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Teaching Conceptual Modeling in Online Courses

Coping with the Need for Individual Feedback to Modeling Exercises

Marian Daun, Jennifer Brings, Patricia Aluko Obe, Klaus Pohl
paluno – The Ruhr Institute for Software Technology
University of Duisburg-Essen
Essen, Germany

Steffen Moser, Hermann Schumacher
School of Advanced Professional Studies
Ulm University
Ulm, Germany

Marcel Rieß
Institute of Embedded Systems/ Real-Time Systems
Ulm University
Ulm, Germany

***Abstract*—Educational approaches for computer science proposing the use of complete online courses or traditional courses employing some kind of online material have received much attention recently. The integration of online materials into traditional courses or the replacement of entire courses offer huge possibilities, including increased teaching quality and better study and work alignment. However, researchers and teachers also identified some drawbacks of using online material, including the lack of interaction between students and teachers, and the need to discuss and provide feedback of the students' exercise results. A solution for providing such feedback are automated assessment tools which can generate feedback. However, these tools are not applicable in all situations, e.g. for providing feedback to conceptual modeling exercises. In this paper, we report on the design and implementation of an online course for teaching conceptual modeling. In this course, we use explicitly ambiguous exercises and sketch multiple solutions in brief whiteboard-style videos, thus enabling students to assess their own solutions. Evaluation results show that the proposed approach is able to fulfill students' educational needs.**

Keywords—computer science education; conceptual modeling; online courses

I. Introduction

In computer science and software engineering, educational teaching approaches such as blended learning [1] and the flipped classroom [2], [3] have gained much interest (e.g., [4], [5]). The use of online materials in traditional university courses and industry training is increasing [6]. Online elements are used for several purposes; for example, the use of additional online material allows for the introduction of supplementary exercises and thereby allows providing more training to specific students in need of it [7]. Furthermore, the reduction of traditional course elements that require attendance in class allows to better align work, study, and personal life [8]. Additionally, recent studies have shown that the use of online elements within courses or courses nearly entirely held online not only aid the students' learning experience and their motivation (e.g., [9], [10]), but also improve students' performance (e.g., [2], [11]).

However, several drawbacks from the use of online courses are reported. Commonly mentioned is the lack of interaction between students and teachers [12], which hinders some students in their learning abilities, due to the lack of individual feedback for exercises [13]. To overcome these shortcomings, interactive elements such as class meetings [14], online webinars [6], the use of forums and chats [5], or even the implementation of interactive online courses [5] have been proposed. Additionally, the use of automated assessment and feedback generation for handed-in exercise solutions has widely been suggested (e.g., [15], [16]). However, the proposed solutions are not always feasible, when the use of online courses is desired. For example, in conceptual modeling automated assessment of handed-in solutions is not feasible (c.f., e.g., [15], [17]).

Among others, students need to understand that the perception of a conceptual model can differ between users. For example, perception may differ based on users' knowledge and experience [17]. Furthermore, a given content can be typically modelled in the same language using different modeling elements and different compositions thereof [18]. Consequently, a modeling task given to students must either be prescribed very precisely (to allow only one correct solution), or different solutions are possible for the given modeling task. While the former typically leads to rather dull exercises [18], the latter assumes that there is a describable finite amount of possible solutions. However, using realistic industrial case examples to improve student motivation and provide industry relevance typically results in a multitude of different solution possibilities [19]. The use of interactive sessions might not be a viable option either, in particular when it comes to courses meant to be available permanently for self-study, if the long-term availability of a suitable instructor cannot be guaranteed.

In this paper, we propose a solution concept to cope with ambiguity and different correct solution possibilities of conceptual modeling tasks in educational online courses. The solution is based on the idea to actively increase students' awareness for different potential solutions and hone their ability to grade their solutions on their own. Therefore, we use a combination of different online materials such as scripts, instruction videos as well as solution and FAQ videos, which explicitly discuss varieties of potential solutions, possible benefits and shortcomings to enable the students to assess their exercise solution on their own. We implemented the solution idea by defining an online course for conceptual modeling focusing on the area of goal- and scenario-oriented requirements engineering. In addition, we contribute an initial

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evaluation of the proposed course setup, which indicates feasibility of the approach.

The outline of the paper is as follows: Section II introduces the state of the art on teaching with online materials. In doing so, Section II sketches also the needs and proposed approaches for automated assessment of learning materials and interactive elements in online courses. Section III will elaborate on the limited usefulness of automated assessment when teaching conceptual modeling and the requirements for online materials. To this end, Section III also proposes a combination of different online materials, among others, the use of lecture-style and whiteboard-style videos. Subsequently, Section IV briefly sketches the technical realization of the proposed online materials for teaching conceptual modeling in goal- and scenario oriented requirements engineering. Section V reports insights from evaluation of the proposed teaching materials. Finally, Section VI concludes the paper.

II. State of The Art

Section II.A will give a brief overview on approaches proposing the use of online elements within courses and entirely online courses. Section II.B will give insight into conducted research on the effects of such online courses, concluding that the use of online materials can increase both, students' learning experience and performance. Section II.C will elaborate on the need for interaction and individualized feedback within online courses.

A. *Online Courses in Software Engineering Education*

In recent years, the use of online courses and materials has been widely suggested to improve university education (e.g., [6]) as well as industrial training (e.g., [4], [20]). In particular, blended learning [21] and flipped classroom courses [22], [23] gained much interest. In both cases, traditional in-class teaching is combined with online elements to form a course. In the flipped classroom, lectures are typically streamed or provided downloadable as videos and shall be accessed by the students at home. The classes focus instead on exercises and case studies which traditionally would be considered homework.

While online courses are often provided for teaching programming and basic computer science education, the use of online courses is less common for more theoretical topics such as formal methods or even conceptual modeling. However, related work on improving education on conceptual modeling exists. For example, *Sedrakyan et al.* propose in [24] to use feedback-enabled simulation to increase the students learning abilities in conceptual modeling of business requirements. As Section II.C will discuss, the need for individualized feedback is also common to other educational topics and plays a big role in online courses to provide helpful exercises.

B. *Impact of Online Materials on Students' Learning Experience and Performance*

In [25] *Weston and Quinn* report on a survey conducted among instructors, who use online materials from a digital collection for teaching basic computer science classes. They found out, that the online-materials are used differently by different instructors. While 50% use the online material as out-of-class labs, 25% use them as in-class exercises, 13% use them as supplementary material for training individual students, and 12% responded to use them as background material. In the same survey is reported that instructors experienced multiple benefits from the use of the materials, e.g., more efficient learning and more student engagement.

In the case of flipped classrooms, for example, *Amresh et al.* report in [26] that the flipped class room can significantly improve students learning and thus their grades when used in basic computer science courses. However, *Amresh et al.* also report that the flipped classroom was found intimidating and overwhelming by the students, which might in part result from too long video sequences of lectures that had been used.

Beside such general surveys, many experience reports from different areas of software engineering education exist, reporting that the use of online courses or online materials in classes aids the students' learning experience as well as their motivation (e.g., [9], [10]). Even more important, it is often shown, that the students' performance has improved (e.g., [2], [11]). Further advantages deal with the individualizability of online courses, students can follow the course in their own pace and decide, which elements are supportive for them [6].

C. *Interaction and Individualized Feedback in Online Courses*

Simon et al. report in [27] that interactive instructional style teaching in class positively impacts students learning, compared to classic lecture style instruction. This concept is also adaptable to online courses [21]. Hence, approaches have been proposed to integrate interactive elements within online courses (e.g., [5], [6], [14]). Such interactive elements comprise, among others, forums and chats, as well as online-seminars, typically called webinars.

As exercises are a vital part of computer science and software engineering education [28], it is argued by *Staubitz et al.* [15] that this concept shall be transferred to online courses. To assure feedback on the exercises in a timely manner *Staubitz et al.* conclude that there is a need for the use of automated exercise assessment tools in online courses.

Automated exercise assessment is often suggested for the use in offline teaching as well as online courses (e.g., [13] [15], [16]). For automated exercises assessment, for example, trace visualization is used [29], as trace visualization has shown positive effects for comprehension purposes [30]. However, automated feedback throughout a course, in particular when taking students' skill acquisition into account, has shown to be effective, but also as difficult to achieve [31]. In particular, as we will argue in the next section, automated exercise assessment is not feasible when it comes to an indefinite number of potentially correct solutions, as is often the case in the area of conceptual modeling.

III. Teaching Conceptual Modeling with Online Materials

In this section, we will discuss our goals in teaching conceptual modeling in general and the concrete goal- and scenario-oriented model-based requirements engineering approach in more detail, thereby showing examples of exercises and their intended learning goals. We will conclude that automated assessment of handed-in exercises is not applicable in this place and propose building blocks for a teaching approach using online materials that does not need to rely on simple automatically appraisable exercises.

A. Background

In conceptual modeling the focus of development are graphical models aiming at describing a certain aspect under consideration to foster, among others, communication between stakeholders, quality assurance, or other kinds of analyses. For instance, conceptual models are commonly defined in model-driven development approaches [32], in requirements engineering [32], or for formal verification approaches [33].

Educational aspects of teaching conceptual modeling are, for example, abstraction mechanism, definition of (partly overlapping) views on a system or software, and model perception. When it comes to the latter, it has long been acknowledged that different model users perceive models differently [33]. Hence, during definition of the model, potential interpretations [14] and possible misinterpretations must be considered [14]. This effect is exacerbated by the increasing number of modeling languages with semantics which partly contradict each other. For example, UML class diagrams make use of multiplicities, while entity relationship models use cardinalities, which can lead to serious misinterpretations, for instance, when it comes to n-fold relations. Teaching conceptual modeling must make students aware of these problematic situations.

Each created model is not only defined for a specific purpose, but is also influenced by the modeler's abilities and also by the modeler's assumptions about the readers' interpretations thereof. Furthermore, a wide variety of modeling languages with sometimes only nuances of differences exist, which can negatively impact the readers' interpretation and should be considered during model creation. In consequence, students must be aware that multiple correct solutions with different advantages and shortcomings for one task may exist. Thus, educational approaches cannot rely on simplified examples where only one single solution exists, which impedes the concept of automated assessment approaches as outlined in Section II.C.

B. Scope of Teaching

The focus of teaching lies on the continuous model-based engineering of embedded systems. An online course to foster industrial training in this area is designed to cover the modeling and analysis techniques developed and evaluated in close collaboration with industry partners during two publicly funded joint research projects (SPES[1] and SPES XT[2]). One aspect of the project results and, hence, of the online course, is the use of conceptual modeling already in early phases such as in requirements engineering. Additionally, these topics are partly overlapping with a master-level university course focusing on advanced concepts on requirements engineering, which also shall benefit from the online materials. In both cases, model-based requirements engineering is centered around a goal- and scenario-oriented approach, which is supplemented with context analysis as well as solution-oriented design space exploration and scenario-based validation and verification.

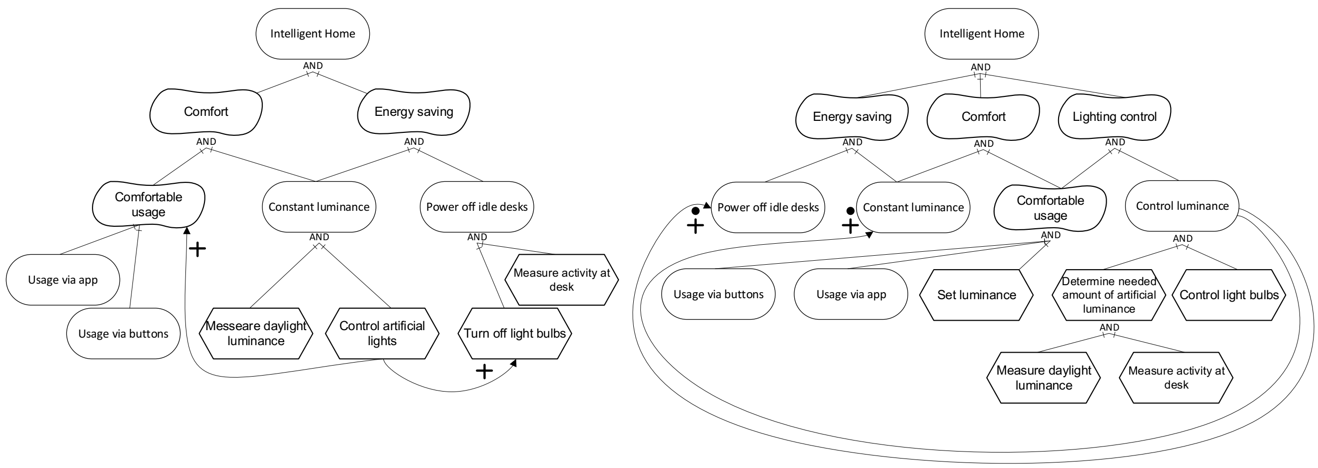
The goal- and scenario-oriented requirements engineering approach uses GRL as modeling language for goal models and MSC for scenario models. Both are formally defined by recommendations issued by the International Telecommunication Union (cf. [36], [37]). Experiences from project work and application to industrial case examples have shown that both languages meet industrial needs in the embedded domain.

ITU GRL [36] is a language to hierarchically structure goals and to define influences and dependencies between them. GRL differentiates between different kinds of goals, in addition to hard and soft goals as used by most languages for goal modeling, tasks and resources are defined. Additionally, GRL allows differentiating between goals of different actors and analyzing their relations. GRL is also used in the popular i* framework [38] indicating its high suitability for goal-oriented requirements engineering.

ITU MSC [37] is an interaction-based language to define the intended system behavior in terms of interaction sequences. MSC and comparable languages such as sequence diagrams or live sequence charts are commonly used in scenario-based requirements engineering approaches (e.g., [18]). The recommendation defines two types of diagrams: Basic MSCs (bMSC) define the interaction-based behavior as intended by one scenario. Additionally, high-level MSCs (hMSC) are used to structure the scenarios in terms of their execution order within complete system executions.

The main learning goals are knowledge of model based requirements engineering and the ability to apply goal- and scenario-oriented requirements as well as the ability to make use of the learned modeling and analysis techniques in a realistic industrial setting. Furthermore, the students shall understand different possible solutions and their purpose specific benefits and shortcomings. For example, when it comes to the definition of hierarchical structures, which is applicable in GRL goal graphs as well as in high-level MSCs, a wide variety of different structures might be created. Where each structure cannot be considered as either correct or wrong, but must all be accepted as correct. However, depending on the specific circumstances, they might be a better or a worse fit.

[1] Software Platform embedded systems, http://spes2020.informatik.tu-muenchen.de, 2009-2012, funded by the German federal ministry for education and research. Major project results have been published in [34].
[2] Software Platform embedded systems XT, http://spes2020.informatik.tu-muenchen.de/spes_xt-home.html, 2012-2015, funded by the German federal ministry for education and research. Major project results have been published in [35].



(a) Goal model focussing on quality requirements **(b) Goal model emphasizing the functionality of the system**

Figure 1 Two different goal models serving both as correct solutions for one exercise

C. Example Excercise and Teaching Goals for Goal Modeling

Figure 1 gives an example for two differently structured GRL goal models describing the same requirements for the same system. In this case, as system an excerpt from a home automation control focusing on the lighting system is used. The model in Figure 1(a) focuses on quality goals the system shall fulfill to benefit the user (namely: "The system shall increase the comfort of the user" and "The system shall contribute to energy efficiency"). These top-level goals are subsequently refined until functional goals, or in this case tasks, are defined. For instance, in the given example, tasks are defined to turn the system automatically off, if no user is around or to measure the daylight intensity to adjust the proper use of artificial lights. In contrast, the model given in Figure 1(b) directly defines a function goal "Control lights" at the top-level. In this case both, functional and quality goals, are refined and the realization relationship between quality goals and functional goals is shown using contribution links.

Based on this example, the student shall not only learn how to create a goal model for a lighting control system, but furthermore shall learn that there are different ways. Particularly, the students shall be able to realize that the left model focusing only on quality requirements is a good start to show the intended benefit for the user and can hence aid communication with management. In contrary, the right model taking functional requirements into account right from the beginning is a suitable starting point for the definition of the functional design and discussions with developers and engineers.

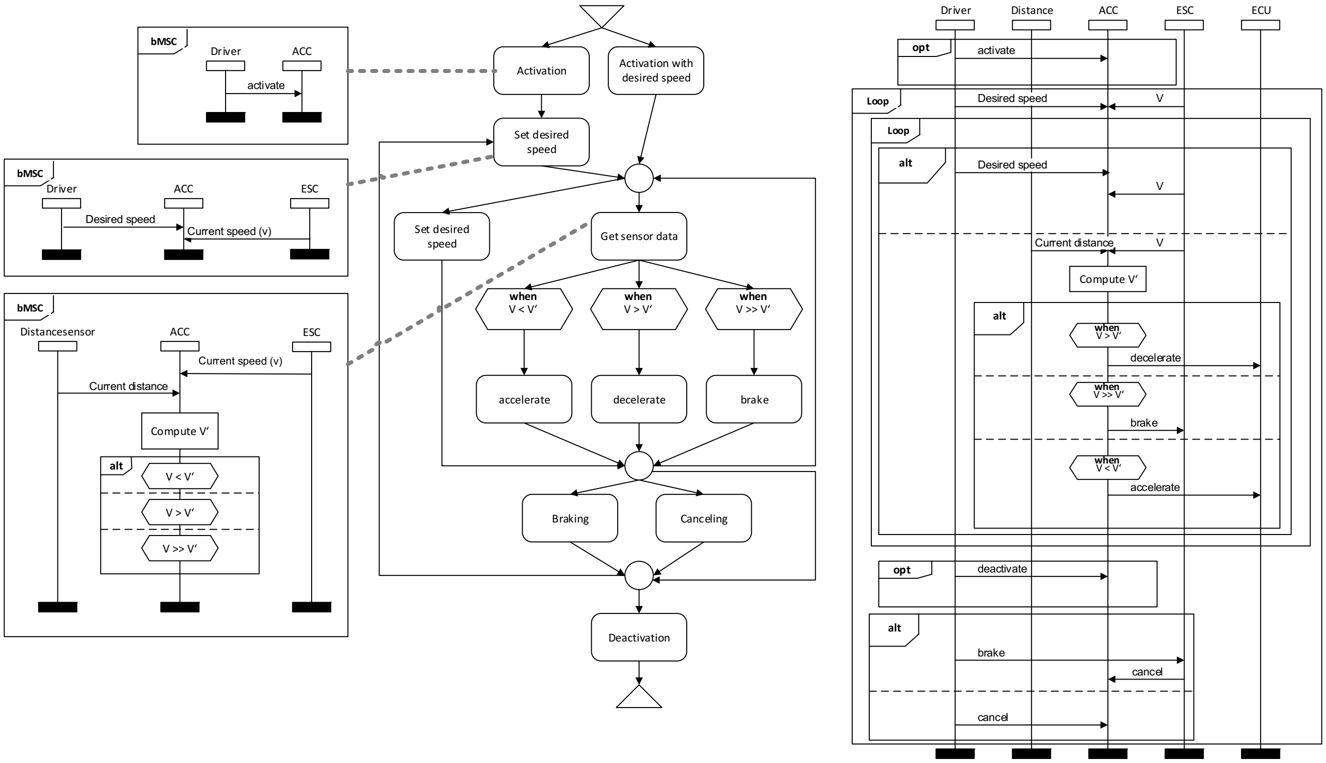
A description for an exercise will typically emphasize the user benefit over functionality as requirements engineering commonly starts with the vision of a system to be built. Hence, it is a desired cognitive achievement by the students to be able to evolve their goal model from Figure 1(a) to Figure 1(b) on their own. Nevertheless, it must be mentioned that even for such small exercises, depending on the user's desires and purpose, many correct different goals and goal models can be defined.

D. Example Excercise and Teaching Goals for Scenario Modeling

One issue arising in conceptual modeling is how to slice large models into diagrams. To this end, many modeling languages provide abstraction concepts that allow for structuring parts defined in separate diagrams. In the context of MSCs, this is supported by the distinction between hMSCs and bMSCs. bMSCs are used to define the interaction steps in a scenario, while hMSCs are used to order bMSC thus allowing modelers to divide large scenario specifications into small chunks as opposed to having one enormous diagram. While this feature of MSCs obviously enables the modeling of semantically identical models in many different ways that all represent the correct scenario steps, some ways of slicing will be more sensible than others.

For instance, defining smaller chunks and integrating these through the hMSC is beneficial for reducing redundancy of the specification and placing more emphasis on the structure giving hMSC. As structure giving characteristics like loops are explicitly defined in the hMSCs, the intended system executions are better perceivable. On the downside, this leads to a situation where each single bMSC diagram contains so little meaningful information by itself leading to the need to frequently refer to the hMSC for context.

Figure 2 gives an example for such an exercise. In Figure 2(a) a modeling approach is chosen that heavily relies on an hMSC and uses very simple and trivial bMSCs. In figure 2(b), the same situation is depicted using one single bMSC. While both models are correct specifications for an initial specification of an adaptive cruise control, which enhances a cruise control with the ability to maintain a safe distance to the vehicle ahead, the students shall become aware of the different benefits. In Figure 2(b) the whole functionality is described as one scenario, which makes use of loops and alternatives to



(a) Correct solution within one hMSC referencing multiple trivial bMSC **(b) Correct solution within one single bMSC**

Figure 2 Scenario modeling with hMSC vs bMSC

describe the entire behavior: the system is activated at the beginning, subsequently the driver can change the desired speed, the distance to the vehicle ahead and the own vehicles velocity are measured and based on these values either the engine torque is increased or decreased or the brakes are actuated. As result of this approach the specification keeps to one diagram and is hence of very handy size but also the use of loops in the bMSC makes it hard to read and opens the risk of missing important parts when skimming over. In contrast, in Figure 2(a) each of these functionalities, the activation, the distance determination and so on, are described in single bMSCs. The overall scenario is described by the hMSC, which often seems a better fit for documenting structures such as loops, furthermore, the bMSC are very small and thus easily readable. On the contrary, there are lots of diagrams used (which are only indicated in Figure 2(a)) and the specification of such a small scenario becomes rather large, which can easily increase further, when considering further aspects of the scenario such as alternative, exception, and misuse scenarios.

As a consequence, automated assessment of MSC modeling exercise not only needs to take a plethora of semantically correct solutions into account but should preferably provide the learner with feedback about the suitability of their approach to structuring the scenario.

Beside the learning goal of the aforementioned trade off in slicing of scenarios and the distribution across hMSCs and bMSCs, students shall become, for instance, aware for the use of advanced modeling constructs and their implications. For example, the use of parallelism in requirements models. On the one hand, parallelism operators will typically lead to simple models, which are, hence, easy to perceive and, therefore, good for communication purposes. But on the other hand, students must be aware that parallelism in requirements models might forestall design decisions, which should not be made during requirements engineering. For example, the specification of behavior to be executed in parallel will end in the need to use either multiple engine control units or engine control units with multi cores. But indeed, in the embedded domain it is often sufficient to implement some kind of pseudo parallelism, where different functionality is executed very quickly in interchangeable order.

E. Building Blocks of the Approach

The proposed idea mainly relies on online resources. The online materials comprise videos in classical lecture-style, textual learning materials as scripts, exercises and whiteboard-style videos discussing potential solutions and benefits of different solutions. Additionally, tool support and online tutorials for solving the exercises with the tool are given. To structure the course, the concept of constructive alignment as proposed by Biggs in [39] has been applied. Subsequently, we will elaborate on the different building blocks and the teaching and learning goals connected with them:

- *Lecture goals.* Each part of the course starts with a competence-oriented description of the learner's goals using Bloom's taxonomy [40].
- *Script.* The main structure-giving source for the course is the script, which introduces the instructed material. The script introduces the lecture-style videos as well as suggested exercises at appropriate moments. Also the solution videos for exercises are accessible via reference from the scripts.

  The mainly textual scripts highlight aspects of importance as well as additional information and teaching material that is not part of instructed material but often requested by students for personal interest and deeper understanding.
- *Instruction videos.* Online lecture-style instruction videos are used to give an introduction into the teaching materials as well as replacing classical lectures in giving profound information and on the instructed material.
- *Questions for self-assessment.* Throughout the script, questions for self-assessment are given to allow the students to check whether the sufficiently understood the materials covered by script and lectures so far.
- *Exercises.* Two kinds of exercises are defined. First, exercises are given to deepen the understanding of modeling constructs or analysis approaches right after the introduction in the script. Second, exercises are given at the end of each learning unit to comprise all instructed material and allow the students to work on integrating exercises of realistic size and complexity.
- *Solution videos.* Exercises are accompanied by solution videos. Solution videos do not show one single correct solution but place emphasis on the task to enable students to know of differences between acceptable solutions as well as purpose specific benefits as outlined in Sections III.C and III.D. Also the impact of potential industry or company specific approaches for conceptual modeling is discussed and students are made aware that the use of conceptual modeling in industrial practice might differ from the original pure approach due to company specific guidelines (cf. [19], [41]).
- *FAQ videos.* Additionally, FAQ videos are provided discussing frequently asked questions by students, which are known from when the material was taught offline before. FAQ videos are much akin to the solution videos used to discuss general understanding regarding model perception and purpose specific differences and their according benefits. Other than solution videos, these videos are general in nature and commonly make use of abstract examples (e.g., a bMSC consisting of the instances "A", "B", and "C") rather than concrete exercises.
- *Tool support.* As tool support is commonly requested by students and even more by industry professionals, shapes and plugins for commercial and free tools are provided to the learners and introduced with online tutorials. Additionally, exercise solutions are not only given in solution videos but it is also shown how to adapt the solutions for individual strengths and shortcomings of the respective tool. However, the focus of the material is explicitly not on the tool usage but on the theoretic concepts.
- *Seminars.* In addition, we strongly assume that some kind of seminar or workshop is desired by the learners and intend to integrate such elements in a course. Such activity can either be conducted physically in class or online, for instance, combined with a round of topic and question gathering in advance.

  However, such interaction activity is often not applicable. For example, if the presence of a suitable instructor cannot be guaranteed or the course shall be independent of any timing constraints. Hence, we want to investigate how far the use of multiple solution discussing and industry specific purposes highlighting videos (lecture, solution, and FAQ) can reach.

Throughout the script and the instruction videos references to industrial practice are given. Exercises are specifically designed to give insight in realistic industrial problem situations as outlined in [42] and [43]. In addition, some FAQ videos also explicitly discuss typical industrial problem situations and different ways of handling conceptual modeling often found in industrial practice.

IV. Technical Realization

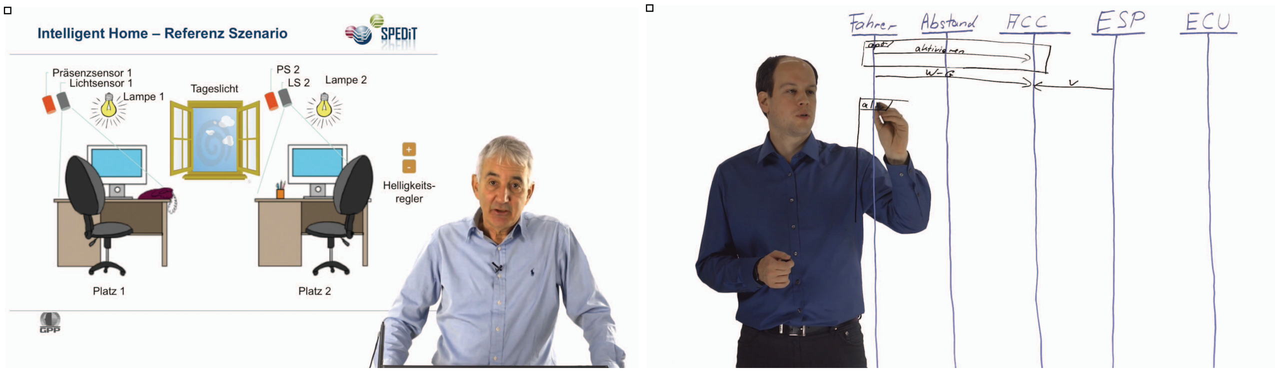
In this section, the technical details of the course implementation are described. At first, we show how we derived technical requirements on the course implementation from the above-mentioned building blocks. The media types which have been used are motivated. We also describe the integration of the material into the open-source learning management system (LMS) *Moodle*, which is a pivotal component of the technical realization. Furthermore, we derive the demands on the e-learning platform as a whole.

A. Media Types

The lecture script is one of the most important components of the course. For linear reading and offline learning, we release it as a simple *PDF* file. For learners who prefer the interactive way of online learning, all script contents are also available as *Moodle lessons*. The lesson activity in Moodle allows the combination of e-learning content and questions for self-assessment which interrupt the learners regularly.

It further allows to setup alternating learning paths based on the results of the quizzes, so it is possible to redirect learners to additional background materials if necessary. Moodle offers the integration of libraries like *MathJax*, which is important in the production of web-based contents, as mathematical notations are used in the course materials.

The text-based contents are enriched using instruction *video sequences*. Using complete recordings of classical lectures (90 minutes) is completely out of the question. Especially, extra-



(a) Slide-based presentation **(b) Whiteboard-like presentation**

Figure 3: Two alternative production modes for e-learning video sequences

occupational learners expect the contents to be condensed to short and intensive learning sessions. For this reason, the video sequences we produce are rather short, *from 10 to 15 minutes* as a maximum. The same applies for presenting and solving *exercises*, which may contain modeling or analyze tasks. Exercises typically consist of a short introduction text or video sequence used to define the task. Video sequences are typically used to present standard solutions. The technical production of lecture and exercise video sequences takes place in a prepared green screen studio room using a *4k production flow*. Two production modes are used: Lecture-like slide-based presentations on the one hand and whiteboard-like presentations on the other hand. Screenshots from both styles are provided by Figure 3 to allow for comparison. Recording the videos in a 4k raw resolution (3840 x 2160 pixels) allows digital zooming during the materials' post-processing while the final videos are exported in Full-HD resolution (1920 x 1080 pixels). This is especially interesting for whiteboard-based presentations where we have to alternate between showing the whole overview picture on the one hand and some details on the other hand. To show both, the whiteboard-contents and the presenter's face simultaneously, the whiteboard is a Plexiglas board placed in front of a green screen.

While all mentioned media types allow asynchronous learning, our courses are interrupted from time to time by synchronous sessions using *on-campus workshops*, distance-learning *webinars* or a combination of both. Synchronous sessions help the learners to discuss with each other or with instructors about open questions and different variants of exercise solutions. To allow an easy access to webinars, we included the open-source video conferencing tool *Big Blue Button* into the LMS Moodle. This allows synchronous webinar sessions to be topically linked to learning contents. It further allows storing recorded webinars directly in the Moodle course at the right place.

B. *E-Learning Platform*

While an LMS like Moodle allows to distribute course materials and to capture a learner's progress, it does not cover all requirements, especially the learner-centric view is not considered thoroughly. For example, cooperative e-learning as proposed by Johnson and Johnson in [44], doing modeling work using design tools or checking exercises by a software tool is an unsolved problem in traditional LMS. This becomes even more crucial when it comes to extra-occupational learners who are typically rarely on campus. As presented in [45] based on a survey, they often study at varying work places (at home, at their offices, when commuting), which leads to special demands that have been described in [46]. When offering online courses, we cannot assume that all learners have all tools they need for modeling exercises always on their local computers which they are currently working on. They also do not necessarily have all documents they need at one place.

To tackle this problem, our LMS Moodle has been extended by a set of additional tools. We use *ownCloud 9.1* to provide a collaborative and document-centric cloud storage service for our students. Documents can be edited using a web browser and can be easily shared in per-course folders. Course-wide calendars allow the schedule of synchronous seminar or webinar sessions.

Using a tool chain based on *GNU/Linux Debian, XRDP, XVNC* and *Guacamole 0.9.12*, we offer our learners a browser-based terminal solution for the software tools which we make use of. It further allows to start a tool directly from a Moodle course using a simple hyperlink. Figure 4 shows a screen shot of the Eclipse-based modeling tool *AutoFOCUS 3* running completely within a web browser tab.

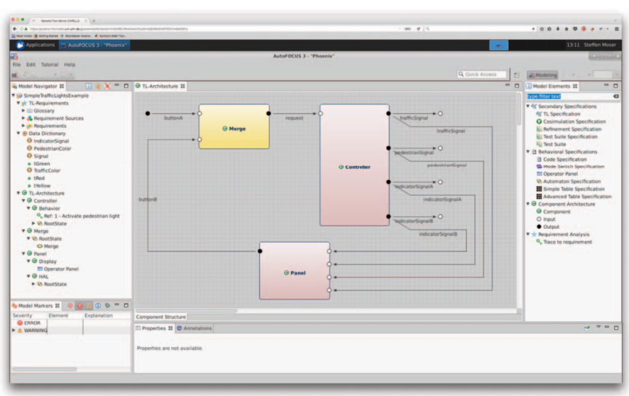


Figure 4: Eclipse-based modeling tool AutoFOCUS 3 available to learners within a web browser tab

V. Initial Evaluation

The online teaching material was evaluated using the focus group method [47], [48]. Emphasis was given to evaluating whether the proposed combination of online materials (especially the combined use of lecture-style and whiteboard-style videos) can be used for teaching conceptual modeling. It was also investigated, how much teacher interaction students deem necessary to understand the possibility of multiple correct solutions as well as purpose specific benefits and shortcomings of different solutions.

A. Focus Groups

We conducted a study employing two different focus groups. In both cases, participants were recruited among university students. The recruiting must be considered as opportunity sampling. Group A consisted of four students, three of them undergraduates ranging from freshman to seniors and one second year graduate student. Group B consisted of seven graduate students, all in their first or second year.

Almost all participants had previous experiences with using online courses or courses including online elements. Three out of the four participants of group A had previously participated in online courses; two of them in a course that included online videos and one of them in a online class using class notes and videos. Similarly, in group B two participants had participated in an online course that was part of their university curriculum, while all five other participants had participated in classes that included online study materials.

The focus group sessions were conducted by two of the authors, one acting as interviewer and moderator, while the other transcribed the discussion. The interviewer moderated the discussion and ensured that the predefined topics were discussed in the same order in both groups. Therefore, several predefined open questions were asked to gather comparable feedback and to start the discussion among the participants, which was explicitly encouraged and helped to clarify the intention of participants' remarks. For the latter, the interviewer also asked direct questions for clarification.

B. Results

While we conducted two focus groups to avoid effects from single participants taking control of the group opinion, we did not observe any discernible differences between the opinions expressed in the two focus groups. Hence, we report the results clustered by topic and not by group.

1) Attitude Towards Online Courses

Nearly, all participants stated they prefer online courses to traditional lectures, only in group B one participant liked traditional lectures more. As key reason for their preference for online courses the participants mentioned the possibility to adapt the pace of the course to their needs including being able to take breaks and repeating parts difficult to grasp.

2) Need for Additional Offline Meetings

Regarding the need for offline meetings, one participant of group A expressed the wish to have the possibility to ask questions in person and not just on a message board, while another participant disagreed and considered classes held completely online sufficient. In a subsequent discussion on this matter the participants stressed the benefits of videos with respect to the repeatability of hard to understand topics, which makes the need to ask questions on every topic superfluous.

3) Lecture Style Videos vs. Whiteboard-style Videos

With respect to the two different formats used within the online class (lecture-style and whiteboard-style), the participants directly expressed their satisfaction with the provided whiteboard-style videos used for solution and FAQ videos. The participants had never been confronted with such a kind of online learning material before. However, all found them very useful and helpful. It was explicitly mentioned, that they liked the more open and interactive attitude of this video style. Regarding the use of the different video formats in an online course, most participants expressed a preference for a combination of both styles within a course as opposed to one particular style. They stated that they liked lecture-style videos as an introduction to a certain topic, followed by more in-depth explanation delivered as whiteboard-style videos. Only one participant from group B stated he prefers the whiteboard-style videos for any situation.

4) Suitability of the Online Videos for Raising Awareness of Conceputal Modeling Specific Issues

Participants were also asked whether watching the videos helped them become aware that there are often multiple correct models with varying advantages and disadvantages. The participants stated, that this was well explained within the videos teaching scenario modeling with Message Sequence Charts but only to a lesser extend in the videos teaching goal modeling. However, participants stressed that the whiteboard style videos helped them understanding different solution possibilities as well as assessing their own solutions.

5) Self-assessment of Modeling Solutions

All participants stated that the different modeling videos helped them to assess the correctness of their own modeling solution. In particular, the incremental explanations of how to create the model were seen as vital for self-assessment. In addition, one participant pointed out the importance of the examples being of regular size and complexity and not over simplified.

6) Points for Improvement

Asked about points for improvement, beside some technicalities (e.g., varying sound levels across the videos) the participants criticized that some videos were rather short. They consider a length of 10-15 minutes optimal with lecture-style videos being longer than whiteboard-style videos.

C. Inferences

The discussions in the focus groups and the attitudes of the participants towards the course materials indicates that participant like the idea of online courses.

The participants stressed that live teacher-student interactions can significantly be reduced, as videos can be repeated as often as needed. Furthermore, solution videos explaining possible solutions and allowing the students to get a feeling for how to assess their own solution can further reduce the need for teacher-student interaction. Specifically, participants did not see a need to discuss their own solutions with an instructor or to have the exercises discussed in class. Concerning the possibility to directly interact with an instructor at some points throughout the course some participants stated that this should be an optional offer; other participants stressed their desire to complete such a course completely online without any interaction with an instructor.

We conclude that whiteboard-style videos are a significant improvement for online courses teaching conceptual modeling. In addition, the use of such videos for discussing solution options can drastically reduce the need for live sessions. While some participants explicitly desire live sessions to improve student-teacher interaction, most participants mentioned they do not intend to use it and others pointed out that they only liked having the possibility to do so. Therefore, future work will have to deal with the question, whether such sessions are really used and if other means exist to address the students' desire for having the possibility to talk to an instructor.

Discussions regarding the suitability of online videos for raising awareness of conceptual modeling specific issues showed that the proposed material, in particular the whiteboard-style videos, are in principal suitable for this task. However, differences between the videos for goal modeling and scenario modeling show that there is a need for testing if a video really transports this matter. In addition, it might be valuable to investigate in future work, whether there can be defined some characteristics on what a "good" video is, to give some guidance in video creation.

Regarding the use of the different video styles, discussions revealed that participants liked online materials to clone classical university education concepts. Namely, participants liked to have first a lecture-style video introduction and subsequently whiteboard-style videos for the solution. However, participants also stressed that lecture-style videos should only be used to give introductions and to transport the basic concepts. For thorough explanation of complex concepts participants preferred an introduction in lecture-style combined with in-depth whiteboard-style videos.

Finally, students stressed the need for longer but not too long videos teaching concepts. The participants deem 10-15 minutes optimal. However, longer videos are also acceptable and suitable for complex situations to not disintegrate cohesive parts. In principal, exercise videos should take as long or as short as they need. However, exercises should not be too short or too simple but rather realistic in size and complexity. Otherwise, participants claimed to lose interest and to be annoyed by too short solution videos.

VI. Conclusion

Online courses are commonly suggested to improve software engineering education at university level as well as industrial training. Recent surveys have shown that there is commonly a need for individualized student feedback, specifically with respect to handed-in exercises. However, as outlined in this paper, the use of automated exercise assessment is not always feasible. For teaching conceptual modeling, among the learning goals are for example, the existence of a multitude of correct solutions with different purpose specific degrees of benefits and shortcomings. Hence, there is commonly no finite set of correct solutions, which can be used for automated exercise assessment. In this paper, we proposed the setup of an online course, which makes use of lecture-style videos and whiteboard-style videos. With the latter, we show how solutions to exercises can be derived and discuss different ways of reaching correct solutions as well as their benefits and shortcomings. In first evaluation results, we have shown that this can decrease the amount of interactive sessions needed and that students feel no need for individualized feedback on their own solution as they are enabled to assess the strengths and weaknesses on their own. Future work should deal with investigating the right amount of interactive sessions and online video instruction, thereby taking potential differences between industry professionals and university students into account. Furthermore, we identified the need to investigate criteria to determine whether a whiteboard-style video is good or bad in the sense of enabling students to assess their own solutions.

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