Bus Inf Syst Eng 61(2):241–252 (2019)
https://doi.org/10.1007/s12599-019-00584-5

DISCUSSION

Five Inspiring Course (Re-)Designs

Examples of Innovations in Teaching and Learning BISE

Stefan Strecker · Ulrike Baumöl · Dimitris Karagiannis · Agnes Koschmider · Monique Snoeck · Rüdiger Zarnekow

Published online: 31 January 2019

1 Introduction

The innovation of teaching and, correspondingly, learning in higher education has been producing numerous examples of inspiring and stimulating course designs and redesigns only too rarely reported. Tying in with Strecker et al. (2018), the present compilation adds five examples of innovative course (re-)designs, each including a reflection on student and instructor appraisal ("lessons learned"). Intended as a contribution to sharing teaching experiences much like flying pilots practice knowledge sharing, and to inspire further reflection on teaching and learning in higher education, the contributions in this compilation discuss course (re-)designs from introductory courses to more advanced courses in five different institutional settings.

Ulrike Baumöl discusses the challenges of redesigning an existing course and places the challenges she faces as a course instructor in the wider context of societal change. Among others, mixing media including videos produced by the course instructor *and* videos produced by the students considerably changes the learning experience and receives positive student feedback.

Dimitris Karagiannis reports on a newly designed course and the corresponding sophisticated set of software tools to enable students to experience the interlinkage of complementary conceptual models. He underlines the importance of conveying the value of models and modeling to learners as a key success factor.

Agnes Koschmider delivers insights into a particularly innovative learning approach based on a crowdsourcing scheme in which students work with a software tool that adapts to individual learning progress. She describes workable solutions to the challenge of incentivizing students to participate, and reports on positive effects on the participating learners' performance.

Monique Snoeck details her stepwise refinements of a course on conceptual modeling to develop elaborate means for automated feedback on object-oriented models, e.g., UML class diagrams. Teaching this course for many semesters, she has continuously been receiving positive feedback from students on her course revisions.

Rüdiger Zarnekow reports on the redesign of an introductory undergraduate course transformed from a traditional lecture-style to a blended learning approach with short online video lectures, unit-based worksheets and inverted classroom face-to-face meetings. Again, the redesign was positively acknowledged by the learners and, meanwhile, more than 1000 students have successfully completed the redesigned course.

Prof. Dr. Stefan Strecker
University of Hagen

Prof. Dr. S. Strecker (✉) · Prof. Dr. U. Baumöl
University of Hagen, Hagen, Germany
e-mail: stefan.strecker@fernuni-hagen.de

Prof. Dr. D. Karagiannis
University of Vienna, Vienna, Austria

PD Dr. A. Koschmider
Karlsruhe Institute of Technology, Karlsruhe, Germany

Prof. Dr. M. Snoeck
KU Leuven, Leuven, Belgium

Prof. Dr. R. Zarnekow
Technische Universität Berlin, Berlin, Germany

2 Evolutionary Change of Education Techniques: Not Only Technology-Driven

2.1 Introduction

Changes in society change the educational system – and since we face fundamental changes in our society, we can expect changes to our educational system to the same degree. This may not happen in the next few years, but will eventually happen over time. Some of these changes have already taken place; on the one hand, e.g., by abolishing the obligation to attend courses and, on the other hand, in the form of massive open online courses (MOOCs). Drivers are manifold and despite the, at the moment, ever-present discussion around the term "digitalization", they are not only technology-based, but are also triggered by the changing value system and life-style of people. Although this is difficult to objectively prove, certain observations can be made. Two main drivers influence changes in the way teaching and learning processes are shaped. The first driver is the so-called sharing paradigm. It can be observed as the sharing economy: homes, cars, knowledge. The second driver is also behavior-induced and bases on mobility, flexibility, and collaboration. These two drivers seem to also inflict the observable changes in the behavior of younger generations. It can be concluded that, due to this, the so-called Generation Y, but even more so Generation Z, also have changing requirements with respect to the way they learn (Pinzaru et al. 2016; Erenli 2016; Guthrie 2014).

In the following, the redesign of a course is addressed which was on the one hand triggered by the above-mentioned changes and on the other hand driven by the day-to-day challenges students face when trying to coordinate successful studies, work, and life.

2.2 Design Base

The challenge is to coordinate the evolving requirements on the demand side (students: successful studies) with the intentions on the supply side (lecturers: creating knowledge). The basic assumption is that students belonging to the above-mentioned Generation Y, or soon Z, want to contribute, be involved, collaborate and share knowledge as well as immerse in a flexible learning scenario.

In this concrete case, the requirements of the demand side are influenced by the fact that the students are very busy due to their tight and sometimes rigid plan demanded by bachelor and master programs. In addition, with the cost of the programs they try to do as many courses as possible in parallel. This results in the constant quest of minimizing the presence in courses while gathering all the important information and meeting the requirements to pass the course. Their lifestyle also leads to a low degree of concentration and attention which renders the structure of a "normal lecture" (e.g., input, discussion, reflection) difficult.

The supply-side now faces the challenge on the one hand to still provide the input, which is not trivial and requires a certain attention and focus to be understood. However, facing the wish for ever faster success, it is important to create a theoretical and conceptual basis to build upon for further learning and understanding the mechanisms behind a certain subject. On the other hand, the challenge is to adapt to the requirements of the demand side, otherwise facing the danger of losing the attention and motivation of the students.

2.3 Set-Up of Learning Environment

The prior set-up of the course was very traditional: input lectures with small break-out and discussion sessions, based on the input lectures a preparation task in teams for a two-day "knowledge transfer" workshop, the workshop itself with intensive work on and discussions of case studies, separate preparation of results and presentation for the whole class with the respective discussions, personal feedback in the last lecture slot. The trigger for a change was the highly fluctuating presence of students during the lectures (there is no obligatory presence) and the ensuing lack of knowledge at the start of the transfer workshop.

The concrete requirements for actually redesigning the course were from the students´ perspective the least possible physical presence, availability of mobile contents for learning anywhere and anytime, virtual exchange for questions and solving tasks. The requirements from the teaching perspective were the provision the input for a course worth three ECTS (90 h workload), enabling virtual and physical team- and casework, organizing the exam corresponding to the course and giving feedback with respect to the contribution during the course and the results.

As a consequence, the following elements were created and combined in a blended-learning, flipped classroom approach, also based on experiences made or written down by other colleagues (McPherson and Bacow 2016; Guthrie 2014):

- Theoretical and conceptual input was divided into small (15–20 min) and medium-sized (30–45 min) logical and coherent pieces and provided as streaming videos for all mobile devices, completed by a (traditional) set of slides (IBM-based, self-developed learning platform of the university).
- A preparation task was given based on that input for teams working on a case study; the teams could choose

to either virtually or physically prepare the task (platform chosen by students).

- A 2-day presence seminar was organized for transferring the theoretical and conceptual input to the case studies.
- The students then prepared a 20-min video based on specific tasks and with clear requirements as the result of the workshop and as first part of the exam (technology for videos chosen by students).
- The video was shared with the course mates and a discussion with one other group was prepared (learning platform).
- A discussion took place in presence of both teams and reflected the results as second part of the exam.
- Written and oral feedback was provided for the teams in either virtual or presence sessions.

The influencing factors for the redesign, the different media for the phases of the course and the respective tasks are presented in Fig. 1.

2.4 Experiences and Conclusion

It has to be said that at the beginning skepticism prevailed. There were many open questions: Would the students learn with the videos, slides and other sources? Was the material comprehensive enough to allow for the learning goals to be reached or would (too) many open questions remain? Would the students take on the challenge of producing videos and would the contents have sufficient depth? Would there be a substantial discussion?

The results were truly surprising. Not only did the students learn with the material, they came to the workshop very well prepared, and even better than ever before, and had the required knowledge of the theoretical and conceptual basis. They valued the possibility to learn at their own leisure and pace in any place convenient. They also valued the small, but coherent pieces of input. The videos were very creative and professionally made and at the same time they were of high quality contents. The discussions were focused and well prepared, which was much more satisfying than before, when the discussion was more of an annoying must after the presentation.

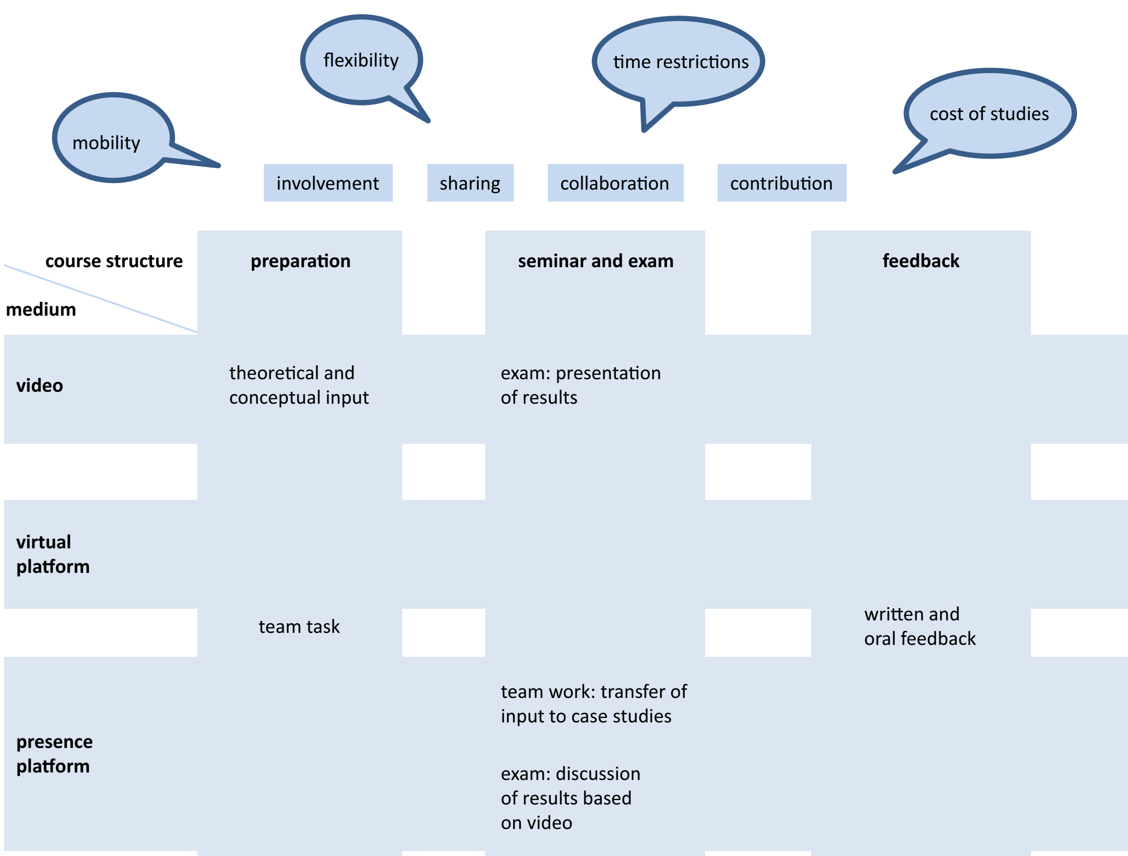

Fig. 1 Structure of course and media used for the different phases

As a consequence, the feedback was very good and the students definitely encouraged me to keep the format of the course.

Points that earned some criticism were the convenience and structure of the learning platform for organizing and sharing the contents, as well as the time-consuming preparation of the videos. Key "success factors" were the organization of the contents in small yet coherent pieces, the possibility to contact me any time for questions via e-mail (though not much used by the students), the mix of virtual and physical touch points, the freedom to choose the tools of their liking to organize the preparation task and the production of videos, and overall the ensuing flexibility for the students to organize their learning schedule.

Prof. Dr. Ulrike Baumöl
University of Hagen

3 Teaching Conceptual Modeling with the OMiLAB: The Value of Models

In our Conceptual Modeling course, we teach how to "use abstraction to reduce complexity for a specific purpose".

This teaching approach covers two layers: Conceptual modeling and metamodeling.

- On the undergraduate level, we introduce the foundations of conceptual modeling. Thereafter, the fundamental conceptual modeling languages, BPMN, ER, EPC, UML and Petri Nets, employed in computer and information science are theoretically introduced and practically applied (Karagiannis et al. 2016a);
- On the graduate level, we teach students how modeling methods can be designed in order to enrich model value with the aspect of "modeling agility". We focus here on the design of domain-specific conceptual modeling methods (Karagiannis et al. 2016b) as complementary to the fundamental or standardized modeling languages.

At university level this is an essential part of computer and information science (Jung and Lehrer 2017). Using the material publicly available through the OMiLAB web portal (The OMiLAB web portal 2018), our ambition is not only to teach students to use a particular modeling language (i.e., illustrating its syntax, semantics, and notation), but, equally important, to train them to develop modeling methods which produce specific kinds of artifacts and value. We rely on open tools to establish practical modeling experience on the students' side. The teaching strategy is in line with the principles and value creation desideratum outlined in the Memorandum on design-oriented information systems research (Österle et al. 2011).

3.1 Model Value Co-creation

From a domain point of view, teaching conceptual modeling starts at the level of factual knowledge (Krathwohl 2002). Starting 2017, we have been teaching this factual knowledge generation by emphasizing the procedural and semantic aspects of conceptual modeling. After becoming accustomed to the creation of models, we amplify the model value from its traditional role of supporting communication and understanding towards the role of a machine-processable knowledge structure on which various mechanisms can be built. For example, we do not only teach ER modeling, but we show how the created models can be used as a basis for the automatic generation of SQL code, or for the generation of semantically rich knowledge structures such as RDF.

Our teaching philosophy is depicted in Fig. 2, illustrating that model value is co-created by the two key skill profiles that are being trained by our conceptual modeling curriculum:

1. The Modeler is responsible for designing the model artifact, thus having a direct influence on model value. She/he needs to possess knowledge about the relevant domain and of applying a certain modeling method for specific goals—this emphasizes the subordination of model value to a purpose. Application of a modeling method is not limited to model design, it also involves the execution of mechanisms that process model contents, e.g., such as simulation.
2. The Method Engineer has an indirect influence on model value, as he/she is responsible for creating the modeling method employed by the Modeler, from whom domain knowledge and requirements (purpose) must be acquired. The modeling method needs to be designed in a way that enables model value, e.g., by extending strictly representational means with mechanisms for consistency checking, transformation, code generation, model queries etc.

The Method Engineer creates, by defining a metamodel, "models of concepts", whereas the Modeler creates "models that use concepts" (which have been modeled by the Method Engineer). Furthermore, maximization of model value can be enabled by applying the framework of Agile Modeling Method Engineering (AMME) (Karagiannis 2016) - this empowers the Method Engineer to customize a modeling method according to evolving needs or a gradual understanding of the application domain. We thus emphasize the subordination of model value to domain knowledge acquisition.

For teaching purposes, the domain knowledge can be available in any of these two skill profiles. For specific project-based case studies, interaction with external

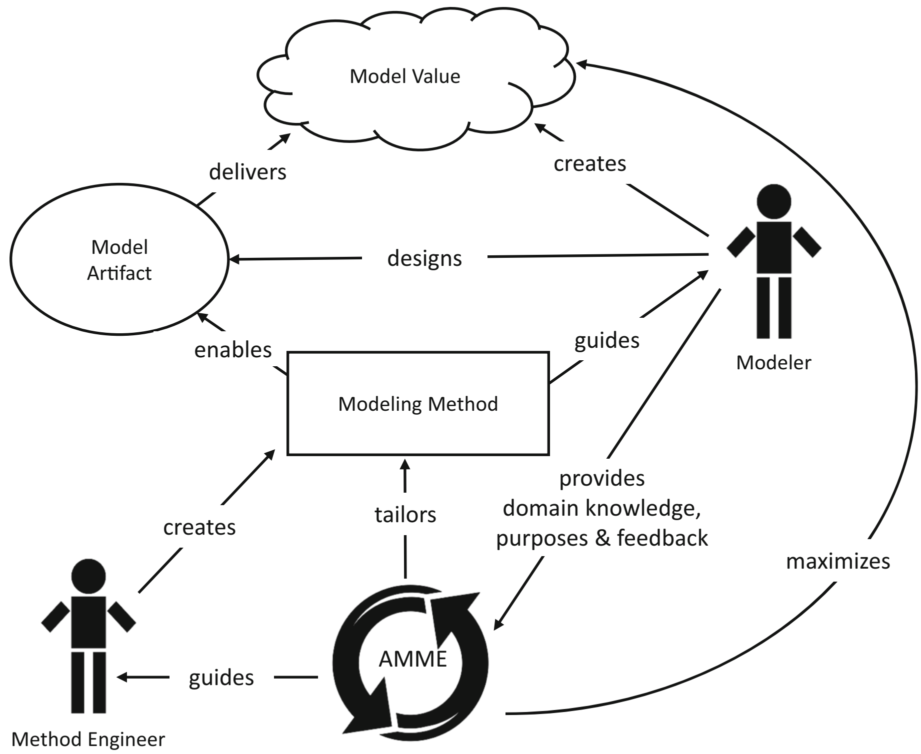

Fig. 2 Co-creation of model value by applying AMMEAdapted from Bork et al. (2019)

domain experts is required to reach an adequate model value.

Both skill profiles need adequate tool support to achieve their goals. In our case students exercise conceptual modeling with fundamental languages using the BEE-UP tool (The BEE-UP Modeling Tool 2018) and produce new modeling methods using the ADOxx metamodeling platform (The ADOxx metamodeling platform 2018).

3.2 Open Access Tools for Practicing Conceptual Modeling

At the undergraduate level, students use the BEE-UP modeling environment which includes BPMN, ER, EPC, UML, and Petri Nets in one environment, thus conveniently avoiding the need to install and interact with a multitude of tools. By using the text annotation service provided via the BEE-UP web page (The BEE-UP Modeling Tool 2018), students learn how to annotate a natural language case description and to derive, in a stepwise manner, at an initial conceptual model. Thus, we not only introduce the metamodel and the semantics of a modeling language, but we also discuss the cognitive tasks involved in modeling.

Moreover, we amplify the value of fundamental modeling languages by running various mechanisms such as, e.g., analysis, simulation, generic transformation of models to RDF, specific transformation of ER models to SQL etc. Such mechanisms are demonstrated in the BEE-UP tool. We also demonstrate and exploit the integration between fundamental modeling languages, as part of a comprehensive exercise titled “The IMKER Case Study” (Karagiannis et al. 2017)—e.g., exporting interlinked models as RDF graphs, extending UML Activity Diagrams with organizational models, semantically linking Petri Net elements to model elements from different abstraction levels (represented by other languages in the same tool).

In the graduate level studies, we run a course named Metamodeling which guides the students to walk through the AMME cycle to produce a new modeling method, i.e., from the requirements phase over the design phase (syntax and notation), to the development of a tool prototype. This stimulates the students’ lateral thinking and ability to generalize the value of models beyond traditional use cases such as software modeling.

For this purpose, we target alternative application domains like Smart Cities (Bork et al. 2015, 2016) and Cyber-Physical Systems (Walch 2018). Students show particular motivation when working with such domains, or when given the opportunity to define their own application domain. Based on a domain analysis and the identification of key modeling stakeholders and their concerns, students start with the design of their domain-specific modeling language. After several iterative revisions of the metamodel, students eventually develop a modeling tool prototype based on the ADOxx metamodeling platform which they present in plenary sessions. During this course, students perceive modeling languages not as an inflexible artifact, but rather as a conceptual representation of a specific domain that can provide value to heterogeneous stakeholders aiming for diverging purposes. Students gain the understanding that, as domain understanding is enriched or modeling requirements evolve, the conceptual modeling language may face a need for agile adaptation.

Using the ADOxx platform, students are enabled to experience and reflect on the implications of metamodel design decisions and consequently on how model value can be enriched. Based on this new teaching approach, students gain a deeper understanding of the foundations and applicability of conceptual modeling [see Bork et al. (2016) for a detailed empirical evaluation]. This will eventually also foster understanding of new modeling languages.

3.3 Lessons Learned

From our experience, teaching conceptual modeling needs to focus on the value of models and the relationship between modeling methods and model value. Moreover, teaching of conceptual modeling needs to incorporate openly available modeling tools to enable all students to participate without obstacles regarding tool availability.

Teachers should not concentrate on explaining existing open specifications of well-known languages. Rather, we aim to educate students to interpret the specifications as knowledge structures that can be employed or tailored for specific purposes. Teaching conceptual modeling should focus on the cognitive tasks involved in creating model value and the ways the knowledge conveyed by models can be used. This naturally requires a clarification that (1) different stakeholders have different purposes for using modeling methods and (2) those purposes may require agile customization of modeling methods and their respective tools.

Students can create models using different conceptual modeling methods and practice the processing of these models by algorithms. By emphasizing the different values of conceptual models and by using a single modeling environment, it is also easier to concentrate students' attention to the respective strengths and weaknesses of different modeling languages. Consequently, students are empowered to analyze and compare different modeling languages based on the respective value they provide in a given context. This eventually fosters metacognitive knowledge on conceptual modeling.

The use of BEE-UP does not intend to address the level of detail required in obtaining certifications for using complex/demanding languages (e.g., UML or BPMN) – instead we focus on developing competences for agile conceptual work demonstrated across various languages in order to highlight relevant knowledge and representational patterns.

The conceptual modeling knowledge of students influences the way they perceive the usefulness of modeling tools. Some modeling novices, accustomed to work with graphical tools (e.g., the drawing features of vector-oriented drawing applications), state they feel limited in their creativity when working with a modeling tool. With the progress of the semester, however, they gain gradual understanding of the distinction between unconstrained drawing and conceptual modeling as an enabler for model-based functionality that goes beyond representational concerns, thereby delivering additional model value. The student's willingness to engage in modeling is increased as they acquire a comprehensive understanding of "model value" in a knowledge acquisition context.

Finally, members of the global OMiLAB community started sharing their own teaching experiences on conceptual modeling topics (Buchmann and Ghiran 2017), benefitting from the open resources made available through the OMiLAB portal at http://omilab.org/. This contributes to fostering a teaching-oriented agenda which we consider an essential enabler towards the "modeling for the masses" vision that was formulated in recent publications, e.g., in the field of Enterprise Modeling (Sandkuhl et al. 2016).

Prof. Dr. Dimitris Karagiannis,
University of Vienna

4 Crowdsourced-Based Learning as Instrument for Active Learning

4.1 What was your Teaching Innovation?

It is well known that active learning is superior to passive learning. We have applied and evaluated a learning approach that seeks to foster active learning for Information Systems courses at two German universities. With this approach, students use the Crowde tool (Crowdsourcing exam)[1] throughout the semester to design questions and solutions involving the content of the course and submit these tasks to the Crowde repository. They improve their tasks according to specified guidelines and peer-review the tasks' quality according to perceived difficulty and by comparison with other questions. "Excellent" questions (i.e., exam quality) are released into a pool from which individual exams are generated according to personal learning style preferences. The system decides which questions are assigned to learners, and statistical data is obtained when working with the Crowde tool. For instance,

[1] https://crowde.net/.

the answer time and the statistical difficulty are assessed and can be used to recommend questions matching the current learning progress to learners. The Crowde approach is effective because it requires an effort from the "crowd" (i.e., the learners and lecturers in order for a question to become "excellent." Learners work to improve a task until it follows all guidelines, and lecturers are encouraged to actively participate in the peer-review, as well as to give feedback. Using this approach, we gained experience with intrinsic (i.e., exchange one exam quality question for three learner questions) and extrinsic incentivization (i.e., bonus points) in order to motivate learners to work with the Crowde tool. The Crowde tool also resolves issues affecting the Intellectual Property of questions and peer reviews, since all learners are equally involved in the design, revision and feedback of tasks.

While crowdsourcing is an established learning instrument for e-assessment and peer reviewing, this crowdsourcing-based approach goes beyond the current status quo. The Crowde tool automates the entire process, from the design of tasks to the use of those tasks for individual exams. The crowd improves the learning progress of each learner by revising questions until they become excellent questions.

This crowdsourcing-based learning approach is beneficial for learners as well as for lecturers. When working with the tool, learners use the Crowde repository to prepare for exams individually, to broaden their knowledge of particular topics, and to practice representing tasks in a way that might differ from their individual preferences (e.g., visual vs. text). Lecturers are able to identify problems with the comprehension of particular topics when peer-reviewing tasks and resolve them through individual feedback, or additionally, through tailored exercises. The use of the Crowde tool also stimulates interaction between learners and lecturers which is often too limited in mass-lectures.

The crowdsourcing-based system might also be used for work-related, life-long learning. People in industry intending to broaden their knowledge or attending MBA courses could be asked to contribute exercises based on their practical experience. A tandem of novices and experienced learners would allow collaborative work on tasks and, thus, would complement the knowledge of both.

4.2 What did you Change Compared to Your Earlier Teaching Approach?

The crowdsourcing-based learning approach was applied for three lecture courses: "Foundations of Information Systems" (Grundlagen der Wirtschaftsinformatik) in the summer terms of 2016 and 2018, "Distributed Information Systems" in the summer term of 2017, and "Integrated Information Systems" in the summer term of 2018. While in 2016, the design of tasks was voluntary and incentivized with bonus points, starting from 2017, the design of tasks has been part of regular exercises. The exercise is organized such that learners either design tasks during the exercise in class, or they design tasks at home in place of the exercise.

4.3 What are Your Experiences with Interlinking Teaching Strategies and Tools?

The crowdsourcing-based learning approach is in line with findings related to literature on receiving feedback and giving feedback. My observation is that receiving feedback improves students' awareness and knowledge which is necessary for self-regulated learning. Giving feedback leads to an improvement of an individual's capacity for reflection which is emphasized as being essential for self-regulated learning (Lehmann et al. 2015). Additionally, the feedback given by the crowd improves students' ability to communicate their individual state of development and to formulate specific requests for help.

4.4 What did you Perceive as Primary Challenges with Implementing the New Course Design?

Despite these advantages for learners and lecturers, the crowdsourcing-based learning approach presents several challenges: How to motivate learners to design (very good) questions and improve them, and how to motivate lecturers to engage in quality assurance? We learned that a small repository of questions does not motivate students to create and submit new questions, since they do not have access to enough exam-quality questions. Furthermore, if learners do not receive immediate feedback to their questions, they are not motivated to improve the questions of their peers. To counter these challenges, we tried intrinsic and extrinsic incentivization. In the past, we incentivized the design of questions with bonus points which served as credit for the final exam. The bonus points were only granted if a certain level of quality was achieved. Since granting bonus points is not always an option, we also tried different incentives such as to swap three questions for one exam question. However, extrinsic incentivization with bonus points seems to work well and has shown positive effects on learners' acceptance of the effort required to design questions (Koschmider and Schaarschmidt 2017). Intrinsic incentivization is still in its infancy. In the future, we plan to use gamification in order to motivate learners to revise their peers' questions in such a way that only minimal improvements are necessary before the questions are released for "real" exams. With respect to quality assurance by lecturers, the additional effort required of them needs to be proportionate to its benefits. However, feedback should also be given as soon as possible. This is especially demanding as the time between two waves of submitted tasks is relatively short, which makes it difficult to revise questions to a satisfying degree.

4.5 Lessons Learned

The implementation of the crowdsourcing-based learning approach is a challenging task, but most of our experiences have been positive. For instance, our empirical studies reveal a significantly positive indication of the perceived influence of the learning approach on learner-content interaction, satisfaction, and learning success. It was also shown that students perceive feedback as very important for their learning process and that the current amount of feedback was deemed to be insufficient. Additionally, we observed positive effects on passing the exam (Koschmider and Buschfeld 2016; Dieterle et al. 2018). Students who did not participate in this learning approach were less likely to pass the exam, while participants' assessment of the learning material and the feedback of their peers reduced the failure rate of exams. We consider issues that did not work well to be the challenges described in Sect. 4.4, and intend to address them in the future. For instance, we could imagine offering a functionality in the Crowde tool that directs students to learning videos for certain topics in case of comprehension problems. We believe that audio and visual material will play a significant role in the future. To modify the approach for next semester, we will replace a teacher-centered exercise with a collaborative design of tasks in order to quickly generate a large pool of questions.

So far, two advices can be given in order to exploit benefits from the crowdsourcing-based learning approach. A large repository of questions is necessary to sufficiently motivate learners to participate in the learning arrangement. If bonus points can be granted to students, then the repository fills up quickly. Intrinsic incentives work well with a large repository. Also, learners must be given a detailed description of the task as well as comparable example exercises. If learners are required to give feedback, then they must be shown comparable example exercises with scores (percentage of guidelines satisfied by the question) or questions deemed "excellent." Otherwise, learners tend to submit "simple" tasks for which a large number of revisions are needed and disappointment arises when they do not receive full points.

PD Dr. Agnes Koschmider
Karlsruhe Institute of Technology

5 Technology-Enhanced Learning of Conceptual Modeling

Learning to model well is not only important for the quality of modeling in the workplace, but also because learning conceptual modeling is instrumental in developing competences in abstract thinking, problem analysis and problem solving in general.

When I started teaching conceptual modeling more than 15 years ago, I initially copied the teacher-centered and paper-based approach from my predecessors, characterized by the prevailing use of corrective feedback. Since then, my teaching has evolved to a student-centered and technology-supported approach making extensive use of cognitive feedback. Despite the course's (correct) reputation of being hard, it receives very positive evaluations, also from students who failed the course. The new way of teaching is also much more rewarding for me as a teacher.

5.1 From Corrective to Cognitive Feedback

Conceptual modeling is a complex learning task: quality modeling requires the integration of a series of competences, and there are neither unique correct solutions, nor unique paths to arrive at a good solution. Students are, therefore, in permanent high need of individual feedback. As my understanding of the deficiencies in their cognitive schemas to approach conceptual modeling tasks grew, the feedback I gave to students evolved from simple corrective feedback to more advanced forms of feedback (Serral Asensio and Snoeck 2016).

Corrective feedback (right or wrong) is the simplest form of feedback and may work for the simplest conceptual modeling exercises (e.g., a single association in a UML class diagram). However, one quickly experiences that *elaborative feedback* is required to make students *understand* why certain solutions are more right or wrong than others. Elaborative feedback can be provided in a form of model solutions annotated with comments resolving frequently asked questions and annotated student solutions, indicating their good and bad elements.

However, this is still not enough. You would like to develop a student's ability to elaborate themselves on the correctness and suitability of a conceptual model, given a set of requirements. Such competences are better developed by providing students with *cognitive feedback*: prompts, cues, questions, etc. that help the learners to reflect on the quality of their modeling process and resulting models, so that they construct more effective cognitive schemas to improve future performance (Serral Asensio and Snoeck 2016; Sedrakyan and Snoeck 2017). A very simple form of cognitive feedback, such as translating a student's model to text (This is what your model says…;

Is this what you meant to express?) already proves to be quite effective to foster a student's self-reflection on his/her modeling performance.

5.2 From Teacher-Centered to Student-Centered

Individual feedback fosters the evolution towards a more student-centered, active learning approach. This can be achieved by cutting down on lecture time in favor of lab sessions where students can practice at their own pace. Also, "flipped classrooms", where students study the easy parts on their own, allow for reserving contact hours to deal with students' individual questions rather than for lecturing.

5.3 Technology Support

The experience with the positive effects of cognitive feedback and the increase of the class size to around 100 students has triggered a search for automating feedback. To this end, our modeling tool was enriched with different forms of automated "on demand" cognitive feedback. It started with simple forms of feedback: model-to-text features and verifying the model for obvious missing elements (e.g., no way to create or end objects in a class) (Snoeck et al. 2007).

More advanced cognitive feedback followed. An in-depth understanding of a model requires the ability to mentally picture and "test" the software application that will result from the model, something that is very hard to achieve for novice modelers. Therefore, the tool was enriched with an easy to use code generator, enabling the students to simulate a model by means of a prototype application. Moreover, as it turned out that students had difficulties linking the application's behavior to its origin in the model, the code generation was enriched with cognitive feedback: When the application refuses an action, the error window visualizes the location of the constraint in the model. Experimental research shows that such cognitive feedback enhances the students' performance significantly (Sedrakyan et al. 2014, 2017). Mining the logs of student activity furthermore shows a difference in the process of modeling between better and worse students (Sedrakyan et al. 2016). This opens up the perspective for process-oriented feedback as a complement to the current task-oriented feedback (Hattie and Timperley 2007; Serral Asensio et al. 2016).

5.4 Instructional Design Theory

The course's improvements were initially performed based on own insights rather than instructional design theory. The more I advanced in developing the course, the more I was interested in what I could learn from instructional design methods. Starting with simple instructional models such as Bloom's taxonomy (Krathwohl 2002) worked well, but turned out to be not rich enough to cater for complex learning. Richer instructional design theories, such as 4C/ID (Van Merriënboer and Kirschner 2012) which specifically targets complex learning, are inspirational to add more fundamental refinements to the course design. However, the application of instructional design methods requires an in-depth understanding of cognitive schemas and knowledge required to perform a task. For conceptual modeling, much of this knowledge is still tacit. In retrospect, using a rich method such as 4C/ID right from the start would have been too overwhelming, whereas the increased understanding of students' cognitive schemas now allows reaping the benefit of instructional design methods.

5.5 Lessons Learned

Automated feedback, code generation and course material all score high on perceived utility with students. Short videos and recorded lectures are deemed useful for re-watching material students missed or did not understand fully, slides are appreciated because of their more visual character, while the textbook is appreciated for its completeness and found easier when trying to grasp the global picture compared to online material. The different types of material clearly serve different goals and different learner preferences.

And while the student-centered approach is appreciated by all, it seems to only work well for students with high self-regulation capabilities: A self-paced course leaves more room for procrastination. This could be partly addressed by means of permanent evaluation and process-oriented feedback. Yet, it remains an open question to what extent this is the responsibility of teachers at higher education level, especially when teachers face large groups.

Automated feedback and the use of MOOC technology changes the nature of teacher-student interaction. The development of the tools, automated feedback and online lectures is extremely time consuming. Nevertheless, it is worth the effort as it creates more time for coaching student on more interesting and challenging questions.

Prof. Dr. Monique Snoeck
KU Leuven (Katholieke Universiteit Leuven)

6 Blended Learning with Educational Videos and Inverted Classroom

In 2015, we decided to completely redesign our course "Introduction to Information Systems" (Einführung in die

Wirtschaftsinformatik) at TU Berlin. Until then, the course consisted of a traditional lecture and accompanying tutorials. The course is attended by about 400 students each winter semester, mostly first and second semester bachelor students in information systems and computer science. The goal of the course is to provide students with a broad overview of basic concepts and topics in information systems.

6.1 Course Design

In order to make better use of digital media and blended learning concepts, and also to create more space for dialogue, discussion, and practical examples within the course, the redesigned course is now made up of three components:

1. Online Lecture: We divided the course content into 34 separate teaching units, with each unit focusing on a specific topic. Based on prior research findings (e.g., Guo et al. 2014), we produced a 10-min-long educational video for each unit, explaining the core concepts of the particular topic. Some units also include short texts, taken from textbooks or research articles. In addition, we developed a worksheet for each teaching unit, containing an abstract, learning goals, control and discussion questions.
   The online lecture is designed for self-study. All videos and materials are provided to students through the e-learning system of TU Berlin. Students are free to download the videos and watch them at a time of their convenience on their personal devices.
   The videos contain all relevant course contents. Students can prepare for the exam solely by working their way through the videos and the accompanying materials. All other course components, as described below, are optional.
2. In-class Lecture: In addition, students can attend an in-class lecture every second week. The lectures are based on an inverted classroom concept (Strayer 2012). Students must work through the relevant teaching units in advance and gain an understanding of the topics covered in the units. The content of the teaching units is not explained and discussed in the in-class lectures. Instead, lectures focus solely on current practical examples, applications, and case studies. These are introduced by the lecturer and then discussed with the class. The goal of the in-class lectures is, on the one hand, to illustrate the content of the educational videos through the help of examples and, on the other hand, to spark student interest in information systems. Since class-size is still quite large, digital voting and discussion tools are employed throughout the lecture.
3. Tutorials: Tutorials continue in their original form. They allow students to discuss course contents in small groups with a tutor, ask questions, and prepare for the exam.

6.2 Course Production

The production of the educational videos proved to be much more time-consuming than originally anticipated. The reasons for this were mainly content-related. A majority of the time was spent on breaking down the course content into the 34 units, working out the core concepts for each unit, and deciding on how to best communicate these concepts in a 10-minute video. In addition, we wanted to design the content in a way that allowed us to use the videos for a period of at least 5 years. It turned out that almost none of the existing teaching materials from the traditional lecture (slides etc.) could be used for the videos. Instead, they had to be created mostly from scratch. The development of the worksheet for each unit was also time-consuming. In total, the design of the online course contents took several months, even though it covered basically the same contents as the existing traditional lecture.

We also encountered several obstacles during the actual filming and production of the videos. At the time, there was no professional recording studio available at the university. We chose a pragmatic approach and converted a regular office room into a small studio, setting up camera, microphone, 3-point-lighting, green-screen, and room acoustics. It took numerous iterations and tests until a stable setup was achieved. During production, we followed recommendations by other online-lecturers and focused on audio quality and good readability within the videos. More recently, other studies have further analyzed the implications of video design decisions on student experiences (e.g., Crook and Schofield 2017).

6.3 Experiences

We have now conducted the course over a period of three years with more than 1.000 students attending. In the following, we would like to report some of our experiences. From a student's perspective, the feedback is overwhelmingly positive. The vast majority of students accept and actually prefer to study the course content through educational videos. It provides them with a high degree of flexibility in regard to where and when to study. Furthermore, they like the precise structure and the compact form in which the content is presented in the videos.

The in-class lecture also receives positive feedback. Students appreciate the additional room for practical examples and discussion. Class attendance is higher (and more constant throughout the semester) than in the traditional lecture, even though it is purely optional.

The new course design requires a higher degree of personal responsibility from the students, since they mostly work in a self-study mode. We, therefore, found that committed and dedicated students profit the most.

From our personal point of view, the new course design offers a number of advantages, especially for large introductory bachelor courses. The combination of online and in-class lectures enables us to implement a blended learning approach. We deliberately decided against a pure online course (e.g., MOOC), because we believe a face-to-face component is important in a university context. The in-class lecture proved to be far more fulfilling and motivating for the lecturer. Instead of repeating basic information systems concepts over and over, there is now a lot of space for presenting and discussing current topics. Having said that, in-class lectures based on an inverted classroom require substantially more preparation and need to be updated frequently.

Key learnings were, as mentioned above, the unexpectedly high amount of time required for designing the video content and creating a stable technical production environment. Finally, our course design is oriented towards introductory courses. Advanced courses, such as master courses or seminars, very likely require different blended learning approaches.

Prof. Dr. Rüdiger Zarnekow
Technische Universität Berlin

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