experience the usual problems when validating requirements specified in a way that does not support a suitable view for stakeholders.

To achieve our goals, we embedded a requirements engineering session consisting of elicitation, specification and validation of requirements into an undergraduate lecture on modeling complex software systems. Based on the lecture’s assignment provided by the authors, groups of students were exposed to a virtual stakeholder in order to elicit additional requirements, to synthesize and specify them, and to validate them together with this stakeholder.

The contributions of this paper consist of a discussion of our experiences from the introduction of a stakeholder meeting experience within an undergraduate lecture. Furthermore, we present our experiences with virtual stakeholders who do not have a software engineering background and are usually unfamiliar with the application domain – a
category of stakeholders which is usually considered unsuitable. Moreover, we report on our efforts for planning and preparing requirements elicitation sessions with such stakeholders.

This paper starts by discussing related work concerning the usage of real and virtual stakeholders in Section II. Afterwards, Section III reports on guidelines for planning sessions with virtual stakeholders without a software engineering background. Then, the established undergraduate lecture within which we introduced a requirements engineering experience is discussed in Section IV. The conduct of the planned education is then presented in Section V. The results are finally discussed in Section VI and conclusions are drawn in Section VII.

II. RELATED WORK

Macaulay and Mylopoulos [2] argue that there is an educational dilemma in teaching requirements engineering since it is required to provide a solid foundation in the subject of matter while exposing them to the inherent uncertainties, inconsistencies and idiosyncrasies associated with real requirements problems. The common way of exposing students to such uncertainties is to arrange stakeholder meetings for elicitation, validation or negotiation for them, since meeting with stakeholders is an important part of requirements engineering activities [8].

As pointed out by Polajnar et al. [3], there are two distinct kinds of stakeholders available for teaching requirements engineering – real and virtual stakeholders.

Real stakeholders have many advantages: they know their application domain, they usually are not software engineers themselves, thus leading to a semantic gap between them and the students. Additionally, they are also usually interested in the results, which motivates them to negotiate with the students. However, if a real stakeholder is not satisfied at any point in time, the cooperation might be terminated. While this sense of risk is realistic, coping with the worst case scenario might not be feasible. Consequently, reports of successful stable lectures throughout multiple iterations, similar to the cooperation with a local company discussed by Gnatz et al. [9], are rare.

Virtual stakeholders, on the other hand, are normally not familiar with the application domain. The same, however, is also true for an optional software engineering background. These are two important factors which can be considered when looking for persons who are suited to enact virtual stakeholders. However, they usually cannot expect to gain anything from the results of the elicitation and validation sessions. Thus, it might be hard to motivate them accordingly for the role they are going to play.

This classification into real and virtual stakeholders was extended by Callele and Makaroff [7] who introduce a more detailed distinction between these two kinds of stakeholders. Due to the commitment necessary to provide a real stakeholder, they are instead most commonly simulated by students. However, while students of the same class (cf. [1], [10]) or graduate students with industrial experience are considered as alternatives, students of other faculties are not mentioned. Although external students usually need to be motivated differently, e.g. financially, and also need to be prepared for the role of a virtual stakeholder more intensively than software engineering students, it seems worthwhile in our opinion. Firstly, it explicitly introduces a semantic gap between the students and the virtual stakeholders, which is more realistic than somebody who has the same technical knowledge as the students, even if these stakeholders try to hide it. Secondly, providing the students with “new faces” is also important. The interaction between students who know each other, e.g., from another lecture, cannot be compared to how they have to behave in front of somebody they never saw before.

III. PREPARING VIRTUAL STAKEHOLDERS

Especially for students from other faculties who enact virtual stakeholders it is important to consider what they know and how truthfully they can answer questions during the elicitation. As discussed in Section II, students enacting virtual stakeholders do usually not have enough application domain knowledge to answer elicitation questions truthfully, let alone authenticly. This observation holds for students of all faculties, although software engineering students as well as faculty members tend to concentrate on technical details or requirements engineering methods (cf. [1], [7]). Thus, it is necessary to introduce the required knowledge to these potential virtual stakeholders in order to prepare them to answer elicitation questions as truthfully as possible. During this discussion, we refer to a stakeholder’s knowledge as facts. Therefore, stakeholders have knowledge in form of facts that can be elicited by requirements engineers. These facts are either already known to the stakeholder, or they need to be learned before the elicitation starts. Otherwise, the requirements engineers are not able to elicit the necessary information from the respective stakeholder.

Due to the fact that virtual stakeholders rarely have the necessary domain knowledge to be perceived as knowledgable by the requirements engineers they need to be prepared for the elicitation. By introducing them to the problem domain, they can memorize the important facts that need to be elicited. The amount of facts and implicit requirements introduced or taught to them is presented as the set Preparation $P$ in Figure 1. Presenting them more facts leads to an increased $P$. Consequently, without any preparation session whatsoever, they have little consistent knowledge about the problem domain.

Furthermore, each person has an individual background which is essentially the sum of all experiences, i.e. facts,

\footnote{In this paper, we use set theory only to discuss the relationships between the presented sets.}
acquired so far. This is represented by the set Personal Experience $XP$ in Figure 1. This set also includes the professional background of each person. If a software engineer is asked about a technical detail, the answer strongly depends on whether or not the problem was already considered and, thus, is somehow included in the personal experience. More importantly, individual virtual stakeholders might already have insights into the application domain through such personal experience. This allows them to answer certain questions truthfully, even without being explicitly prepared to answer them. E.g., this might be the case if the elicitation session considers call center agents and some of the students enacting virtual stakeholders have already worked in a call center. In any case, querying about related experiences helps to avoid inconsistencies with presented facts and also to benefit from potentially more realistic insights into the problem domain.

The goal of the preparation session is to introduce the facts necessary to authentically enact a virtual stakeholder to somebody who in turn learns them. Thus, a fact $p \in P$ which can be elicited later on has become an element of $XP$ since it has been learned by the virtual stakeholder. Usually, such a preparation is conducted for multiple virtual stakeholders simultaneously. This is due to the fact, that it is not feasible to prepare each virtual stakeholder individually, since conducting multiple sessions takes much longer and the results of such sessions are not necessarily consistent. Thus, a preparation should always conducted with groups of potential virtual stakeholders.

For an elicitation as part of a lecture, the students gather information according to what they need to know to fulfill their assignment. In turn, this implies that the assignment influences which facts and information are considered necessary. The set Assignment $A$ in Figure 1 represents these facts which are implicitly required to fulfill the assignment. Thus, the students should elicit all facts $fact \in A$ in order to be able to complete the assignment. Accordingly, the preparation of the virtual stakeholders should at least include the facts necessary to answer the questions implicitly raised by the assignment. To be perceived as authentic, the virtual stakeholders should be able to answer all these questions with ease, plus the occasional divergent question along the way.\footnote{Generally, a checklist of facts that need to be consistently elicited by the students can be provided to the virtual stakeholders in order to help them to get the important facts consistent throughout all session of all virtual stakeholders.}

On the other hand, the stakeholders’ authenticity decreases if questions implied by the assignment cannot be answered. Thus, to avoid this loss of authenticity the stakeholders need to be instructed uniformly on how to handle such questions which they do not know the correct answer to. Some inconsistencies can be avoided by instructing them to give a reasonable answer, however, also to tell the students that they are not entirely sure. Otherwise, telling them to refer to other colleagues who are usually in command of fulfilling the corresponding task or providing this information might also be viable to at least maintain an authentic appearance, e.g., “You should ask Ben. He is usually in charge of this.” Generally, the latter option is recommendable for all information that were not considered during the preparation, or when dealing with multiple, different virtual stakeholder roles.

A good combination of preparation $P$ and assignment $A$ would be $P \supseteq A$. This ensures that all stakeholders gained enough insights into the problem domain to be able to answer the questions that are implied by the assignment. While additional information $(P \setminus A)$ are optional, they might increase the perceived authenticity, especially for divergent questions during the session.

General questions which are not considered to be important for the assignment (questions eliciting facts which are not in $A$) depend on the preparation $P$ or the personal experience $XP$ of the virtual stakeholder. If they were not covered in the preparation, it is improbable that all stakeholders answer the question in a consistent manner. Only if all virtual stakeholders happen to share the same experience concerning this questions, it might be answered consistently.

The discussed approach is different from using only one person who enacts the virtual stakeholder for multiple or even all sessions. In this case, carry-over effects are to be expected. Since a virtual stakeholder might learn what seems to be important for the requirements engineers, the answers might reflect these insights by becoming more direct and of
a higher quality. Thus, the results of the last sessions are potentially much better than the results of the first session. The problem of growing experience is usually addressed by using knowledgable faculty members [7] who are already experienced and, thus, need to hide their experience or by relying on students of the same class who only experience the corresponding sessions once [1]. For virtual stakeholders who do not possess this knowledge yet, such carry-over effects should be avoided by employing multiple persons, one for each elicitation session.

IV. THE LECTURE

The lecture is a second semester undergraduate course, that aims at teaching students how to model a complex system within a group of eight to ten students. Participants already have basic knowledge about the fundamentals of modeling since this lecture is a follow-up event of a first semester course about principles of modeling techniques. Within the course an introduction to the Unified Modeling Language (UML³), a general purpose modeling language in the field of software-development, is given. Within each lecture a specific project in form of a textual problem definition is provided. The topics covered during past lectures ranged from workflows within a car sharing company to a system of autonomous robots for the exploration of unknown territories. The participants first have to understand and reformulate the provided problem definition in a more concrete and complete way by creating an analysis document using the UML in combination with textual descriptions. Based on this analysis document, that is used for the description of the starting point and the given requirements on the desired solution, a design document has to be created. The design document has to describe a plausible solution based on their analysis results. Up to the point when the design document is delivered to the organizers, feedback is scarcely provided to the students.

Each group has a tutor assigned, i.e., a student who successfully attended the same course priorly. The tutor is responsible for guiding their efforts, for assisting the overall coordination of the procedures of the lecture and for delegating open points concerning the problem definition as well as questions concerning the UML between the students and the organizers of the lecture. As part of the lecture, these tutors can be considered rather as peers who provide feedback about the lecture on a meta level than as stakeholders. Since they have only the same application domain knowledge about the assignment as the students, they advise the students on how to employ UML and what they need to consider to fulfill the assignment.

Structured templates for the analysis as well as for the design document are provided to the students. These documents define an overall structure, the specific diagrams that have to be used for the description of the specific parts and they provide simple examples how the diagrams can be used. The purpose of these templates is to gain more formally structured, less ambiguous and well formed documents. Both documents have to be elaborated in a cooperative fashion where students are organized in groups of eight to ten participants. Predefined responsibilities are chosen by the students. Table I shows the different roles for a group of eight students and the responsibilities associated with each role. E.g., the two students enacting the roles 1 and 2 are responsible for the creation and presentation of the analysis document.

The lecture has been offered by two of the authors for four years now. As mentioned before, detailed feedback from the organizers has rarely been provided before the students delivered the design and analysis documents. Thus, due to the dependencies between the design and the analysis document inadequately understood or omitted requirements had a major negative impact on the delivered solutions in form of the design documents.

To provide a more realistic experience for the participating students, an iteration of requirements elicitation, specification and validation was introduced. This was done to initially evaluate the reaction of the students when being introduced to these concepts as well as the possibility to extend the lecture accordingly with more feedback cycles.

A. The Case Study: an Online Supermarket

The task at hand for the students was to model an online supermarket based on requirements provided by the authors. These requirements were specified explicitly to mimic different perspectives within the assignment document. Throughout the document’s 12 pages, the level of detail changed based on the topics covered. While the requirements for the workflows were rather rudimentary as to be expected from someone starting a new business, the restrictions for passwords of customers were quite thorough. This was done in order to stimulate the students’ sensibility to different roles and their different needs within the considered company.

Apart from the requirements that were to be expected for an online supermarket, one special feature was emphasized. While customers usually have to rely on external delivery companies to bring the ordered goods at some point in time, customers living nearby are eligible for straight to the point deliveries with a scheduling period of half an hour. E.g., fresh apples can be ordered at 9:37 AM to be delivered between 1 PM and 1:30 PM on the same day. Thus, the

³For more information about the UML see http://www.uml.org.

Table I: Abridged Table of Responsibilities and Roles.

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<th>Responsibility</th>
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<td>Design Document</td>
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<td>Requirements Engineering Block</td>
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<td>Presentation of Analysis</td>
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<td>Presentation of Design</td>
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system has to be able to organize deliveries for different categories of customers and must be able to arrange time-slots for the delivery accordingly. However, the assignment contained only vague indications about potential problems, e.g., “If the goods cannot be delivered in time, the bill can be reduced by up to 10%.”

B. Extension for the Requirements Engineering Sessions

During the first lecture, it was announced that an evaluation of the results of the individual groups would take place with an external stakeholder. Based on the size of the groups, we decided to limit these stakeholder meetings to four students from each group, since more participants would have introduced more communication overhead within the individual groups throughout these sessions. Also, to balance the workload within all groups, not all students were exposed to this experience (36 out of 81 students).

For us, it was important to distinguish between the work invested into the project and the efforts for the requirements sessions. Everything the students learned about the application domain was modeled as an extension to the lecture’s case study. Therefore, we introduced the role of a call center agent, referred to as support agent, into the case study. A support agent acts as a negotiator between several other roles within the online supermarket, e.g., accounting, warehouse, and the person delivering the goods and the customer. The main task of a support agent was to negotiate in cases of problems or whenever problems might arise. The enactment of this role was the task of the employed virtual stakeholders.

After the students delivered the analysis of the case study, we coordinated dates for the meetings between the four students from each group and the stakeholders. Then, two weeks prior to these meetings, an announcement was made to prepare the students according to their case study: “The company responsible for the project you all are working on is able to send someone over whose role within the considered online supermarket was not sufficiently present in your original assignment. Thus, to avoid errors due to omission, this person will be available for an interview session as well as a validation session afterwards.” The whole requirements engineering block was planned for four hours which were allocated as follows:

1) Requirements Elicitation: The supervisor introduced the four students to the stakeholder and proposed to refer to each other on a first name basis. The students were instructed to work problem-oriented only, i.e., without focussing on solutions at all. Thus, their main objective was to elicit enough information from the stakeholder to understand what they do and how they do it. The students had 50 minutes to interview the stakeholder about his or her role within the company of the case study, including the interaction with other employees of the company. After these sessions, all participants including the stakeholder were asked to fill out a questionnaire designed to evaluate the perceived success of this session.

2) Requirements Specification: Afterwards, the students had 100 minutes for synthesizing what they had learned during the interview. During that time, the stakeholders were not needed. The students were told to either use a free modeling or a formal modeling approach to specify their findings. The focus was on discussing and specifying everything that was learned about the workflows of the stakeholder in order to present and validate it with the stakeholder afterwards. Brief examples of what was produced by the students is presented in Figures 2 and 3 (German). Afterwards, another questionnaire was filled out to evaluate the common understanding of what was synthesized, the students’ satisfaction concerning their results, and the students’ team work.

Figure 2: Examples of the synthesized models created using UML as specification language.

3) Requirements Validation: During the last 45 minutes, the students were asked to present their specifications to the stakeholder. Therefore, the students used projectors, whiteboards, or flip-charts for their presentation. The stakeholders were asked to comment on errors they found concerning what they told the students beforehand during the elicitation. A last questionnaire for all participants was handed out to evaluate the success of the validation presentation in terms of found misunderstandings and understandability for the
stakeholder.

All questionnaires used a 5-point Likert scale (1 being agreement, 5 being disagreement) and free text questions. These questionnaires where handed out to the 36 participating students as well as to the 9 stakeholders.

Since the sessions were distributed throughout 10 days, we asked the students to not tell anyone about the content of their session to avoid a bias for other participants.

V. CONDUCT

A. The Virtual Stakeholders

As mentioned before, each stakeholder was only involved in one meeting in order to avoid carry-over effects between different sessions. Our approach was conducted in order to evaluate the following hypothesis: We can teach students without software engineering knowledge the application domain knowledge necessary to become viable virtual stakeholders.

1) Selection of Potential Stakeholders: Based on the constraints mentioned in Section II concerning stakeholders, we chose to recruit graduate students explicitly from other faculties who do not have any software engineering background. We thereby explicitly introduced the semantic gap between the stakeholders and the students. The potential disadvantage of missing application domain knowledge can be considered irrelevant, since the application domain was designed to be suitably easy to understand for the stakeholders (see Section IV-A). Also, we prepared the stakeholders accordingly to work around the potential lack of domain knowledge (see Section V-A2).

To find suitable stakeholders, we sent an email to the public student list of the University of Potsdam which reaches up to 20,000 students. The email was sent by a faculty member who was not officially involved in the lecture. Thus, we tried to avoid that the students of the lecture might suspect that we are casting stakeholders. In this email we searched for people without a software engineering background and stated that “acting talent might help.”

From the student list, we received about 224 applications. We chose nine applications of students using the first-in-first-out principle but under the condition that each one is a graduate student with different background.

2) Preparation of the Stakeholders: To prepare the stakeholders for the role they had to enact, we invited them ten days before the first elicitation date for three hours. They had no software engineering background, therefore, the role of requirements engineering had to be explained to them in order to motivate their role and why they need to enact it. Afterwards, we defined requirements suitable for the extension of the case study as discussed in Section IV-B. After everybody understood the case study, their role as a support agent was explained and we brainstormed potential different problems that one could experience between ordering and receiving goods from an online supermarket. These problems were then synthesized into different scenarios. Essentially, the stakeholders came up with ten different scenarios of what might happen. They also had to explain their individual understanding of these requirements by reusing them in a scenario from the perspective for their role, i.e., speaking in the first person. This ensured a deeper understanding, created and limited the stakeholders’ need to bring a checklist into the elicitation sessions.

Through the articulation of own thoughts during this preparation, we hoped for a sense of common ownership which we believe to be the basis for a successful adaption for the stakeholders. Thus, they might enact their role more convincingly when telling the students their scenarios than they would do reciting scenarios we gave them.

The general goal of the preparation was to create a common understanding between the stakeholders what a support agent has to do. The assignment potentially included questions about other roles within the online supermarket as well. However, the stakeholders were briefed to convincingly tell the students to redirect this question to another person from the company. This separation between the support agents and other roles within the company is illustrated in Figure 4.

Still, to counteract the delay between the preparation and the last requirements session, a summary of the preparation was created and sent to the stakeholders as a reminder.

B. Preparation of Students

Apart from a five minute announcement about our slight changes to the lecture, i.e., that a requirements engineering
Figure 4: The stakeholders were prepared to correctly answer as much of their role as possible in an authentic manner.

session will be conducted this year, the students received no additional training or education than what was taught as part of the lecture anyway. This was based on considerations of Callele and Makaroff [7] who argue that requirements engineering education might employ shocking or even traumatic events in order to convey the uncertainty or the sense of risk. Such a shock was not explicitly created. We rather tried to create a relaxed situation by, e.g., introducing the students and stakeholders on a first name basis.

C. Requirements Elicitation

Due to the lack of training, the interview sessions were only partially structured. Nobody was assigned to ask questions or write down the answers, thus, nearly everybody did both. In one group, the interview grew more aggressive as all of the four students individually came up with new questions, asking all the time without letting the stakeholder finish her sentences.\(^4\)

Regarding our goal \(G_1\) – the students should experience a semantic gap – we are convinced that the stakeholders were quite authentic in their roles. Since they were cast without a software engineering background, they would have needed additional training to close the gap that was there already. When we asked the students whether they had to ask multiple times due to ambiguous answers of the stakeholder, they rather disagreed (\(\bar{x}=3.58, s^2=0.71\)). While they also rather disagreed that they needed to reformulate a question based on ambiguous terms multiple times (\(\bar{x}=3.47\)), their individual perception was quite inconsistent with a variance of 1.34.

The perception of the stakeholders differed concerning the semantic gap. When we asked the stakeholders whether they perceived that the students asked multiple times to ensure that they understood [the stakeholder] correctly, they rather agreed (\(\bar{x}=2.22, s^2=0.94\)). However, they also rather agreed that these redundant questions were justified, e.g., due to inconsistent statements (also \(\bar{x}=2.22, s^2=0.94\)). We conclude that the students were able to bridge the semantic gap surprisingly good without any prior training. Generally, the students of the nine individual groups were considered as confident (\(\bar{x}=2.0, s^2=0.25\)), curious (\(\bar{x}=2.0, s^2=0.5\)), relaxed (\(\bar{x}=1.89, s^2=0.61\)), intelligent (\(\bar{x}=1.67, s^2=0.25\)) and competent (\(\bar{x}=1.78, s^2=0.44\)). Also, their conduct of the elicitation session was considered rather authentic (\(\bar{x}=2.0, s^2=0.5\)).

Out of the nine groups, only two used the whole interview duration without any pauses longer than 30 seconds. Three groups hesitated multiple times for more than 30 seconds, but still continued through the whole 50 minutes. Four groups decided to end the interview before the 50 minutes were over.\(^5\) The students were asked whether they required additional interview sessions with the stakeholder directly after the interview (rather not with \(\bar{x}=3.54, s^2=1.15\)) as well as after the specification stage (rather not as well with \(\bar{x}=3.43, s^2=1.07\)).

Generally, the students perceived the stakeholders as quite confident (\(\bar{x}=1.83, s^2=0.71\)), intelligent (\(\bar{x}=1.94, s^2=0.47\)), competent (\(\bar{x}=1.69, s^2=0.56\)) and authentic (\(\bar{x}=1.75, s^2=0.59\)). When asked about the authenticity of the atmosphere, the students also rather agreed (\(\bar{x}=2.11, s^2=0.62\)). These results are also visualized in Figures 5 and 6.

D. Requirements Specification

As mentioned before, the students were told to use different modeling approaches, either informal or formal ones. The general goal was to expose them to consistency issues when it comes to synthesizing the information they gathered during the interview (\(G_2\)).

As it turned out, most of the students were rather satisfied with the specifications they created (\(\bar{x}=2.19, s^2=0.96\)). Also, the students were quite confident about the correctness of their models (\(\bar{x}=2.13, s^2=0.46\)). The students were asked after the specification whether or not they agreed about the structures within the company before and after the specification session. While they rather agreed when the specification session started (\(\bar{x}=2.25, s^2=0.88\)), there was a significantly improved common agreement at the end of the specification phase (\(\bar{x}=1.36, s^2=0.35\)).\(^6\) This is also visible in Figure 7. Judging from the results of the free text questions, they most commonly discussed about suitable representations. When certain details were identified as inconsistent, they usually agreed upon the intersection of the different interpretations and skipped the parts they argued about.

For our goal concerning the specification, we have a significant increase of common understanding after the

\(^4\)As it later turned out, this was not perceived at all by the group. However, the stakeholder graded the results of these students significantly worse compared to how other stakeholders rated their groups in their respective sessions.

\(^5\)They ended their interviews after 35, 37, 43, and 48 minutes, respectively.

\(^6\)All groups presented a similar progress of agreement except for one group. For this group, a graduate student emerged quite early as the group leader since he had the most experience. This, however, distorted their perspective on the agreement process, since all of them stated that their agreement was the same throughout the whole session (\(\bar{x}=1.0, s^2=0\)). Without their unusual agreement values, the mean of the remaining eight groups is 2.41 (\(s^2=0.77\)) before and 3.41 (\(s^2=0.38\)) after the specification session.
students synthesized their notes. Additionally, most of the comments about when and how they needed to compromise dealt with how to handle inconsistencies. Thus, we exposed most of them successfully to inconsistencies within their elicited requirements.

**E. Requirements Validation**

Although all stakeholders were instructed to question what the students present to them based on their real understanding of what they told the students, the results differed quite a lot. It was our goal to expose the students to the problem of validating specified requirements with a stakeholder ($G_3$).

Generally, the stakeholder strongly agreed that they understood what the students presented to them ($\bar{x}=1.22$, $s^2=0.19$). When asked whether they had to inquire often about what was presented, they rather disagreed ($\bar{x}=3.78$, $s^2=0.94$). However, the questions they had were mainly concerning the understandability what was presented ($\bar{x}=2.67$, $s^2=1.5$). Not surprisingly, most of the understandability questions were asked by stakeholders for students who used UML models ($\bar{x}=1.67$, $s^2=0.33$, 3 groups), although the students that used UML rather disagreed when being asked beforehand whether their models are quite technical ($\bar{x}=3.83$, $s^2=0.15$).

As a general observation, the validation stage was highly dependent on the stakeholders and their individual capacity for providing critical feedback. The shortest validation session took only 13 minutes. After the students explained what they understood in ten minutes, they asked the stakeholder whether he had any comment on what they presented. When he said that his requirements were sufficiently represented...
and shortly explained which aspects he liked most, the validation was officially finished, since pointing out minor errors would have diminished the stakeholders authenticity and authority.

VI. RESULTS AND LESSONS LEARNED

Based on goals specified in Section I, we conclude that our effort of teaching students the basics of requirements engineering hands-on was partially successful.

When we asked whether the students believe that the interview and validation session are important for [their] further studies ($\bar{x}=2.86, s^2=1.44$) or [their] professional career ($\bar{x}=2.75, s^2=1.68$), only few students seemed convinced. Thus, the students do not seem to be sensitized that requirements engineering is important for their educational and business career. However, they agreed that this experience should be repeated within [their] university curriculum ($\bar{x}=1.75, s^2=0.65$).

Maybe our project raised the sensitivity; however, students are primarily focused on providing solutions for given requirements. How they get the requirements does not seem to matter. This is also one of the reasons we chose to use an undergraduate course for our approach. As argued by Callele and Makaroff [7], the students have to overcome the conditioning from school, where all assignments were stable and marks were granted on the basis that you only fail if you do not try. We are convinced that the expected results can be enforced by adding more iteration cycles of elicitation and validation with additional time in between for the gathered assumptions to sink in. Two hours of specification before the validation seem insufficient for that to happen.

The feedback that we received shortly after each session as well as during a debriefing within the lecture indicated that the students were pleasantly surprised and gained insights into the problems typically encountered by requirements engineers. The general satisfaction of the students was highly dependent on whether or not they got feedback immediately after the session or later. Due to the efforts for supervising several sessions in parallel, two groups were unsatisfied with the abridged feedback they received. Thus, the effort was futile in their eyes, until they received corresponding feedback belatedly.

A. Evaluation of Hypothesis

We hypothesized that we could successfully employ students without a software engineering background as virtual stakeholders. Our conduct seems to be a viable proof of concept. The students that acted as virtual stakeholders seemed to understand their application domain and during the elicitation and validation phase they were commonly able to present their domain and its problems. Additionally, they were also able to discuss the presented results with the students. Still, while the results concerning our teaching goals are rather good, the stakeholders themselves did not feel appropriately prepared according to the questionnaires they filled out after the interview session. When asked whether they felt confident enacting their role during the interview, they did not agree as strongly as we hoped them to ($\bar{x}=2.44, s^2=0.28$). This might be due to the fact, that they were not able to use all the prepared scenarios (Did you use many of the prepared scenarios? $\bar{x}=2.67, s^2=0.5$), while at the same time they agreed that they reached the limit of what was prepared ($\bar{x}=2.39, s^2=1.36$). In these cases, the stakeholders commented in the questionnaires that they tried to evade such questions or improvise something sensible.

In conclusion, the effort spent to prepare the stakeholders seems to have been underestimated. While we reached our goals, the stakeholders felt not confident enough. This might have been avoided by extending their preparation with a simulated interview situation. Although all of them approximately knew what to expect, some of them seemed to be rather unprepared for the students.

On the other hand, exposing them to a simulated interview might also present the expected semantic gap too explicitly. In turn, this might diminish its effect during the interview session. Thus, a good balance between the need for a simulated interview for the virtual stakeholders and their genuine perspective concerning the semantic gap needs to be found.

B. Perceived Authenticity of Stakeholders

Most of the students admitted after the interview situation that they were not sure whether the stakeholders were real. Although some students were not convinced, they did not want to risk any failures in case the situation was real.

Certain aspects worked in favor for the authenticity. Firstly, by introducing new faces, i.e., students they never saw before. Additionally, the students were told to dress in a business casual manner to emphasize their expectations concerning the interview session. Although all sessions began with the introduction between the students and the stakeholder on a first name basis, several students started to address the stakeholder more formally after a few minutes.

On the other hand, some stakeholders gave inconsistent information, e.g., one of them claimed that the support agents are reachable for 18 hours for six days a week. Five minutes later, she also claimed that she was the only support agent working for this company. The stakeholders were not explicitly briefed about such details since the assumption was that they would be able to answer details from their personal experience in terms of what makes sense. Another shortcoming that was perceived from the students was the need of some stakeholders to get visual feedback from the supervisor whether the answers during the interview session were correct. To avoid irritating the stakeholders the University of Potsdam is distributed over three locations. While some students have to visit all three for their lectures, others spend their studies in one location only.

$^7$The University of Potsdam is distributed over three locations. While some students have to visit all three for their lectures, others spend their studies in one location only.
supervisors were told to nod all the time when being looked at by the stakeholder. This was contrary to the stakeholders’ briefing which stated that all facts are acceptable as long as they are to the best of one’s knowledge and belief.

While the setting (clothing, new faces, etc.) was judged as suitable, the perceived authenticity was mostly based on the stakeholder’s character. Thus, the confidence with which they were able to tell their stories and to react the same way when confronted with potential inconsistencies was most important. As outlined in Section V-C, the authenticity of the stakeholders and the atmosphere was rated quite good.

C. Potential Improvements for the Presented Setting

As argued before, the stakeholders felt that they needed to be prepared in a more detailed fashion. Also, the amount of information that could be elicited differed depending on the additional time they spent preparing at home, ranging from shortly thinking about it on the way to the meeting up to three hours of online investigation and practice. Based on the best practice, additional time has to be scheduled to allow for this kind of preparation. In a controlled setting, it is also possible to induce additional stress for the students, e.g., by telling the stakeholder to drop in after one hour demanding them to present their results earlier than planned. The scenarios dealt with different complex situations in a simple application domain, but focused on only one perspective of it. By introducing a second or third role, the students should be better able to experience inconsistent and conflicting requirements.

VII. Conclusion and Future Work

We presented our approach of introducing students from other faculties, i.e., without software engineering background, to incorporate virtual stakeholders into the requirements engineering education. We chose students without any software engineering experience to deliberately introduce the semantic gap between engineers and stakeholders which can typically only be simulated by all other variations of virtual stakeholders, i.e., faculty members or students from the same class. Additionally, we provided preparation guidelines on how to set up requirements elicitation and validation sessions with virtual stakeholders. This also includes instructions for these virtual stakeholders on how to behave when asked divergent questions they were either not prepared for or forgot the answers to.

As mentioned in Section II, external students might need to be motivated financially. We cast the virtual stakeholders and hired them according to the tariff of the university. Thus, the whole setup of embedding a requirements engineering block into an existing lecture was possible for 1.200 Euro which makes it feasible in terms of expenses and results.

To further refine the idea of employing students from other faculties and the corresponding guidelines, we are going to repeat the requirements engineering block of this lecture, only this time with multiple iterations instead of only one cycle of elicitation and validation. This will allow us to measure the progress of the students in a more detailed manner, and thus to further evaluate the effectiveness of our approach.

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