Teaching Requirements Engineering with Industry Case Examples

Marian Daun
paluno - The Ruhr Institute for Software Technology
University of Duisburg-Essen
Essen, Germany
marian.daun@paluno.uni-due.de

Bastian Tenbergen
Department of Computer Science
State University of New York
Oswego, USA
bastian.tenbergen@oswego.edu

***Abstract*—Project-based learning has proven useful in software engineering education to increase student engagement and learning performance. In this paper, we illustrate our experiences from applying industry projects in graduate and undergraduate requirements engineering courses in Germany and in the United States. We furthermore discuss our experiences in light of differences between graduate and undergraduate students as well as between the educational systems. Results show that our course design is well received in both countries in terms of learning outcomes, student motivation, teamwork, attention to detail, and performance in the exam.**

***Index Terms*—Requirements Engineering Education, Industry Projects, Case Examples, Project Based Learning**

I. Introduction

In this talk, we report our experiences from using a course design relying on industry case examples to teach requirements engineering (RE). The course design combines problem- and project-based learning with industry orientation and has been subjected to three different courses: a Master-level requirements engineering course at the University of Duisburg-Essen [1], a Bachelor-level requirements engineering course at the University of Duisburg-Essen [2], and a Bachelor-level safety requirements engineering course at the State University of New York at Oswego. [3].

A. Motivation

Graduates of University-level software engineering programs are often hired straight out of college into industry. As industry representatives often feel that university graduates require additional training before they can be useful in a company (cf. [4]), there is a need for universities to make use of more artifact-, project-, and problem-centered educational approaches [5]. Therein, students are encouraged to engage in and structure their own knowledge discovery process, which has substantial benefits for knowledge retention [6].

B. Related Work

Proposed approaches for industry-oriented higher education commonly feature case example-oriented instruction like in problem-based and project-based learning. (e.g., [7]). Other approaches aim at bringing industrial experiences into the classroom [8] or use real stakeholders within the classroom [9]. Doing so, however, is not always feasible and often results in reduced industry involvement over several repetitions of the same course. Another approach is the use of non-profit organization as stakeholders (e.g., [10]), as the recruitment of real stakeholders is difficult to achieve. Similarly, in some approaches instructors imitate real stakeholders to counteract difficulties in achieving commitment of real stakeholders [11].

C. Contribution and Outline

We propose the use of industry case examples as a more reliable source of industry knowledge and experience to be introduced in the course. In this paper, we report our findings from applying the course setup in three different courses. Therefore, Section II briefly introduces the course design and the industry case examples used. Section III reports experiences gained from the application of the course design in the different settings. Section IV concludes the paper.

II. Course Design and Industry Case Examples

To foster student motivation and engagement, we designed the courses to intensively employ realistic industrial case examples in combination with project-orientation. The case examples were created in close cooperation with industry partners in a large-scale national research project. Case examples describe typical embedded systems from safety-critical domains such as automotive or avionics, which are rich with requirements. The case examples, have been simplified to be understandable by non-experts and to protect our partners' intellectual property.

The key aim of the new course design was to foster the following learning outcomes: students shall improve method competence, problem-solving skills, and industrial applicability; gain awareness of industrially relevant engineering challenges; while at the same time foster an in-depth understanding of RE theory.

Resulting in the following major course items:

- A traditional lecture introducing theoretical concepts. Students were encouraged to interject questions whenever they arose, including questions about their case example.
- A tutorial session focusing on case study milestones. A tutorial group was divided into teams, each provided with a case example. The teams were tasked with creating one specification for the case system over the course of

the semester. Several incremental milestones had to be submitted for review and critique, re-submissions were accepted as often as necessary. Final as well as initial milestones were extensively discussed in plenum.
- In addition, voluntary assignment sheets were provided and discussed.

III. Application Experiences

In this section, we briefly report the experiences made in the three different settings. We particularly, emphasize differences made between the courses.

A. German Master-level Course

Experiences in the graduate course include the following (see [1] for a detailed discussion): In the course, we observed lively classroom discussions with a strong focus on theory. Contrary to previous installments, classroom discussions focused on content-centric topics instead of simple technical questions regarding the assignments. For example, students engaged in discussions on how to use different notation alternatives and how to avoid ambiguity. This was aligned with more active student involvement as well as student participation in general. We also noticed a high degree of voluntary work and an increased intrinsic effort in student solutions.

B. German Bachelor-level Course

In the undergraduate course we roughly made the same experiences as in the graduate course. However, in addition, further experiences were made that differ from the graduate course (see [2] for a detailed discussion): In the undergraduate setting most noticeable, students were highly concerned with the exam and the admission thereto. At the start of the semester, students often inquired whether obtaining admission was really "that easy" and how they can prepare themselves to receive good grades. Students often asked about the types of assignments on the exam and what a good solution would lookalike. Regarding the use of the embedded systems case examples, students were at first reluctant as they were unfamiliar with the domain. However, at the end of the course, students appreciated the new insights gained and we felt that embedded systems, albeit initially unfamiliar to undergraduate students, served as a rich domain to illustrate and practice concepts of RE.

C. US Bachelor-level Course

As was the case for both German courses, the US course, was also very well-received by students. In the US course, we made comparable results, with respect to liveliness of discussions, students' interest in industry practices, and teamwork (see [3] for a detailed discussion). However, it must be kept in mind that the US instruction is far more focused on these aspects in general. For instance, in both courses in Germany as well as in the US course, we noticed a large degree of student enthusiasm as well as teamwork. In all three courses, students were informed that case study artifacts shall be created by all team members equally. However, the reality is that often, students segregate their work and only work on parts of the assignment, which is hardly traceable by the instructor. In case of the US course, students were far more concerned with unequal contributions to project milestones. Yet, in our experience, after a few weeks in the US course, this behavior changed in almost all teams towards a truly cooperative environment, where students sought collaboration and discussions about the case study. Much akin to the observations we made in the German courses, where students were less concerned with unequal amounts of work rather than with evolving on the case study.

IV. Conclusions

In this paper, we have reported on our experiences on the use of realistic, industry-typical case examples in requirements engineering courses. We applied the course design in three different requirements engineering courses held in Germany and the United States. Our experiences show that although country-specific differences in grading, student population, degree programs exist, the course design emphasizing the use of industry case examples was applicable in graduate and undergraduate courses, as well as in Germany and the United States. In all settings, the course design was very well received and led to improved exam results.

References

[1] M. Daun, A. Salmon, B. Tenbergen, T. Weyer, and K. Pohl, "Industrial case studies in graduate requirements engineering courses: The impact on student motivation," 27th IEEE Conference on Software Engineering Education and Training. IEEE, 2014, p. 3–12.

[2] M. Daun, A. Salmon, T. Weyer, K. Pohl, and B. Tenbergen, "Project-based learning with examples from industry in university courses: An experience report from an undergraduate requirements engineering course," 29th IEEE International Conference on Software Engineering Education and Training. IEEE, 2016, p. 184–193.

[3] B. Tenbergen and M. Daun, "Industry Projects in Requirements Engineering Education: Application in a University Course in the US and Comparison with Germany," in *52nd Hawaii International Conference on System Sciences*. AIS Electronic Library (AISeL), 2019, pp. 1–10.

[4] C. Wohlin and B. Regnell, "Achieving industrial relevance in software engineering education." 12th Conference on Software Engineering Education and Training (Cat. No.PR00131), 3 1999, pp. 16–25.

[5] Q. Li and B. W. Boehm, "Making winners for both education and research: Verification and validation process improvement practice in a software engineering course." 24th IEEE Conference on Software Engineering Education and Training, 5 2011, pp. 304–313.

[6] V. Varma and K. Garg, "Case studies: the potential teaching instruments for software engineering education." Fifth International Conference on Quality Software (QSIC'05), 9 2005, pp. 279–284.

[7] d. S. C. Santos, "Pbl-see: An authentic assessment model for pbl-based software engineering education," *IEEE Transactions on Education*, vol. 60, no. 2, pp. 120–126, 5 2017.

[8] A. Dagnino, "Increasing the effectiveness of teaching software engineering: A university and industry partnership." 27th IEEE Conference on Software Engineering Education and Training, 4 2014, pp. 49–54.

[9] B. Bruegge, S. Krusche, and L. Alperowitz, "Software engineering project courses with industrial clients," *Trans. Comput. Educ.*, vol. 15, no. 4, p. 17:1–17:31, 12 2015.

[10] G. Gabrysiak, R. Hebig, L. Pirl, and H. Giese, "Cooperating with a non-governmental organization to teach gathering and implementation of requirements." 26th International Conference on Software Engineering Education and Training, 5 2013, pp. 11–20.

[11] G. Gabrysiak, H. Giese, and A. Seibel, "Why should i help you to teach requirements engineering?" 2011 6th International Workshop on Requirements Engineering Education and Training, 8 2011, pp. 9–13.