

Design Science Research as a Guide for Innovative Higher Education Teaching: Towards an Application-Oriented Extension of the Proficiency Model

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Abstract. Constant technological innovation demands higher education teaching to be reactive in an ever-changing environment. Technology-enhanced learning environments provide a foundation for innovative higher education teaching, but the lack of guidance on how to design elements for these environments constitutes a significant barrier. In this context, Design Science Research (DSR) could provide valuable orientation for the iterative implementation of innovative teaching approaches. While the Proficiency Model for DSR summarizes competencies needed to conduct DSR projects, concrete guidance on how to apply DSR to innovative teaching is lacking. Therefore, we address this research gap by extending the Proficiency Model with concrete guidelines that support conducting DSR. These guidelines are derived from an instantiation of two conducted design cycles within a lecture for information system students, resulting in seventeen guidelines that guide lecturers in higher education on how to implement DSR for the iterative transformation of their courses towards meaningful technology-enhanced learning environments.

Keywords: Technology-enhanced Learning · Higher Education · Guidelines

1 Introduction

Technology-enhanced learning environments (TELE) are on the rise as technology is increasingly integrated to enhance traditional lectures [1] to improve students' learning [2]. However, lecturers' perceived lack of knowledge, skills, and confidence in integrating technology into higher education teaching remains a significant barrier towards innovative teaching approaches [3]. A lack of technological adaptation and innovation in higher education teaching can undermine valuable learning experiences [4] and neglect the needs of digitally-native students [5]. While the initial approach to TELE is fundamental, in an ever-changing environment, innovative higher education teaching also

requires creative and evidence-based ways to continually adapt and improve [6, 7]. Consequently, lecturers might no longer be considered exclusively as traditional educators, but also as designers of innovative and adaptive TELE approaches [6], in means of design science [8, 9]. However, to address lecturers' perceived barriers towards TELE, tangible support is needed [3]. Against this background, Design Science Research (DSR) could provide valuable guidance on how to approach the transformation of higher education towards TELE. The methodology addresses the iterative design of innovative artifacts that are designed to benefit its users and created in alignment with the environment as well as the existing scientific knowledge base [10, 11]. As a result, DSR could provide lecturers orientation regarding the initial design of TELE, starting with simple low barrier artifact aiming towards innovating the teaching. Moreover, DSR can further guide how to iteratively evolve higher education teaching [12]. So far, there are isolated approaches analyzing the value of understanding design science as a method for enriching higher education teaching with promising findings [13, 14]. However, despite the understanding of the value of design science for higher education [12], DSR is currently underrepresented in educational pedagogy [15], and, consequently, concrete guidance on how to apply DSR to the design of innovative higher education teaching is not sufficiently analyzed. In terms of orientation for DSR education, the Proficiency Model (PM) addresses the need to further understand the interface between educational pedagogy and DSR by providing guidance on how to teach DSR with the definition of six proficiencies needed to conduct DSR [15]. Nevertheless, how these proficiencies can be used by lecturers to instantiate DSR for higher education teaching has not yet been considered. Thus, we aim towards expanding the PM [15] and derive application-oriented guidelines that include crucial procedural DSR aspects, and therefore, support lecturers in applying DSR for TELE projects. Consequently, this article seeks to answer the following research question:

What are fundamental application-oriented guidelines for DSR projects in higher education for the design of meaningful TELE?

To answer the research question, we follow a reflective approach [16]: Based on experiences from a concrete DSR instantiation, we derive guidelines for the application of the DSR proficiencies towards innovative TELE in higher education. To outline the path from the DSR instantiation to the guidelines in a transparent way, we first present the DSR instantiation in Sect. 3. The description of our DSR instantiation is therefore not presented in detail, but rather serves as a means to provide an experience-based foundation. Based on this DSR instantiation, we then derive concrete guidelines in Sect. 4, in accordance with the PM's DSR proficiencies, to provide guidance on how to implement DSR for designing and adapting innovative TELE. The contribution of this article can be understood as an exaptation [17]: We build on an existing artifact, the PM, and do not use it in its original form, but as an orientation for DSR in education, by applying its defined proficiencies to derive concise guidelines for DSR projects in the context of TELE. Thus the guidelines convey DSR process knowledge [18, 19] for lecturers and guide the process of designing and improving TELE in higher education.

2 Theoretical Background and Related Work

DSR highlights the significance of addressing real-world problems. Central to this research process is the design of an innovative, problem-solving artifact, emphasizing design activities as a vital step in developing innovative solutions. DSR adopts an iterative approach, enabling ongoing enhancement of solutions with feedback and evaluation [10, 11]. Due to this iterative character, DSR addresses the same underlying activities that are demanded when designing TELE: Both approaches address a real-world problem, use existing (learning) theories in order to develop innovative prototypes in an evidence based manner [8]. However, while DSR enables a broad application context and possible synergy effects for Information Systems researchers with a teaching assignment, [15] address the current lack of contributions in teaching DSR. With the aim to support educators in teaching DSR, different approaches with principles for teaching DSR are introduced: [20] present a design of a DSR course for PhD and Master levels. In addition, the teaching framework for DSR education of master students provides tangible design principles for creating DSR courses [21]. While these approaches provide tangible advice, different to our approach, these articles specifically focus on guidance for teaching DSR (e.g. “Get students to speed-up Quickly” [21]). A framework that allows for a boarder perspective of DSR in higher education is the PM which defines six core DSR proficiencies essential to the effective conduct of DSR” (Fig. 1) [15]. These proficiencies, which are formulated more generally, thus allow for a broader application compared to the (design) principles for designing DSR courses.

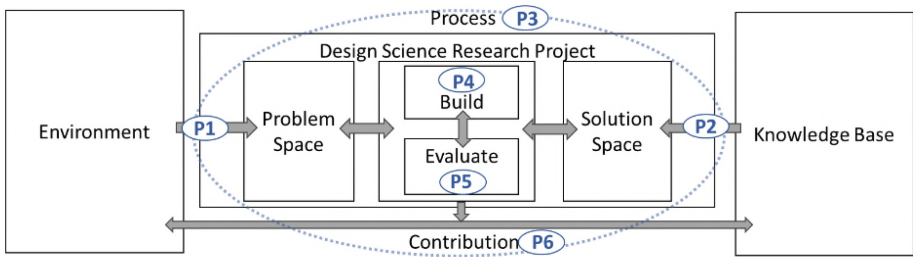


Fig. 1. DSR according to [10] including the six DSR proficiencies [15]

The PM guides and supports the teaching and development of six DSR proficiencies: (P1): Representing the problem space; (P2): Capturing existent knowledge in the solution space; (P3): Controlling the DSR process; (P4): Building innovative design artifacts; (P5): Measuring the satisfaction of research goals through rigorous evaluation; (P6): Contributing to science and practice. The PM offers practical guidance for adoption to various academic, training, and executive audiences, ensuring that DSR education can be effective and accessible. While the PM originally supports the teaching of essential DSR proficiencies [15], the described proficiencies also provide us with a structure for deriving guidelines that support DSR projects in higher education.

While we could not identify existing frameworks for applying DSR to higher education projects for designing meaningful TELE, there is related research. Similar to our

approach also [13] analyze the value of DSR for creating and developing learning methods in higher education settings. Their study suggests that using DSR approaches can significantly improve the understanding of learning in technical subjects such as engineering, and helps to improve the design of learning materials [13]. DSR can support the creation of course materials and their content by its unique iterative character [13]. In addition to studies on DSR in education, there are tools such as ‘MyDesign-Process’ [22] that support DSR project organization and thus, may provide valuable guidance for DSR practitioners.

When analyzing contributions regarding DSR and education in general, most researchers present articles on how they teach DSR as a research methodology in their courses [23, 24]. Since 2022 the DESRIST has the track “Education and DSR” indicating an increasing interest for education in the DSR community [15, 25]. Within this track, most researchers use DSR for their artifact development [26] and usually conduct one iteration [27–29]. Often this iteration is the first step in the development of an artifact (e.g. [27–29]). When using DSR for a lecture design, researchers often take a long time of development [29]. Projects like [29] last for years and represent one iteration of an artifact development that covers a whole course. But usually, DSR is iterative by nature and thus, could take place in, e.g., one lesson. In addition, researcher often teach DSR within their courses and present the structure of the DSR course and how to teach DSR essentials [23, 24]. Apart from teaching DSR, researchers offer solutions for different goals/use cases e.g. design principles for knowledge sharing [30], design principles for e-learning [31], or taxonomies for study designs [32]. Overall, the related articles highlight the value of DSR in education, but the contributions lack guidance for concrete and meaningful recommendations to implement higher education teaching with the help of DSR. While there are some recommendations regarding single DSR projects in higher education, there is a need for further investigation and research towards tangible, comprehensive, and practice-oriented guidance for applying DSR.

3 Instantiating DSR for Designing Higher Education

In order to transparently outline the DSR character of our DSR project, we shortly present our implementation of the DSR process [11]. While the presentation of our DSR instantiation and its findings are not in focus of this article, they rather act on a meta level as the reference for our experiences regarding the implementation of DSR for education. We build on this reference in our reflective approach in Sect. 4 to derive concrete guidelines on how to apply DSR for innovative higher education teaching. In this chapter we shortly introduce the addressed problem space as well as the designed artifact of our concrete DSR instantiation. The iterative DSR project with the aim of addressing real-world problems in our current higher education teaching took place within one semester at a German University (April–July). Within this one semester, we were able to complete two design cycles, starting with a simple prototype and a further evolved prototype based on students’ feedback. Figure 2 depicts the two conducted design cycles in accordance to [11]. The central artifact is a collaboration script. Collaboration scripts typically structure group work process of learners and define distinct phases, assign learners to roles, and provide guidance in form of concrete prompts [33]. Thus, they can

promote effective student cooperation in TELE. Within our DSR project, both prototypes convey a collaboration script that is similar in its pedagogical structure and prompts but differ in their way of delivery: The first rapid prototype is a PDF-based collaboration script, while the evolved second prototype is a collaboration script conveyed by a plug-in for the university's Learning Management System (LMS).

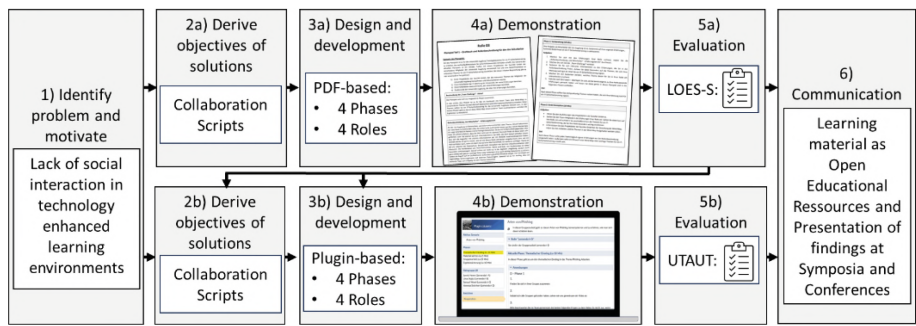


Fig. 2. Instantiated DSR process according to [11]

In the following, we outline the steps of our first design cycle (Fig. 2): **1)** We identified the real word problem: Student collaboration in peer groups can fail to deliver the potential positive learning outcomes because individual students work at their own pace without considering their peers, student participation is uneven, or some students even refuse to contribute [34, 35]. This can have a negative impact on students' motivation as well as learning outcomes [36]. To address this problem, the research field of pedagogical psychology proposes collaboration scripts. These scripts can support students' cooperation in lecturers or seminars by structuring group tasks with phases and phase-specific prompts to clearly outline how students can work together effectively [37]. Their effectiveness has been demonstrated in studies along multiple disciplines in higher education [38, 39]. However, their effectiveness depends on their design and structure. **2a)** Therefore, we aim to design collaboration scripts for our lecture by first developing a generic structure that can be filled with concrete roles and tasks. We understand collaboration scripts as a technological element that we integrate in our lecture. **3a)** As a first prototype we designed a simple collaboration script for students. Each student perceived the collaboration script containing five PDF pages. The collaboration script presented the learning scenario, four distinct learner roles, structured phases for the collaboration tasks as well as phase-specific prompts. **4a)** The demonstration took place at the beginning of the summer term in April. **5a)** To determine how students perceived the prototype of collaboration scripts, we evaluated the initial prototype using the Learning Object Evaluation Scale for Students (LOES-S) [40].

Table 1 provides the results of the LOES-S and as the summarized qualitative feedback.

The quantitative assessment suggests that students ($N = 21$) liked the interaction with the collaboration script overall, as all values (learning, quality, and engagement) show

Table 1. Evaluation of first prototype

Quantitative data		Qualitative data			
Construct	Mean	Students liked	#	Students disliked	#
Learning	3.58	Cooperation in group	17	Timing	7
Quality	3.67	Taking on roles	2	Too complex	4
Engagement	3,70	Practical relevance	1	Group finding	3
1 = strongly disagree 5 = strongly agree		Increased motivation	1	Just one topic	2
		Clear instruction	1		

high values (above 3.5). Besides, the qualitative statements provided further information about specific features of the collaboration scripts students liked or did not like.

Based on the findings, we started the second design cycle with the goal to present students an improved collaboration script prototype at the end of the semester. Based on the evaluation **2b)** we derived the following objectives for the solutions:

Table 2. Requirements as a result of the first design cycle and responses

Identified demand	Objectives for solutions
Student groups miss support regarding timing regarding the change of phases	Guide student groups through collaboration phases to ensure and support their progress
Seeing the entire collaboration script and its tasks are too much information at once	Display only relevant prompts in the current phase, not the entire collaboration script

Considering these additional demands, we developed a generic plug-in for the university’s LMS. **3b)** This plug-in is able to convey the same information as the PDF files, but additionally allows a more structured process and provides only relevant information in each phase. **4b)** We presented the second, plugin-based collaboration script to students at the end of the summer semester. **5b)** To identify the value of the technology-based collaboration script, we aimed for a more technology related understanding. Therefore, we integrated constructs of the Unified Theory of Acceptance and Use of Technology (UTAUT). The assessment suggests that students (N = 17) overall liked the interaction with the collaboration script as all values, show means above 3 (= “neither agree nor disagree”). Students negatively highlighted the need of a VPN-connection to access the prototypes. This is due to a test system being used. This critique will be eliminated after the prototype is transferred to the productive system. Overall, the evaluation reveals that students enjoy the second prototype and noticed the improvements.

Through the evaluations and their resulting insights regarding DSR knowledge, we were able to generate communicable knowledge. **6)** Thus, we will share our prototype as an open educational resource. Besides this, we aim to present our findings of this DSR instantiation at symposia and a conference. These contributions will provide further

Table 3. Evaluation of the second prototype

Quantitative data		Qualitative data			
Construct	Mean	Students liked	#	Students disliked	#
Situation-Specific Skills	3,36	Intuitive handling	11	VPN-Connection	2
Performance Expectancy	3,55	Role distribution	1	Nothing	7
Effort Expectancy	3,72	1 = strongly disagree 5 = strongly agree			
Attitude toward Use	3,51				
Intrinsic Motivation	3,89				

design details, including the concrete content of the collaboration scripts, together with the discussion of the results. In the present article, we only briefly introduce the DSR instantiation at a meta level to provide the basis for Sect. 4, where we derive the guidelines for applying DSR, towards designing innovative higher education teaching.

4 Application-Oriented Extension of the Proficiency Model

In this chapter we outline how we applied the DSR proficiencies in our DSR instantiation for developing TELE. As described in Sect. 3, the central DSR artifact are collaboration scripts which represent a digital component of our TELE. This chapter is structured according to the PM [15]. Consequently, each proficiency is first described (*D*). After that, we outline our *application* (*AP*) of each DSR proficiency along with a brief evaluation of our approach through *argumentation* (*AG*). We then derive the *guidelines* (*G*) on how to apply the DSR proficiencies for creating innovative TELE.

P 1: Representing the Problem Space

(*D*): DSR projects aim to address practical issues and achieve tangible results in real-life scenarios. The initial skill for DSR projects is the ability to clearly define and outline a manageable problem space for their project [15]. To apply P1 and identify a relevant real-world problem, we initially reflected on real learning experiences in our higher education environment. This includes our own impressions, but also communication with students to reveal existing learning problems from their perspective. In our DSR instantiation, we as lecturers identified the problem of dysfunction in student group learning tasks, which led to some groups with good task solutions, while other groups had poor solutions or no solutions at all. When we talked to the students, they explained this in terms of uneven student participation in the group tasks, which led to a decrease in motivation and frustration. (*AG*): This experience-based process of identifying the problem space enabled us to later address a relevant problem for our target group. This is also supported by the evaluation of our DSR instantiation, where 17 (out of 21) students highlighted that they especially enjoyed the interaction within their group through our prototype. Thus, we conclude:

G1: Reflect on your own teaching experiences with regard to problems that arise.

G2: Build your DSR project around your students' experiences and needs.

(AP): Besides the experience-based approach to apply P1, we reviewed literature to expand our knowledge of the real-world scenario. (AG): Regarding our real-world problem, we identified more literature that highlighted the resulting challenges of ineffective student group work, along with other literature that emphasized the importance of effective student group work. Thus, the literature review was able to further strengthen our intention to target the experience-based identified problem space. The results are as follows:

G3: Review literature regarding your students' experiences and demands.

(AP): In addition to the experience-based identification of the target problem and its validation through the literature, it is important for innovative TELE approaches in higher education to take predefined environmental parameters into account. This includes the consideration of defined pedagogical demands, such as curricula, form of examination, as well as technical boundaries, such as the available IT infrastructure, in order to further characterize and define the problem space. (AG): In our instantiation it was important to consider the familiar technological infrastructure of our students. Thus, we aimed for an LMS plug-in in the second prototype. The results of the prototype evaluation showed that the students appreciated the familiar TELE. This leads to:

G4: Consider pedagogical aims and technological infrastructure.

P 2: Capturing Existent Knowledge in the Solution Space

(D): To ensure the rigor of DSR, it is essential to examine the existing knowledge in the field of DSR. This involves exploring existing solutions to identify potential technology solutions or approaches. Here, the main challenge is to gather relevant information from both technical and scientific sources to effectively carry out the DSR project [15].

(AP): We applied P2 through a literature search towards effective solutions targeting the real-world problem. We identified that in the field of pedagogical psychology, collaboration scripts are considered as a valuable tool to support students' learning and effective cooperation in TELE. To quickly get a state-of-the-art overview, we focused primarily on meta-studies and literature reviews. Using the literature on collaboration scripts, we were able to learn about typical structures of collaboration scripts and methods for conveying collaboration scripts to students [37]. Besides, meta studies have demonstrated the success of student cooperation using collaboration scripts, also in IS related courses. (AG): This provided structure and an evidence-based approach towards addressing our identified real world-problem. Our evaluation supports this procedure as the results regarding students' learning and motivation are also in line with existing research (Tables 2 and 3). Consequently, we suggest:

G5: Build the initial prototype on state-of-the-art research.

(AP): Once we decided to use the knowledge base of collaboration scripts to design the learning materials, we searched for existing solutions to implement them. However, we could not find a technical tool in our learning environment that could do this. Therefore, we decided to create our first prototype as a PDF version. For the second version we

decided to build on the existing LMS and design a plug-in. (AG): Building on existing artifacts can save a lot of time and resources. By looking at the existing LMS and its implemented features, we were able to save resources, for example, the functionality to create learning groups for collaboration scripts is already built into the LMS, saving time in developing other needed features. Therefore, we suggest:

G6: Consider existing technical innovations before developing new ones.

(AP): Developing new tools is time-consuming and personal resources are often scarce. Thus, we decided to join a cross-faculty project and outsourced the programming of our plug-in to external professionals. Although, the project management could be also time-consuming, usually common problems are addressed rapidly from the project members (crowd knowledge). (AG): This will help to avoid major pitfalls and may result in a more mature software prototype in the end, that could not only be used by the lecturers, but other interested educators and institutions. Thus, we recommend:

G7: Consider teaming up with partners with similar pedagogical aims.

P 3: Controlling the Design Science Research Process

(D): To be successful in a DSR project, careful research management and a sharp focus on evolving problems and solutions are crucial. DSR projects prioritize adaptable learning through systematic, step-by-step exploration, which is especially valuable in unpredictable and dynamic problem scenarios. DSR teams initiate iterative cycles to construct and refine their solutions with precision, and they may also identify and elaborate on relevant design theories after reflecting on their project outcomes [15]. (AP): To apply P3, we made a schedule for our DSR project. Starting with the lecture unit in which we intend to demonstrate the prototype, we planned backwards in time. We defined several time frames considering individual DSR steps, time buffers for revisions, as well as important deadlines such as the demonstration of the prototype. With the time buffers we considered enough time for low-barrier functional tests of our artifact with student assistants. (AG): This allowed us to identify problems or challenges at an early stage and to quickly remove significant errors: E.g., within one early test, the group task structured through the collaboration script needed to be interrupted due to unclear task descriptions. Through these early and low-barrier tests we could eliminate crucial “showstoppers” that could negatively affect students’ learning experiences, before the demonstration and evaluation phase begins. Therefore, we suggest:

G8: Create a time plan that includes deadlines, time buffers and early, low-barrier tests of the DSR artifact.

P 4: Building Innovative Design Artifacts

(D): After mastering the initial three proficiencies in a DSR project, the creative phase begins, which involves the development of innovative design artifacts. This phase focuses on generating new ideas and making educated choices about the most suitable idea for implementation. Creativity serves as the foundation for innovation, which is defined as the process of generating ideas that are both original and practical [15]. (AP): Based

on our initial testing, we applied P4 starting with an error-free but simple prototype. In our example, we formulated an initial prototype in a text program and shared it with the students as PDF files. This way, we did not have to make massive changes to the students' learning environment. However, the PDFs already allowed students to experience the use of collaboration scripts by structuring a group task with phases and prompts as they would in the final prototype. (AG): This is depicted in the evaluation of the first design cycle: While we presented a rapid prototype, student assessed their learning experiences at high levels (Table 2). Consequently, we suggest:

G9: Start with a minimal version of a quickly developed, but functional prototype.

P 5: Measuring the Satisfaction of Research Goals with Rigorous Evaluation

(D): Comprehensive evaluation methods establish connections between solutions (within the solution space) and problems (within the problem space), offering proof of how effectively a solution addresses a problem through the chosen evaluation techniques. In the context of DSR, we can distinguish between formative and summative evaluations, each serving a distinct conceptual purpose [15]. (AP): To apply P5, we presented the first prototype to our students at the beginning of the semester. After the demonstration, we measured students' experiences of the prototype to enable further evidence-based improvements of the prototype. We also mentioned that students would benefit from their constructive feedback as we consider their suggestions for the next version of the prototype which they may use at the end of the semesters. (AG): In this way, the students seemed to be open to feedback, as they appear as "co-developers". This is reflected in the high response rate within our evaluations. Thus, we conclude:

G10: Present the initial prototype at the beginning of the semester.

G11: Enable students to take the role of "co-developers".

(AP): We applied P5 considering the rigorous evaluation by integrating existing questionnaires. We used a survey tool for students to provide anonymous feedback using quantitative and qualitative items. (AG): This allows for insights at different levels and feedback that might not be covered elsewhere. The use of rigorous questionnaires also allows a rigorous knowledge transfer. Besides, qualitative questions allow students to provide further feedback. In the educational setting, it is also important to consider time constraints. The evaluation should be a small additional element and not take up much time outside of the lecture. In addition, lecturers should consider that students may be more open to critical feedback when it is anonymous. In our evaluation of the prototype, the quantitative evaluation indicated the value of the prototype, while the qualitative statements gave us ideas for improvements (Tables 2 and 3). Thus, we suggest:

G12: Survey rigorous quantitative and qualitative items.

G13: Consider the time constraints and the option for anonymous feedback.

(AP): While the written evaluation provides anonymous feedback, students seem to be more vocal when speaking. In addition, lecturers can ask if some feedback statements are unclear and thereby consider these aspects in the future. (AG): We noticed that students were happy to talk about their experiences and that students' verbal responses

were more detailed and revealed more information than their written responses. The communication with the students allowed us to clearly understand the written qualitative statements of the first evaluation. This is indicated by the results of the second evaluation, which suggest that the students also perceived an improvement in the second prototype as the previously negatively commented issues did not appear in the second evaluation. In addition, while in the first evaluation 16 (out of 21) students mentioned negative aspects of the prototype, in the second evaluation only 5 (out of 17) students had negative remarks. Thus, we conclude:

G14: Verbally ask students for feedback after interacting with the prototype.

P 6: Contributing to Science and Practice

(D): In a DSR project, the main goals are to contribute to both academic knowledge and practical solutions. These contributions typically take the form of design artifacts and design theory. This dual focus ensures that DSR projects have a meaningful impact in both the academic and practical fields [15]. (AP): To contribute to the problem spaces and apply P6, we share our iteratively developed learning materials as open educational resources. In our case, we share the collaboration scripts as open educational resources and the code for the LMS plug-in is open source, so that any university using the same LMS can use the plug-in [see Blinded]. (AG): This way, practical contribution could be used by other lectures teaching IS. As a result, we suggest:

G15: Share the practical contribution of the DSR project.

(AP): In addition, we consider conferences to be especially valuable in contributing to science. This allows lecturers to connect with other educators and researchers to learn from others, but also to inspire others on how to create meaningful TELE. Moreover, lecturers receive academic feedback, and thus, can ground further design cycles on a broader and more rigorous knowledge base. (AG): In our instantiation, we had the opportunity to discuss the first collaboration script (prototype 1) with other lecturers, which allowed us to improve our concept for prototype 2. Therefore, we conclude:

G16: Share the pragmatic and descriptive findings e.g., on conferences or symposia.

(AP): More mature DSR projects with a sufficient number of evaluation participants and a rigorous evaluation design can generate valuable insights, e.g., on user acceptance or learning processes, achievements, or learning outcomes while using technology. (AG): These findings can contribute to new theoretical insights into innovative TELE, not only for IS research, but also pedagogical psychology. This will lead to more guidance for developing meaningful theoretical background when designing further related approaches. Therefore, we suggest:

G17: Share and discuss the theoretical findings e.g., in journals.

5 Conclusion

This study aims to expand the body of DSR knowledge that contributes providing lecturers support in form of guidelines on how to instantiate DSR projects for innovative higher education teaching. Table 4 presents our derived guidelines for applying the six proficiencies for DSR in a concise manner.

Table 4. Application-oriented guidelines for DSR projects to design meaningful TELE

(P1) Representing the problem space [15]
G1: Reflect on your own teaching experiences with regard to problems that arise
G2: Build your DSR project around your students' experiences and needs
G3: Review literature regarding your students' experiences and demands
G4: Consider pedagogical aims and technological infrastructure
(P2) Capturing extant knowledge in the solution space [15]
G5: Base the initial prototype on state-of-the art research
G6: Consider technical innovations before developing new ones
G7: Consider teaming up with partners with similar pedagogical aims
(P3) Controlling the DSR process [15]
G8: Create a time plan that includes deadlines, time buffers and early, low-barrier tests of the DSR artifact
(P4) Building innovative design artifacts [15]
G9: Start with a minimal version of a quickly developed, but functional prototype
(P5) Measuring the satisfaction of research goals with rigorous evaluation [15]
G10: Present the initial prototype at the beginning of the semester
G11: Enable students to take the role of "co-developers"
G12: Survey rigorous quantitative and qualitative items
G13: Consider the time constraints and the option for anonymous feedback
G14: Verbally ask students for feedback after interacting with the prototype
(P6) Contributing to science and practice [15]
G15: Share the practical contribution of the DSR project
G16: Share the pragmatic and descriptive findings e.g., on conferences or symposia
G17: Share the theoretical findings e.g., in journals

These guidelines are derived by applying an existing DSR artifact, the PM, to a new context: While the model was originally developed to guide DSR teaching, we apply the model to facilitate DSR projects targeting TELE in higher education. To do so, we used the six defined proficiencies required to conduct DSR as templates and applied them in the course of a practical DSR project that aims towards designing learning materials for an IS

lecture. In chronological order, we describe the six defined proficiencies and show how we applied each of the six proficiencies in our concrete DSR project. Thus, we expand the proficiencies defined in the PM to construct a proficiency-centered presentation of applicable DSR knowledge in form of guidelines.

Expanding the PM as a framework with tangible guidelines derived from our experiences considers rigor and relevance of DSR. By implementing DSR for the design of TELE, we aim to demonstrate the tangible alignment of the PM addressing DSR teaching content with its application in real-world scenarios. In addition, the PM serves as a critical lens through which we analyze and extend DSR knowledge, highlighting the proficiencies and their application-oriented extensions that are essential for the successful implementation of DSR projects in higher education. This process therefore includes not only theoretical considerations, but also integrates insights from our practical DSR instantiation, thereby enriching the applicability and relevance of the PM.

Our intention to expand the PM to include the promotion of DSR projects in higher education is ultimately aimed at providing higher education institutions with a tool to promote innovation in higher education lectures. We understand the expansion as a valuable addition to DSR, as it can provide lecturers a tangible guidance on how to integrate DSR projects into their teaching. This allows lecturers to benefit in three ways: **1)** From an educational perspective, lecturers get orientation on how to instantiate DSR in their higher education teaching. **2)** Lecturers teaching DSR could gain broader experience and understanding in DSR activities. **3)** From an academic perspective, DSR practitioners could benefit from additional DSR projects in the educational context, as this could expand their usual research area and thus broaden their DSR applications.

6 Outlook

This article and the derived guidelines aim to inspire and guide lecturers who wish to innovate their higher education teaching while gaining DSR proficiencies. Thus, the guidelines can be considered a supporting resource that provides orientation but should not be understood as a normative corset to be strictly followed by higher education lecturers. Building on the PM, the guidelines offer heuristics based on a concrete DSR instantiation and the authors' experience in conducting DSR for iterative adaptation of teaching. As a result, the application-oriented extension of the PM has limitations. **1)** The proposed guidelines are based on concrete experiences in one IS course with two DSR cycles. However, while the guidelines are limited in their single application, they represent the essence of three lecturers involved in the DSR instantiation. **2)** When conducting evaluations with students about their experiences in a lecture, they might be afraid to evaluate the artifacts (in form of learning material) too critically, because they might fear negative consequences for their future learning experiences if they criticize their lecturer and his/her ideas too harshly. **3)** This article derives the extensions of the PM based on the explanation of the model and its application in a lecture. While our application-based extension of the PM is based on a real-world DSR instantiation, complementary evaluations and adaptations may be valuable to further evolve the guidelines. Expert interviews, user feedback, and further instantiations can complement this study and examine whether the seventeen formulated guidelines are understandable and useful

for lecturers aiming at TELE. To apply and further test our guidelines, we will integrate new DSR projects into our university teaching in the future. In the upcoming semester, we plan to address the real problem of the lack of student guidance in TELE. Here we propose a solution in the field of learning analytics. Following our guidelines, we will again start a simple prototype to investigate students' initial acceptance of the new concept within our teaching approach. Then, based on these findings, an iterative development of the learning analytics prototype will take place. In addition to an application-oriented evaluation, our proposed guidelines could also benefit from theoretical insights provided by related disciplines of the design-oriented educational community (e.g., design-based research [41]).

Overall, we highlight the value of DSR for designing TELE to iteratively adapt higher education teaching to the demands fostered by the learning environment and students. Thus, we encourage further approaches to use DSR to design TELE and understand higher education teaching as a DSR artifact that is iteratively adapted based on the demands of the changing environment and its stakeholders, especially students.

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