Increasing Authenticity in Pre-College Software Engineering Education through Role-Play

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Abstract

Contemporary secondary technology education often does not mirror engineering practice. While there is much rhetoric on the need for promoting active, authentic, and real-world professional experiences in upper secondary school, most technology education teaching remains traditional, and teacher centered. This study investigates the affordances for authenticity of role-play-based project work in a Swedish upper secondary software engineering course. The project required students (aged 17–18) to assume the role of software engineer employees at a web-design business with the task of creating a website for a gaming company, where the course instructor assumed the role of the web business owner. The six-week project included the formulation of a design plan, back-end programming, developing and refining the design and layout, adjusting content for accessibility, and publication of the web site. Inductive analysis of observations from the unfolding role-play in five student groups (total 22 students), and interviews with four students and the teacher exposed salient themes related to authenticity of the role-play-based project exposed within *teacher-student interactions* and *student intragroup interactions*. Teacher-student interactions revealed that the teacher exhibited various roles in the project, initially acting as a customer but also the responsibilities of a boss and a teacher-mentor. In the latter instance, students perceived the project as more school-oriented than authentic, expressing a preference for an external customer, and at the same time, the teacher tried to align the task with the project's curriculum requirements. Student intragroup interactions showed that despite highly varied roles, students felt that their assigned roles enhanced the authenticity of their experience, although they were unaware of what a real scenario might entail. Successful students emphasized the importance of structured work and clear responsibilities to meet the project goal. The findings show that while role-playing is not necessarily always equivalent to reality, it was viewed as a fulfilling and situated learning experience that simulated a real-world scenario, but which relied on mutual confidence and responsibility between the role-players. Future work will combine the findings with existing frameworks of authenticity to inform the development of role-play scenarios in upper secondary engineering education.

Keywords: authenticity; role-play; engineering education; software development; secondary school

Introduction

Present-day secondary technology education is often significantly divorced from engineering practice. Students tend to work with small tasks devoid of context, regardless of whether they design gears, sanitation systems, or computer software. Therefore, one way of strengthening the connection to engineering is to provide students with authentic tasks (e.g., Strobel et al., 2013). However, engineering is much more than merely designing, coding, or modelling various technological outcomes. Engineers engage in a professional culture traditionally learned and

acquired on-the-job and not primarily during engineering education. Organized attempts to include such cultural components in engineering education have been made, for example, through the CDIO (conceive, design, implement, operate; see Crawley et al., 2014) initiative in higher education, although they are mostly lacking in secondary education. Role-play – assigning teachers and students tasks where they emulate real-world roles – might be a way to introduce cultural components in engineering and technology education, but so far has not attracted much empirical attention at the secondary level.

The promise of role-play experiences and training in engineering education has been emphasized by Nakamura et al. (2014). They have pointed to benefits of role-play in group-work scenarios, particularly where the task is to determine customers' requirements of a design and to be able to analyze these from multiple perspectives. Nevertheless, the literature shows that role-play is a pedagogical tool that is not often adopted in STEM secondary classrooms (Decker & Simkins, 2015), and that the application of role-play learning methods in higher engineering education is limited (McConville et al., 2015). Despite the continued encouragement of active and real-world learning interventions, with role-playing a strong candidate for promoting such an agenda, most engineering education still occurs via traditional teaching. Hence, there is a need for more work that explores how authentic and real-world engineering practice can be leveraged in role-play tasks.

Aim and Research Questions

The objective of the study is to investigate the affordances for authenticity of role-play-based project work in a Swedish upper secondary software engineering course. The study addresses the following research questions:

- What aspects of authenticity were revealed in the role-play-based project work?
- What were the teachers' and students' views of authenticity in the role-play project??
- In what ways did students respond to the way of working in a role-play context?

Literature review

As strikingly captured by Tomasi (2008, p. 2), "many engineering technology students excel in coursework that fosters the tactile-kinesthetic educational domain". Role-play can serve as a tool to simulate such educational experiences. For example, role-playing can provide unique, meaningful, and real-world opportunities for engineering and technology students to develop skills associated with validating product design, requirements, and development, as well as reflecting on customer desires and specifications (e.g., Nakamura et al., 2014; Tomasi, 2008). In further support of this approach, McConville et al. (2015) purport that role-playing can be adopted as an active learning tool, which is highly suitable for exploring links between technology, complex problem solving, and communication. In relation to teaching strategies around design and software engineering, Erturk (2015) asserts that role-play is a powerful example of an active and authentic learning activity that increases learner engagement. We apply

the above descriptions and attributions of role-play in engineering education in the theoretical position taken by the currently reported study.

Tomasi (2008) explored how role-play could stimulate real-world industrial experiences for mechanical engineering students at a College of Technology in New York. The course instructor assumed the position as engineering manager for a technical design concern, and the aim of the role-play was to represent an internship experience. Of the seven students participating in the exercise, the freshman students took on the function of drafters, while the more senior students functioned as designers and project engineers. The assignments included the design of different products requiring a range of technical detail, and desired needs from the customers. One example included design solutions to recycle used wooden pallets. During the process, students were confronted with various design, economical, and ethical dilemmas, and students had to deal with factors such as working to deadlines, resolving disagreements, and continuously refining solutions. The author found that the "hands-on" and "real-world" situations that the role-play situation afforded were particularly pedagogically valuable for engineering education students.

In the realm of a computer systems analysis and design course in a New Zealand bachelor program, Erturk (2015) explored two class sessions that involved students producing Data Flow Diagrams and Activity Diagrams, where the intention was to demonstrate their analysis of a software "case" by constructing, reviewing, critiquing, and reflecting on the diagrams. The role-play dimension required students to explain and "act out" their diagrams to both novice non-technical peers and technical computer staff. Observations from the lessons revealed that role-play induced an experiential learning opportunity requiring the mapping of an abstract data flow diagram to real life scenarios. An implication of the study is that instructors integrating role-play strategies should commence with shorter variants, and gradually move on to longer and more advanced activities. In another study that leveraged role-play in exploring students' software and game development processes, Decker and Simkins (2016) integrated aspects of role-play in a software engineering course project, where students were the proprietors of a game development studio. The role-play initiative provided students with experiences around development and production constraints, where participants also had to deal with deadline pressure and insufficiently developed products. When it comes to using role-playing gaming in higher engineering education, McConville et al. (2017) showed that a role-playing game, which simulated the planning and design of water and sanitation systems, could be meaningfully implemented in an engineering curriculum. Herein, the role-playing game, set in a Swedish peri-urban context, focused on skills required for engaging different stakeholder agendas in the planning process, the complexities of designing suitable systems, and problem solving around water and sanitation solutions.

Study setting and project implementation

In Sweden, compulsory education spans nine years, after which students can choose a program in upper secondary education (ages 16–19). One of the electable programs is the Technology program, in which this project took place at the end of year two during a course on web

development and back-end programming. The school is located in a mid-sized Swedish town and has approximately 350 students and is specialized in technology and tourism. Participating students were 17–18 years old. The students were enrolled in the Web development 1 course, which includes, for example, basic web development technology, the fundamentals of carrying out a web development project, coding in HTML and CSS, image and video formats, cybersecurity, and legal issues (Skolverket, 2011).

The participating teacher is a former software developer with experience from computer game development and web design. An explicit aim was to create a setting that resembled a project carried out by professional web designers and programmers. The project was based on a genuine website development contract for a now defunct company, with which the teacher had been involved. The teacher described the context as follows:

> It is based on the fact that I myself ran a game company so all the material they have is what I can offer. Even when we who started that company started with the business part, we met a lot of other people who started companies and some of them were starting their own web companies. So, I have received a lot of information during those processes on: What do you have to think about? What is most important? I tried to include that way of working. But then it's still that it's the classroom, it's me as the teacher that you're used to, we have the whiteboard and so on. If you were to have a little more of this sense of reality, you would almost want another building; you go there to meet someone, here we have a room. Now we are here on site and do business work like that.

The teacher took on the dual roles of supervisor and adviser for all groups. The teacher also acted as the customer (presenting demands and wishes), and as a manager. The project was presented by the teacher during class. During the presentation, the teacher alternated between the role of teacher or supervisor, and the role of company manager. For example, at the start of the project description, the teacher addressed the students: "My dear employees, let me introduce you to what this is all about." At the end of each lesson, the group leaders of each group had to report to the "manager" (the teacher). In that way, the teacher could keep track of the groups' progress.

The students' task consisted of creating a web site. During the project, the students partook in a role-play, where they assumed different roles. The intention was for students to *act* (*behave*) *like* engineers in their activities and communication within and outside of the project group. The project work was described to the students as a task where they would act like professionals, with the brief: "You will act as part of a web company and create a website on behalf of a game company".

The students were provided with authentic images, texts, and marketing materials from the real-life project. The customer requirement specification was based on the genuine one that the teacher had previously developed in his company. However, it was shortened, simplified, and

adjusted to encourage learning in line with the curriculum and included aspects such as language, accessibility, search engine optimization, laws, and regulations.

Table 1.
Six-week timeline and activities integrated in the role-play project.

Week	Project activity
1	Group contract. Division of roles.
2	Rough project plan. Initialize project.
3	Create a fundamental structure and organize content.
4	Back-end programming. Develop and refine design and layout.
5	Adjust content for accessibility.
6	Publication and submission of web site. Project evaluation.

The six-week project was introduced in late April and progressed until the end of the spring semester (early June) (table 1). Each week, the students attended two or three web development lessons that were all dedicated to the project. The teacher had set out certain milestones that were to be reached to be able to finish on time, namely programming environment and test milieu, functional specification, user interface, test protocols, and a completed system. The teacher iterated and adjusted the schedule during the project, particularly encouraging the slower progressing groups to increase their working rate during the reporting sessions at the end of each lesson. The project ended with the students filling out a questionnaire where they valued the project and their individual contributions to the group's work. The purpose was to encourage the students to reflect upon their work, their need for improvement, additional studies, and to be part of the summative assessment: Who had done what? Did the groups actually use the plans and specifications that they created? Were there freeloaders in the groups?

One teacher performed the project in two classes (A and B). Participating in the project was optional for the students, and students could also choose other more traditional tasks if preferred. In class A 15 students took part in the project, divided into three groups. In class B, seven students took part, divided into two groups. A total of 22 students selected to participate in the project (2 females and 20 males).

The students were asked to assign and divide the roles between themselves during the introductory class, and the teacher talked about this as an important aspect of the task. Available roles were *Group leader*, *Art director*, *Accessibility and Search Engine Optimization* (*SEO*) *manager*, and *Legal manager*. The group work agreement contract was also a focus of the introductory lesson. Agreeing on the contract made the students invest in the authenticity of the task. In this regard, the teacher insisted that the contracts should be printed and signed by the team members. While the intention was that the students should be able to finish the project during the scheduled lessons, they were encouraged to put in additional work after school hours. Some students were also stressed by approaching tests and tasks in other subjects, which made them reluctant to work on the project outside of regular school hours.

The equipment used for the web development project consisted of the students' individual school computers, together with integrated programming environments such as Visual Studio Code, and software for sharing their web programming with their fellow students (e.g., Codeshare). Instead of real servers, the students used virtual web servers, which were simulators that could show what the web pages would look like on a real server.

Collection and analysis of data from the role-play project

Three of the four authors collected data on seven occasions spread evenly across five of the six weeks that the project lasted. Data were collected through observations of the teacher and the students in both classes, and interviews were carried out with the teacher and four of the students. After the project was completed, 20 written individual assessments were also received and analyzed. The observation protocol was inductive, in the sense that we studied subject content, working methods, and work environment, as well as role-play-based interactions and authenticity. We asked related questions to both students and teachers, to garner their views on the degree of authenticity of the project, and related views of how the project transpired. The interviews were audio-recorded, and observations documented through field notes. All data were collected in Swedish and translated into English. Data collection and data storage were carried out according to Swedish and European law (General Data Protection Regulation, GDPR), and informed by the ethical research guidelines of All European Academies (ALLEA, 2017).

Inductive qualitative content analysis was performed on the data, through three phases: preparing, organizing, and reporting. The analysis was prepared through repeated read-throughs for obtaining an overview of the data. Thereafter, organizing consisted of constructing and refining themes in the data. Finally, reporting involved structuring the results and themes in such a way as to be presentable in the paper (Elo & Kyngäs, 2008). All authors participated in the analytical process. The analysis was informed by implicit and explicit associations to aspects of role-play and authenticity (e.g. Nakamura et al., 2014), namely in activities and work organization, in equipment, in problems, or contextual factors such as financial resources, time, standards, and security regulations.

Findings from implementing the role-play project

Teacher-student interactions in the role-play

During the project, the teacher took on different roles, beginning with acting as the customer, describing what was wanted and within what time frame. Throughout the development work, the teacher acted as both the customer, the company manager to which the group leaders reported at the end of each lesson. They also acted as a teacher or supervisor, helping and encouraging the students, through utterances such as: "I have to balance the role between being a customer and getting it real [Sw. *riktigt*], but I also have the demands as teacher on me, that it should be in a certain way or must have certain frames that I must adhere to." As time passed, the teacher-supervisor role became more pronounced. A presentation for the customer was originally planned for the end of the project. However, due to lack of time and the teacher's duties with the students

who had chosen not to participate in the project work, it turned out shorter and more school-like than originally intended.

The students' impressions of authenticity in the project varied. Although students were aware of it being a school-task rather than a genuine software engineering project, the majority still engaged their roles in earnest (in some cases reluctantly, especially near the project close). In these instances, the teacher reiterated to them that "you may not get paid, but you get a final grade instead." At the end of the lessons, when they were to report to their "manager", they talked clearly in a formal tone. The teacher-manager answered in a similar fashion. Most of the time, the students worked individually or in their groups, without direct interaction with the teacher-manager. When discussing among themselves, the teacher was talked about as a teacher, not a manager: "We regard [teacher's name] as a teacher but being a teacher and being a manager can be similar. It feels more like we are the ones responsible. We decide what [the website project] should look like. The teacher is not really involved in the project but has given some advice about how to work efficiently."

In the final course evaluation, students mentioned that the project would have felt more real if somebody from outside of school had acted as the customer. As mentioned, the teacher had unsuccessfully tried to find some old colleague who could fulfill that role. Regarding assessment, the project work became both authentic and at the same time rather school oriented as the curriculum was often foregrounded. On this note, the teacher described that:

> I link this to the fact that you do a kind of evaluation with your employees and with your manager when you might, for example, negotiate salaries, or who would be suitable to continue in the company and so on, so that there is a little bit of saying, now my company has delivered a product to a customer. These are my employees, and as a manager I want to get an overview of who is valuable to me. Who delivers well? Is there someone who might be a bit problematic, because as a manager you want to find out anyway. How are my employees? So, I've interpreted that myself, I keep that in mind when I try to assess the abilities that the students have achieved at work.

The teacher also said: "So therefore I set my requirements on what is considered the basic course targets in Web development, and actually observe, and do not demand more than that." For example, the students had to write HTML and CSS code manually while the teacher in an interview stated that they would probably have used Wordpress or a similar development tool in a real-life setting. This would have made solving the task easier, but at the same time allow students to avoid many authentic obstacles that would be otherwise useful in forcing them to think, try, and learn. Where to draw the line on how much code that can be borrowed or re-used from earlier projects is not obvious. Code re-use may lead to more efficient development and a better final product but does not necessarily help learning.

The students were provided with a list of the customer's demands and wishes that they had to follow. Both the specified demands and the sheer size of the project added to their impression of

authenticity. In previous courses, most programming tasks had been much more limited and carried out individually. The students also had to consider copyright and integrity issues when selecting images for their web sites, which also contributed to authenticity of the scenario.

Students' intragroup interactions in the role-play
When the groups were formed, the students were asked to divide and assign a set of predefined roles mentioned above. Judging from the group interviews and the final project evaluation, students thought that this strengthened the impression of authenticity. As one student explained: "It feels like you take it more seriously, in that way, you put it into a scenario, as if it had been real." In an interview, one student emphasized the need to learn how to work in a structured manner and with clear areas of responsibility for future working life. One student expressed: "We had instructions that we had to follow, we signed a contract, there were several aspects that made the task seem real."

Despite the positive responses above, the teacher was slightly disappointed with how the roles and division of work turned out in some of the groups. The level of ambition and involvement varied among groups, and some seemed to forget about or ignored the roles early in the project. During software testing, it is often advantageous to make different members design, run, and evaluate the test cases. Most groups did not have a clear division of roles when testing, which frustrated the teacher.

In the final evaluation, students mentioned that the roles and project organization contributed to the authenticity. However, they also mentioned that they could not really judge what was authentic as they lack experience from real-life software engineering projects. This result is captured in the following interview exchange with one of the authors:

> Interviewer:
> Do you think it is realistic then? Or an authentic project?
>
> Students:
> It's hard to say, we don't know how it works in reality […].

In the end, it is up to the students to decide whether they want to take on the roles and engage in the role-play, or whether they prefer to approach the task as a normal school assignment. In this project, we interpret the outcome that the students who are perceived as being more dedicated are more likely to invest in their roles during the role-play.

Discussion and Implications

Our study shows that most students took the project seriously when they engaged in role-play and felt that they received experiences that better prepared them for the future. For instance, the students were more formal and to the point when acting as consultants and updating their manager on the progression of their web designs. The assigned roles helped the students to

organize their work. The clear division of responsibilities decreased the level of conflict in some groups. For example, the art director had the final say when it came to design decisions. However, some students also felt that the project was not deemed real enough just because it was a role-play. For example, the teacher assumed the role of manager, customer, and educator in different phases of the project. Nevertheless, students mostly expressed engagement by the fact that the project was student-centered and was something different than regular schoolwork (e.g., Erturk, 2015). Albeit so, some students expressed during the interviews that they did not know for certain whether the project was realistic or not but trusted the teacher's professional experience.

Taken together, the project exhibited several characteristics that have been seen as indicative of authentic projects in previous research by Herrington et al. (2010), for example, authentic task, multiple perspectives, and collaboration. The context forced the students to make decisions concerning which editor to use, how to plan testing, and how to design the website. The teacher provided a setting, but the students had to work out the details among themselves. There was no "correct answer" that all students strived for. Interestingly, at the same time as the students mostly approved of the authentic tasks, some students also expressed uncertainty about what real-world, authentic tasks really are because they did not have any experience of a real workplace.

Teamwork in assigned roles forced some kind of structure on the (sometimes quite chaotic) group dynamics. The group contract was taken seriously by many participants. Especially deadlines were considered important as they increased the students' sense of responsibility (Decker & Simkins, 2016; Tomasi, 2008). The fact that the teacher played different roles as both teacher, manager, and customer was, however, a challenge and even a bit confusing for both the teacher and for the students. The main challenge for the students revolved around the objective of the project; for the customer the product is most important, whereas for the teacher it is the learning and the curriculum goals that are fore fronted (cmp., Norström, 2016, pp. 37–39; Tomasi, 2008).

McConville et al. (2017) have identified at least three challenges for realizing the pedagogical potential of role-playing in engineering education. These include challenges of clearly communicated learning outcomes, a shortage of teaching expertise, and adoption of an approach that students are not familiar with. In this regard, our study shows that integrating authentic teaching approaches are very demanding for the teacher, even when teachers are highly experienced. In our case, the systematic implementation of the project was made possible thanks to the experience and background of the teacher in the gaming and web design industry. Furthermore, the findings call for effective strategies for developing teacher competence by utilizing their previous experiences if the power of role-play approaches is to be realized. Our study also indicates that students need to be trained in project work and role-play to familiarize them with authentic engineering approaches (Svärd et al., 2022). Furthermore, in relation to Strobel et al.'s (2013) four types of authenticity, our paper builds specifically on strengthening the context and personal/value authenticity of students through role-play activities. Regarding the latter, role-play can build self-efficacy through identity development offered through continuous communication, and self-evaluation inherent in the tasks.

In conclusion, the study demonstrates that while role-playing is not necessarily equivalent to authentic engineering scenarios, it is fulfilling a situated learning process. Such learning may simulate real-world experiences, i.e. bridge theory and practice, and facilitate transfer to a real-world context. Success in these endeavors relies on a mutual confidence and sense of responsibility between students and teacher role-players.

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