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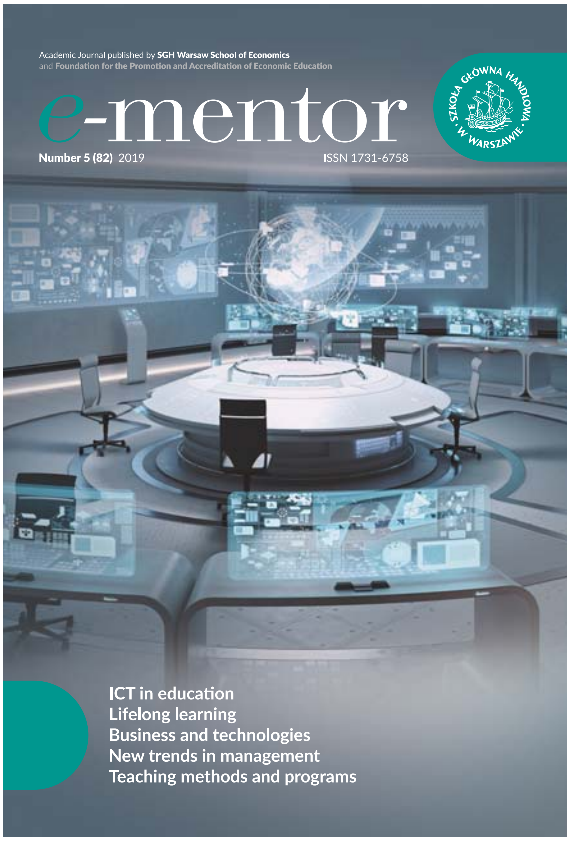

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Developing Scientific Work Practice in Business Informatics – Digital Support for Design Science-based Research Projects

Christian Stary*

Abstract

When academic students are introduced to scientific work, they need to become familiar with how to select a research topic, to identify research goals, and to structure a research project accordingly. In Business Informatics, research practice is increasingly following a design science approach. In this contribution, we introduce a corresponding digital support scheme. It is based on cognitive apprenticeship and scaffolding to specify the research questions and derive requirements from a problem statement for possible solutions. Learners are supported in a socio-cognitive way, as the set of digital learning-support features comprises peer-to-peer interactions, content co-construction, and a portfolio-like documentation scheme. Context-sensitive (focused) interaction and organizing group work facilitate content co-creation and effective information sharing. They support self-managed scientific skill development while being able to follow structured research procedures.

Keywords: scientific work, research practice, research proposal, design science, learning support, social interaction, self-managed learning, cognitive apprenticeship, scaffolding, learning management

Academic studies comprise skill development in scientific work practices. Scientific research, whether in the natural or social sciences, is a set of skills referring to a "continual process of rigorous reasoning supported by a dynamic interplay among methods, theories, and findings. It builds understandings in the form of models or theories that can be tested" (National Research Council, 2002, p. 2). When being introduced to scientific research work, students are guided by several principles. The first and crucial one is posing "significant questions that can be investigated empirically: moving from hunch to conceptualizing and specifying a worthwhile question is essential to scientific research. Questions are posed in an effort to fill a gap in existing knowledge or to seek new knowledge, to pursue the identification of the cause or causes of some phenomena, or to formally test a hypothesis." (ibid, p. 3) The questions lay the groundwork for study designs and should "reflect a solid understanding of the relevant theoretical, methodological, and empirical work that has come before." (ibid, p. 3)

Introduction

Research questions play a crucial role when setting up research proposals. These proposals contain several key elements, the most prominent being what research question is to be developed. Student guides characterize research questions through their usefulness in academic work, such as Zina O'Leary (2017, p. 83): "a well-articulated research question (or hypothesis) should define your investigation, set boundaries, provide direction and act as a frame of reference for assessing your work. Any committee reviewing your proposal will turn to your question in order to obtain an overall sense of your project." Other key elements of research proposals are how the research question will be studied, existing studies on the addressed question, effort in terms of time and costs to be spent (including evaluation of results), and the benefits for the involved or addressed stakeholders (Klopper, 2008; O'Leary, 2017).

Research questions are traditionally developed as part of the initial requirements for writing a seminar work or thesis. As such, they form the baseline and starting point for scientific inquiry. In the beginning, students may experience difficulties, both in terms of scoping and formulating a set of research objectives. This may require a substantial effort in re-adjusting their work and investigation results if the research question was not prepared in an informed way and documented coherently (cf. Klopper, 2008; Thomas, 2017).

In Business Informatics, the field from which this work originates, research questions address engineering as well as empirical, mostly management aspects

* Johannes Kepler University Linz, Austria

(cf. Laudon, K. C. & Laudon, J.-P., 2017). Hence, research in this field can be related to both the organizational and technological aspects. For instance, Business Process Management addresses the organization of human work while aiming to support stakeholders by technological means in accomplishing their tasks. When formulating research questions, students need to be aware of this duality, as research methods can be bound to different aspects.

A research question may then address both aspects, which need to be reflected in the selection of a suitable method for the study, e.g. beginning with a conceptual analysis of the human work in a certain domain through storytelling, followed by subject-oriented process specifications that can be executed, and finally completion by evaluating the effects of digitally supported processes on the KPIs in the affected technical domain. To pursue multiple perspectives and targets, research projects increasingly follow a 'design science' approach (Hevner, March, Park, & Ram, 2004; Hevner & Chatterjee, 2010). This is driven by a problem-oriented research question, and allows the handling of the respective requirements in a step-by-step procedure that also takes into account the relevant theories in an iterative way. In Business Informatics, design science facilitates a structured problem solution approach, since most questions require structuring the research in a multi-perspective and agile way (Wieringa, 2014).

This contribution is about the learning support for developing research capacities through design science cycles. It has its focus on structuring research objectives based on a research question, to create a problem description driven by interest and curiosity, and deriving the requirements for possible solutions. In section 2 we introduce the design science research approach and thus provide the methodological context for setting up a research agenda. We also introduce the educational means for specifying a problem-based research question and the requirements to be met by the solutions. In section 3 we discuss digital support features with respect to encoding scaffolds along a cognitive apprenticeship process. Section 4 provides the first insights into implementing the approach. Section 5 concludes the paper, summarizing its objectives and achievements, and sketching further research issues with respect to effective learner support.

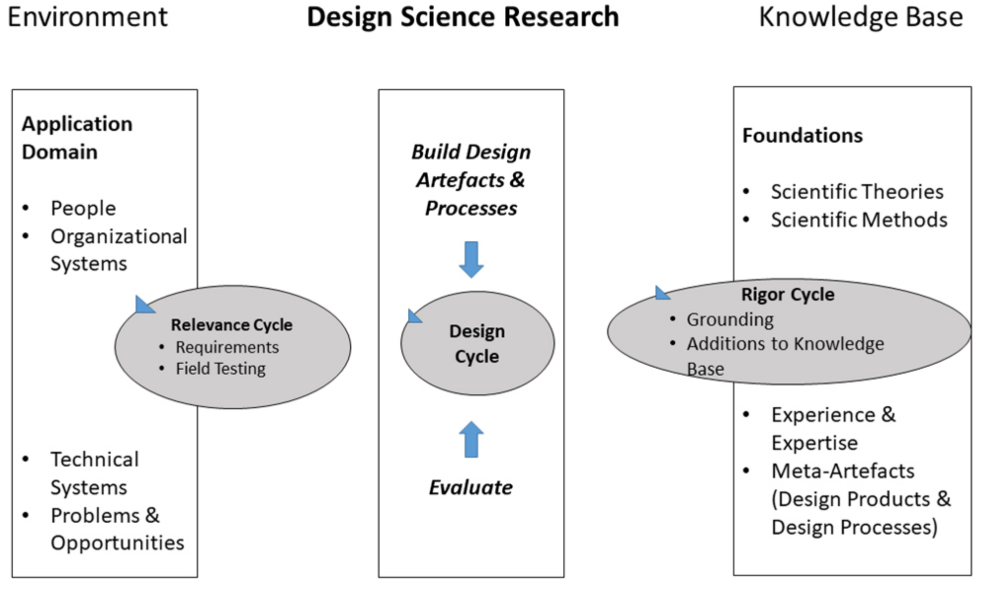
Methodological and Educational Foundation

In this section we provide design science support and educational means for introducing scientific work practice to students. We start out with design science as a methodological framework, before addressing the specification process of a research question, structuring the design cycles. We then introduce cognitive apprenticeship and scaffolding for learner support when building capacity in design science practice.

Objectives and requirements – organizing scientific work practice

Design Science has attracted significant attention over the past decade (cf. Hevner, 2007; Baskerville, Baiyere, Gregor, Hevner, & Rossi, 2018). Its dual while iterative and problem-driven nature with respect to design artifacts and design theory equally supports practical development and conceptual understanding. The Relevance Cycle (Figure 1) connects the environment of a research project with the core development activities. The Rigor Cycle relates these activities to a knowledge base informing the project. The Design Cycle iterates between the core development activities, i.e. building and evaluating artifacts.

Figure 1. Design cycles embodied in a pragmatic and methodological context



Source: Hevner, 2007.

The original format has been operationalized by Ken Peffers et al. (2006) allowing the framing of the research capacity construction stages as shown in Figure 2. In a research project, the learners are in control of the learning process while being guided by a facilitator or mentor. Learning activities are initiated by a research question that stems from individual interests in Business Informatics topics (cf. O'Leary, 2017). In the first step, while detailing the research question, the learners define the problem to be investigated and set the scope of the research project. The research project itself starts with a systematic refinement process intended to achieve a concrete goal, learning outcome(s), intervention and mediation activities in order to meet the objectives. This stage also addresses the competences. Knowing refers to having knowledge and fundamental understanding. Applying empowers the researcher in planning and producing an artefact by means of scientific research in an informed way. Innovating means novel developments through the use of Information System technologies.

In order to structure the activities in the project, a learning contract is negotiated between all the members of the project and those responsible for the project. This is documented and signed by all parties, with the learning outcomes also used to provide the basis for evaluating the research project results. A learning contract comprises the following.

– Research project organization: project name, duration, f2f-requirements, credits, contact, role(s) in the project, relation to other project groups or projects.
– Addressed level(s) of competence: 1 – Knowing, 2 – Applying, 3 – Innovating.
– Research objectives: includes the justification and desired competence level.
– Content-related activities: relates to the research activities in particular, search items and patterns, and resources (digital libraries, infrastructure, prototyping environment).

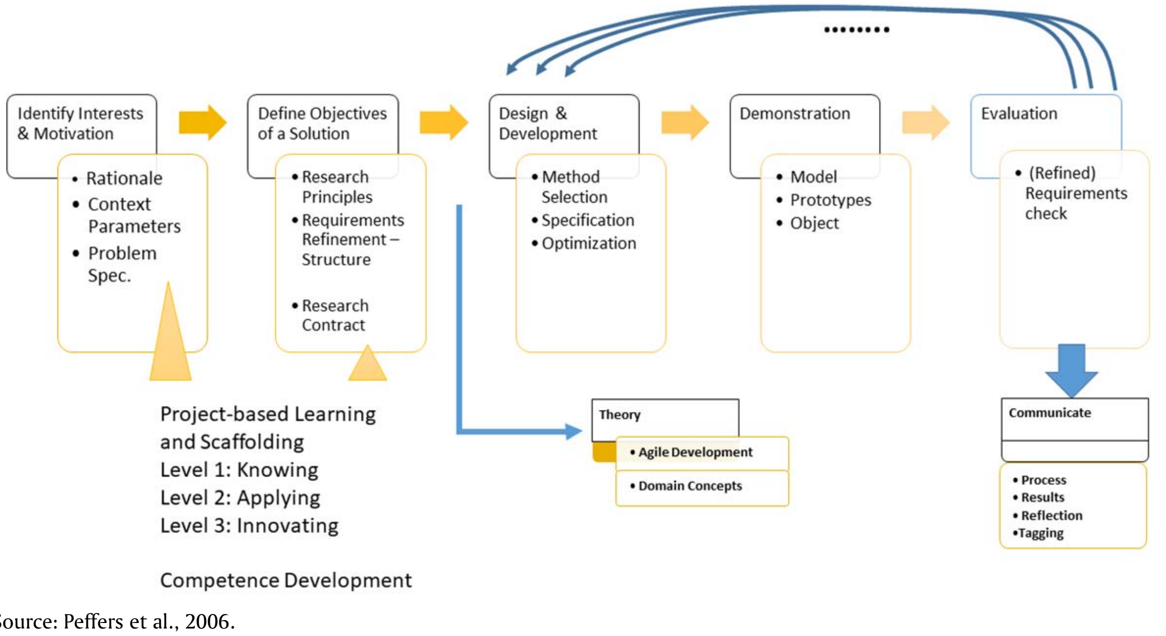
In Business Informatics, research problems are likely to be multi-dimensional. Consider the case of decision support for management in the course of digitizing business processes: social aspects may be affected when reorganizing work processes in terms of information system architectures, such as service-oriented computing, and technological ones, such as shifting operations from a legacy system to a service-based cloud infrastructure.

Design science allows the structuring of the problem-solving procedure along these dimensions. For the problem, the first iteration could include building a prototype from a process-perspective using S-BPM, applying the corresponding agile development concept (Fleischmann, Schmidt, & Stary, 2015). The second iteration could use the running processes to define the services, e.g. using Archimate (www.archimate.org). For both iterations, the initially identified requirements, namely, to achieve vertical and horizontal digital process integration, is evaluated using specific use cases.

The design cycle activities within a research project can be of various types.

– Working on content: this refers to developing the content that belongs to the research project at hand. This content should be available to learners at any time during their project, and thereafter for self-studies in the form of videos, multimedia documents, additional resources, and examples. Usually, content is studied in individual learning phases prior to the interaction phases. This is prepared by facilitators or peers for effective knowledge creation.

Figure 2. Design Science research procedure



Source: Peffers et al., 2006.

- Research Project Management: during their project work, all learners acquire competences in the planning, calculation, execution, and evaluation of research projects. The design science approach already pre-structures a project, including the design and evaluation iterations when working on a problem solution.
- Applying acquired content in the context of project work: here the learners work on their artefact. The learning contract and design science process provides some structure for evaluation and reflection. When support for research practice is required then a facilitator, mentor, or expert can be contacted in addition to peers.

The project work (i.e. problem-solving tasks) can be accomplished in various forms:

- Self-study: each learner acquaints themself with the relevant knowledge content for their concern. Content is prepared for learning support as well as created by learners in the course of their project work. Due to the direct relation to the research project, content is mainly recognized in its respective project context and can therefore be perceived sustainably.
- Peer-to-peer setting: the learners form part of communities they organize in order to collaboratively plan and design the implementation of research projects. The group affiliation, the bottom-up sense of community, and the responsibility of each individual for the success of the project work of the group increases the intrinsic motivation and thus the efficiency and sustainability of the learning process.
- Knowledge transfer: each project step should be documented in a sharable memory, in order to be communicated for further work and/or feedback. Communication is considered a dedicated step concluding a design science projects (see Figure 2).

Overall, the design science framework provides an iterative and procedural approach to organize scientific work based on an initially specified research question defined in terms of a structured problem description and requirements list for possible solutions. It allows the use of multiple work formats, both from the facilitator and learner perspective.

Scientific work practice – Specifying a research question

This section contains findings for setting up a research question while referring to the first two phases or elements of the Peffers et al. (2006) operational framework, as they are crucial for scientific skill development and introducing scientific work practice to learners. A research question has to be in line with learner interests, which should drive the development process. As such it needs to be viewed as a highly reflective and interactive process.

The initial step in capacity building on scientific work practice has a social dimension beyond the cognitive challenges. According to Rüdiger Jacob (1997, pp. 11–18), the choice and concretization of a topic in terms of a research question starts with recognizing some theory or concept framing the question to be examined. This step is essential because it influences the further course of the research process. While in academic research internships or seminars the (general) topic may be given, with promotions, the self-managed framing and formulation of a research question is usually mandatory. In both cases, however, the subsequent step is identical: the topic needs to be scoped and placed into some level of focus. For this purpose it is advisable to document everything in a working group (or even alone) by means of structured encoding, and then arrange it accordingly. For workgroups, a facilitator should ensure that discussions do not create confusion and that the contributions of all group participants are considered.

As the facilitator should not intervene content-wise in the discussion, the role should be concerned about traceable structuring inputs and agreements, e.g. using cards for detailing a topic according to various perspectives. Each card should detail exactly one idea, concept or thought. Such a procedure ensures that the ideas can be arranged and structured in a variety of ways, by assigning the inputs to different headings. It is recommended to make this process public, e.g. by putting it on a digital white board, as used with meta-plan elements leading to clusters of inputs.

The aim of this exercise is to develop a more concrete understanding of the subject area. It helps to scope the research question and to create a descriptor catalog for the search and viewing of problem-relevant information. It may help to look for central concepts related to the respective topic in relevant thesauri or scholarly works, in order to obtain a first overview of the topic. This first systematization of the topic is very likely not the last one, as it is based on more or less deep prior knowledge, assumptions and everyday hypotheses, and may need to be modified in the course of increasing knowledge about the respective topic and understanding of the research question (cf. Jacob, 1997; Lu & Mantei, 1991).

Even though learners likely need to leave their comfort zone to anticipate all the results of building their capacity, they need to be encouraged to keep a record of ideas, thoughts, and arguments – it enables them to experience working with raw information as a positive task. In addition, they can profit from the reduced cognitive load and further reflect on the documented information. Consequently, when a topic is edited, all the intermediate results and working papers should be archived or kept accessible for each community member (cf. Klopper, 2008; Navidi, Hassanzadeh, & Zolghadr Shojai, 2017).

A common repository created in the context of developing a research question could include keywords, bibliography, presentation material etc. as well as the date and the name of the editing person. Such shared documentation increases the liability of group work, and documents the progress of the work in a traceable way. In addition, when information is edited by a workgroup, the internal division of labor increases the productivity of the group. Nevertheless, each member of the group is accountable for the topic and should be informed on the state of affairs, results or problems. Formulating and specifying a research question is an iterative process, during which an initially very generally understood topic or idea is refined through various cycles. How these processes are designed highly depends on the way a learner is organized and committed (cf. Matzler, Renzl, Mooradian, von Krogh, & Mueller, 2011).

Content-wise, setting up a research question includes the (theoretical) frame of reference in which a problem should be understood and solved (Jakob, 1997). Its associated research goals can address exploratory research, where one is interested in the manifestation or distribution of certain characteristics. It could refer to the testing of hypotheses, i.e. whether a problem should be conceptually discussed using very specific theories, principles or lines of arguments. The research goals are always the result of a selection made from a variety of possible questions or potential strands of investigation.

This choice needs to be justified using the (theoretical) frame of reference. When referring to the natural sciences, the work traditionally aligns with confirmed, largely consensual theories, standard procedures and formalized models. Research in the socio-technical, social, and economic sciences are much more theory-based and method-dependent, as in many case there is a special relationship between the researcher and their research topic. Researchers themselves could be an element of the examined object area (as IT user, consumer, citizen, etc.). Moreover, research referring to the social sciences unintentionally changes its subject matter to a greater extent than in the natural sciences. In order to better assess such effects, the process as well as the results of the investigation needs to be the focus of interest.

The frame of reference also captures the background of the assumptions and hypotheses to interpret the (empirical) results, according to the selected methodological design. This design together with the preliminary data (supporting the research claims or hypothesis) form the basis for the work plan, which needs to be structured according to the research objectives and goals. If expertise is required to justify the method design, work packages, deliverables, and milestones, then respective checking of the initial version of the research question and its underlying frame of reference is advised before starting work. It needs to become part of the learning contract, which can be considered a milestone in the Peffers et al. (2006) framework.

Means of support – Cognitive apprenticeship and scaffolding

This section examines the findings with respect to effective educational means while implementing the design science approach, namely that cognitive apprenticeship and scaffolding are introduced when building capacity in scientific work practice, in particular when specifying a research question.

Cognitive apprenticeship is already an effective means of introducing scientific work to learners. In particular, it creates opportunities to engage learners in scientific practices and motivate them to continue in scientific work (Thompson, Pastorino, Lee, & Lipton, 2016). According to Allan Collins (1991; Collins, Brown, & Newman, 1989; Collins, Brown, & Holum, 1991) it should incorporate several steps:

1. *Modeling*: the presentation of a (handicraft) product with subsequent assignment or presentation of guiding information, e.g. text.
2. *Coaching*: guidance and supervision in the execution of the task.
3. *Scaffolding*: support for the learners by expert(s) in individual steps and withdrawal of the expert from the process ("fading"), adapted to the respective learning situation; support is provided by situating and contextualizing the subject to be acquired.
4. *Articulation*: practicing the learned skills and abilities in various situations and under changed conditions.
5. *Reflection*: comparison and review of the solutions, products, and learner results, including feedback from experts.
6. *Exploration*: autonomous transfer of the learned in new situations and contexts. The acquired knowledge is abstracted adequately that it can be transferred and used without the further assistance of an expert – the learner has become an expert.

Cognitive apprenticeship helps to structure the learning procedures by triggering construction processes, e.g. as language concept comprehension (cf. Gibbons, 2002). Scaffolding works through framing knowledge or information utterance, which is then dismantled once the learners have successfully accomplished the learning tasks or achieved specific learning steps. It can be applied to facilitate individual learner processes as well as group learning. The facilitator plays a crucial role in framing and dismantling the content for the learner.

The facilitator needs to be able to switch between the technical and learner perspective, e.g. being knowledgeable in Business Process Management and guide learners to become knowledgeable in related concepts and methods. Although at a first glance such a process might look like arbitrary flip-flopping, it has an inherent structure:

- The dual role of the facilitator requires the application of one specific role at a time when being approached by a learner with a certain level of knowledge competence.
  - When approached by a learner with little or no knowledge in the subject at hand, one behavior pattern is applied.
  - For learners who are familiar with specific concepts the facilitator activates an informed pattern. Depending on the competence level, the facilitator can introduce new concepts and content to qualify a learner for the next level.

– The facilitator even abandons peer-to-peer interaction, once the basic inputs can be processed by the learner ('fading'). Hence, even the control of the learning process can switch between learner and facilitator or coach.

In setting up research questions we can learn from Gibbon's experience in language learning, since structuring the wording to express situation-sensitive information is also an essential task in research. Hence, the levels of bilingual scaffolding can be regarded as examples for learning to be articulated in scientific work practice. It can be summarized as follows:

1. *Listening* in the language chosen by the learner – the facilitator resonates in the way learners are able to express their knowledge.
2. *Understand* using the language chosen by the learner – the facilitator is capable of constructing feedback and input for further learning tasks in a way the learners are able to understand, as it is constructed in the same way.
3. *Transferring* the learning to the language production of the respective target language – the facilitator introduces the language structure and relevant expression types used in academic discourse. They practice collaboratively until the learners are able to utilize both the structure and the expression types of verbal scientific articulation.
4. *Building up* scientific articulation support as scaffolding – the facilitator provides scaffolds to enable capacity building for research-practice skill development through scientific language expressions.
5. *Marking* the end of facilitation and thus the interaction situation, by reflecting on the process so far and indicating the completeness of task accomplishment.

According to this approach, design science targeted scientific work practice needs to be separated from the learner language capabilities so far – a process that could be termed systematic and criteria-based code-switching, which takes into the account the opportunities and capabilities of the targeted learners at their current stage of development. In this way, learners in academic work practice can be guided continuously to an academic form of articulation that uses each of the strengths of one language to build the other.

Based on these findings the suggested scaffolding scheme is composed of several parts. They can be used as a sequence or when needed. As shown in the table the scaffolds refer to:

– the existing situation, representing the frame of reference scoping the planned research;
– problems that needs to be solved, or the potential that is recognized in the situation at hand which has been observed and could be used to change the existing situation;
– future scenarios (or learning outcomes) once changes have been implemented in solving the problem or exploring the potential.

The existing situation (scaffold I) is described as:

– representing the frame of reference scoping the planned research,
– a setting for starting the research activities.

For instance, a research question concerning process management can refer to Knowledge Management and Systems Thinking (cf. Senge, 1990) as contextual ways of dealing with knowledge, ranging from elicitation to processing. The corresponding description of the situation is: "Business Process Management can profit from Knowledge Management and Systems Thinking, as it allows the contextual acquisition, representation, and processing of knowledge." This statement can be made when the existing studies refer to successful intertwining of Business Process Management with Systems Thinking and Knowledge Management methods. It sets the frame of reference by addressing the integrating perspective on the fundamental techniques of Knowledge Management (cf. Dalkir, 2013) with Systems Thinking. This perspective also corresponds to the starting point of research activities in this case.

The problem or potential (scaffold II) is described through the following items:

– problematic elements or behavior patterns that are subject to change,
– enablers that could trigger the change process.

Table 1. Scaffolds for setting up a research question

Scaffold	Scaffold Item	Scaffold Example
I – Describe the Existing Situation	Setting the frame of reference Starting point of research	Business Process Management can profit from Knowledge Management and Systems Thinking, as it allows contextual acquisition, representation, and processing of process knowledge.
II – Formulate the Problem or Potential	Problematic elements or behavior Potential change carriers	How do existing approaches to knowledge elicitation enforce Systems Thinking?
III – Capture the Envisioned Situation	Result parameters Change of quality	An informed setting of elicitation facilitates project design.
IV – Label your Project	Self-explanatory and appealing identifier	Contextual Process Knowledge Elicitation

Source: author's own work.

For the sample case involving Knowledge Management and Systems Thinking the potential is expressed in the core question: "How do existing approaches to knowledge elicitation enforce Systems Thinking?" The focus is applied to one of the traditional starting points in Business Process Management projects, namely the acquisition of knowledge. It addresses the already mentioned integrative capacity by issuing the enforcement of integrating Systems Thinking into the process of knowledge elicitation from business processes.

The envisioned situation (scaffold III) is described including:

- parameters manifesting the results of the research,
- qualities that are addressed through change.

Hence, the envisioned scenario addresses changes when being implemented after having explored some potential or solved a problem. In our sample case, the effect is described by "An informed setting of elicitation facilitates project design." It leaves open the way in which context can be represented, since it refers to the knowledge elicitation setting rather than the methods used. It addresses qualities and result parameters only indirectly, namely through the terms 'informed' and 'facilitates'. When formulating this part of the research question in this way, it is not yet clear which qualities are addressed (for project designs) in what way (allowing result parameters to be specified). This will be clarified when performing the actual research.

Finally, the research question should refer to a project that has a self-explanatory and appealing identifier (scaffold IV). The provided example "Contextual Process Knowledge Elicitation" indicates the quest for eliciting knowledge on processes while recognizing their context.

Each of the scaffolds can be used following the cognitive apprenticeship procedure proposed by Collins:

1. *Modeling*: the facilitator presents a sample piece of research, e.g. a paper about method appropriation in knowledge management with the subsequent assignment and presentation of how to set up a research question.
2. *Coaching*: the facilitator considers whether the learners need guidance and supervision while working on their learning task.
3. *Scaffolding*: the facilitator identifies which step of the setup process a learner is working on and decides whether to intervene with a scaffold. In terms of the scaffolding, the facilitator has to decide whether to select:
   a) the entire set of scaffolding (I–IV), e.g. to trigger the description of an existing situation if a learner does not know where to start;
   b) one of scaffolds I–III, depending on the status of the work, in order to address a specific part of the research question;
   c) two adjacent scaffolds (I & II or II & III), depending on the status of the work, in order to clarify the interplay between specific parts of a research question.

   After accompanying individual steps through one or more scaffolds, the facilitator elects to withdraw from the process ('fading'), depending on the respective learning situation.
4. *Articulation*: the learner starts practicing the learned skills and abilities in different situations and under changed conditions, e.g. addressing problem solving instead of potential exploration.
5. *Reflection*: the facilitator supports the learner's comparison and review of achievements and provides methodological feedback.
6. *Exploration*: the learner transfers the acquired knowledge into new research situations and contexts autonomously. It needs to be abstracted by the learner so that it can be applied without requiring the guidance of the facilitator.

From these findings we can conclude that social interaction between the learners and the facilitator, peers, and experts needs to be considered an essential part of the learning support processes, and can be framed by educational interventions as suggested above. Hence, the various threads of interactions need to accompany dynamic content management when providing proper digital learning support.

Digital Learning Support

In this section we discuss the technological means supporting cognitive apprenticeship, including scaffolding, when learners are introduced to scientific work practices utilizing the design science approach, and are asked to come up with a valid research question. In the first subsection, we address the respective process support through digital learning features. This is followed by a practical demonstration of how learners can co-create content when asked to set up a research question. We use the experiences from developing the UeberLearn learning support system (Stary & Wachholder, 2016a, 2016b).

For experimenting with digital learning support technology, any system providing dynamic (hypermedia) content management can be used, as long as social interaction forms an inherent part of it or is directly coupled with the content management features. The reason for the coupling, either through respective tagging mechanisms or system architecture, is that the content for the baseline emerges as part of the interactions that occur throughout the learning processes.

Process

When beginning, research students need to answer the question: What is the problem or opportunity they would like to address? As research is a logical endeavor, becoming acquainted with scientific work practices is a synthesis of an introduction to a field and known literature or existing knowledge. As discussed in the previous section, setting up a research question should contain an introduction in itself, including a description of the situation. The addressed problem or potential needs to be specific to recognize that it is worthy of focus or consideration.

The target should focus on the subject of concern and demonstrate what should be changed and in which way. The latter particularly refers to "how" questions like "How could project designs in Knowledge Management change when enforcing Systems Thinking for knowledge elicitation?" These questions either address particular activities, such as designing Knowledge Management projects, or a set of relations, such as interfacing Knowledge Management elicitation with Systems Thinking. In the following we detail the process from a learner's perspective, and assign socio-cognitive support features, including scaffolding.

As shown in Figure 3, the learner's perspective can be decomposed into several phases:

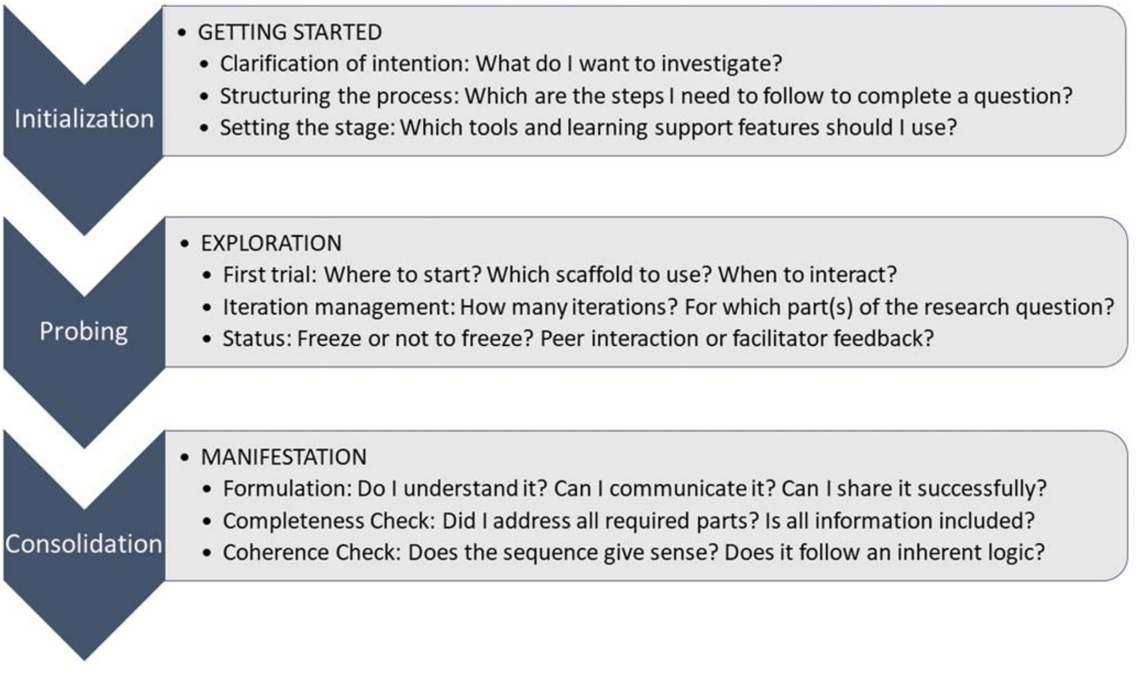
– The *initialization* phase comprises all activities required to begin formulating a research question.
– The *probing* phase comprises all activities to arrive at a valid solution.
– The *consolidation* phase contains all results to be delivered for setting up the research question.

The questions listed in Figure 3 have been collected from facilitators and students of a course in scientific work practice, through storytelling and qualitative content analysis over two terms in 2018/2019. The course addressed scientific topics in Business Engineering and Management and was part of the Business Informatics master curriculum at the Johannes Kepler University of Linz. Learners are supposed to build scientific capacity in particular, by setting up valid research questions. The course is fundamental as it prepares the Business Informatics students from a methodological perspective for their final master thesis.

The collected data illustrate actual concerns which academic learners confront when asked to specify a valid research question, e.g. before starting an in-depth literature search and excerpting information from scientific material. In Figure 4, (digital) learning support features have been assigned to each of the phases and their activities – see on the right. They will be exemplified in the subsequent sections and represent a minimal set of tools that can be used, through the various learning phases:

– *Note taking*: this feature allows information to be collected and stored for further processing in a structured way. This feature is particularly useful for getting learners started.
– *Content generation*: this enables content creation, e.g. writing a first version of the research question, either to be probed or delivered as the result of an assignment.
– *Interaction*: this feature allows communication threads to be started and followed, in order to clarify issues, to give feedback, or simply to ask questions (similar to Slack.com).
– *Share content*: once content has been created, it can be shared. In the course of the interactions the users and user groups can be selected. In the course of defining it as a baseline for further work, it becomes part of the learning content.

Figure 3. Learner Process Design for Setting up a Research Question



Source: author's own work.

- *Scaffolding*: this feature allows facilitators to make structured interventions when guiding students toward accomplishing the next learning step or assignment task.

As we shall see, from the user-interface perspective the features for notetaking, interaction, and sharing of content have been aligned to facilitate interaction with other learners and the facilitator. The same holds for content generation and scaffolding, as they address domain-specific structures and allow metadata management to be streamlined. In this way, both the usability and user experience can be influenced towards high user acceptance.

Features

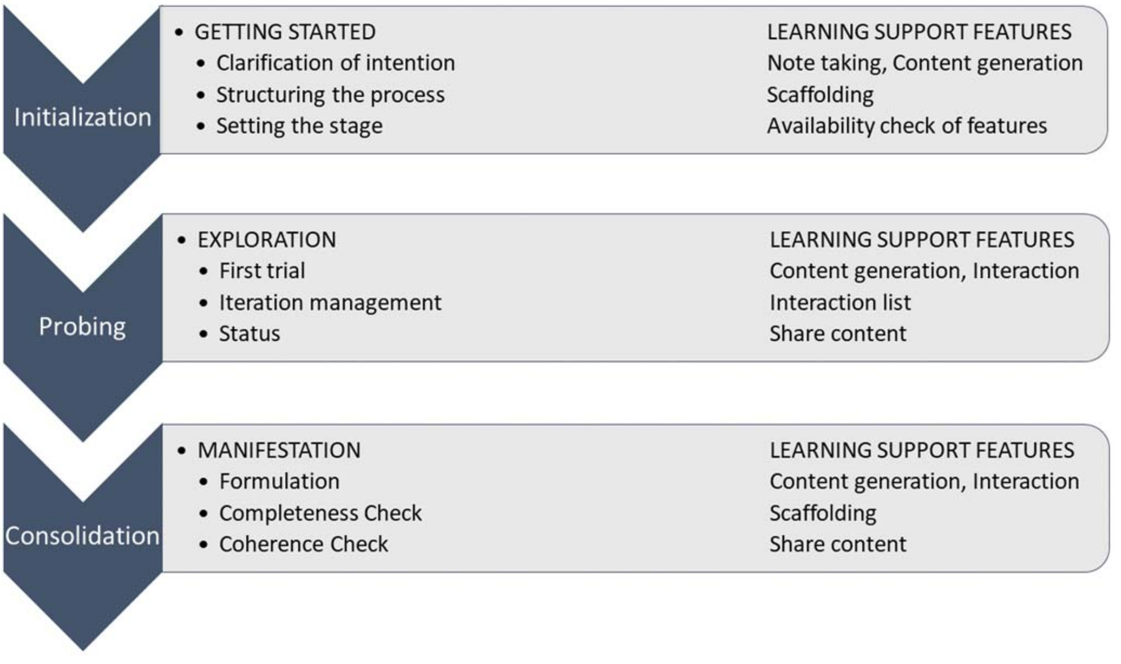
In this section we examine cognitive apprenticeship while using an existing digital learning support system for individual and group learning processes. It allows not only cognitive aspects to be addressed, e.g. through tagging learning content and knowledge to be acquired, but also social interaction among the participants of the learning processes. Moreover, the platform links the cognitive support features (referring to content and metadata management) directly to the social interactions. The latter allows socially generated content elements to propagate from interaction features to content management.

The user interface design of the learning support system is kept minimal to focus on documenting the flow of learning processes while providing relevant content. In the upper right corner, the icons from left to right indicate the main functional areas: note taking and interaction (social medium), study content (learning management), group management (allowing individual groups to be set up), and basic settings (to individualize the features).

The entry point is a notepad (see center part of Figure 5). It can be understood as an individual notepad, but it can also be used as part of a social medium such as a blog or forum since it forms part of a content repository. Each element of the notepad can be propagated into a group discussion (Figure 6) or into the content of a learning unit or course (Figure 7). Hence, this feature can be used whenever learners or facilitators want to keep something in mind, to ask a question, to start a discussion, to create preliminary content, or to start scaffolding. Learners use it for preserving ideas and inputs received from facilitators, peers, and experts. When setting up a research question, each step, such as Probing, can be mapped to a dedicated thread of notes. These are termed interactions, since they are also supposed to become part of the discussions and feedback cycles.

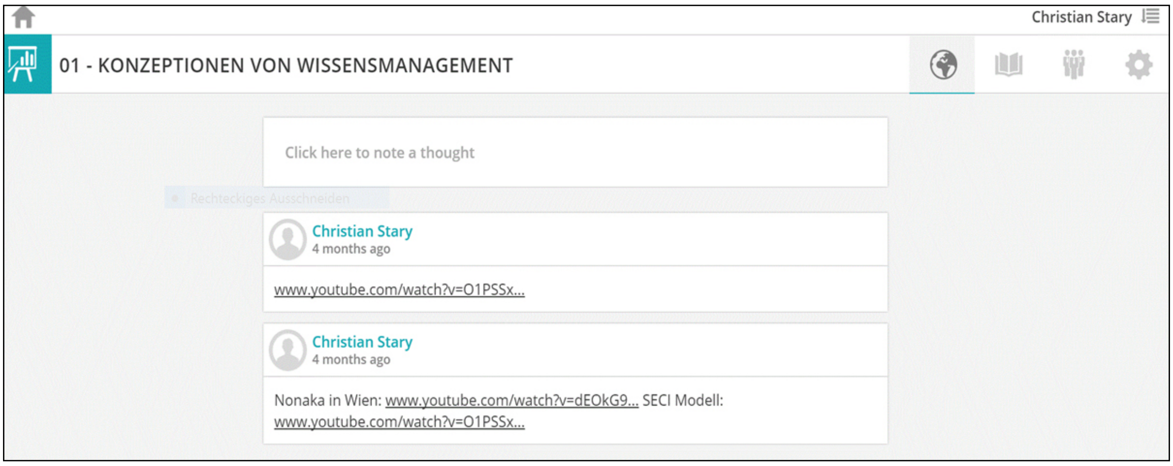
Figure 6 shows a private note example with a list of interactions on the left hand side that can be accessed by the current user as the other users have set them public. Accordingly, the user can switch between their own private notes and public ones. On the right hand side in Figure 6, contacts can be displayed if the current user decides to set a private note public. The current user can select from a list of individual users or user groups, depending on the configuration of the platform and the assigned user privileges. In this way, learners are in control of allowing others to join a conversation on a certain communication thread, such as when preparing a research question.

Figure 4. (Digital) Learning Support for Setting up a Research Question



Source: author's own work.

Figure 5. Notetaking for social interaction and content generation



Source: author's own work.

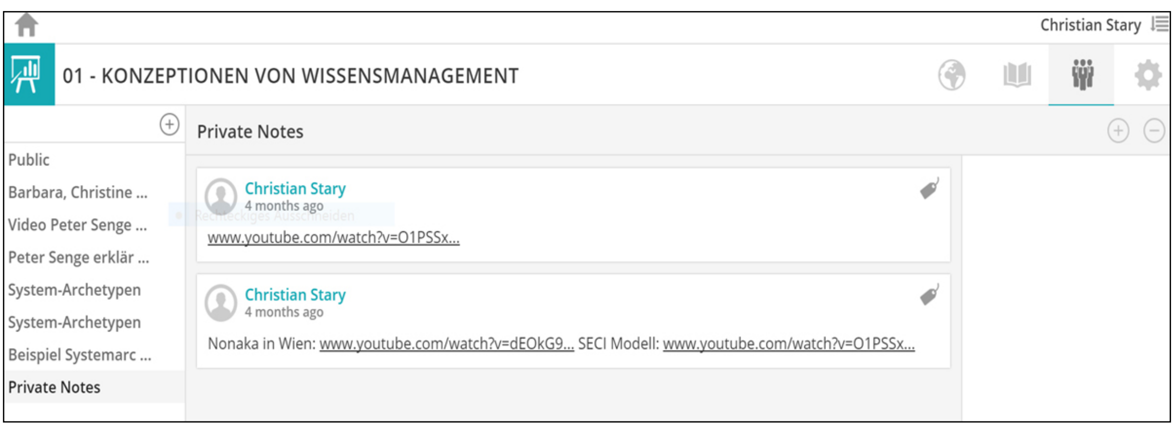
The individual handling of interactions is particularly helpful when a learner seeks input from selected peers, as these can be picked from the list of contacts, depending on the (informal) network of the student. The list can be modified at any time, either to enlarge the visibility of interactions, e.g. when a specific thread should be used by additional users, or to restrict access, e.g. when the student has collected all the information required to proceed with their individual task accomplishment.

When using scaffolds along interactions, the learners should not recognize their origin as they can be phased in by the facilitators to guide the learner, and direct the next learning step. The flow of interactions should maintained, and thus not include switching to different threads of interactions or the content management parts of the learning support system. Material, scaffolds, and other (domain) inputs can be edited or imported in a structured way into the learning support system, and are provided to learners when the facilitator decides.

Note taking is one of the features that have been designed for the aligned individual and joint creation of knowledge. As shown on the left-hand side in Figure 7, content can either be Documents, Resources, or Collected Content. Documents contain tagged content elements, i.e. domain-specific or educationally relevant blocks of information such as background information, scaffolds, examples, explanations, code snippets, and frameworks. Resources are any type of material that can be downloaded for further use, e.g. textbooks, case studies, standard specifications, and assignments. Finally, Collected Content contains material that has been generated dynamically and set public for further use, e.g. intermediate results, completed scaffolds, and additional examples.

Utilizing this 3-part structure in a learning support system enables facilitators to generate and offer self-contained material as part of Resources, e.g. scientific papers that learners need to read and work with. It further enables the pre-structuring of the content that learners generate, such as the research question or, later, the project proposal. It helps learners to follow a certain structure when organizing their data and results. The Documents part also enables facilitators and experts to provide content snippets and tag them,

Figure 6. Private interactions can be set public



Source: author's own work.

e.g. defining a research question, or exemplifying the requirements for a solution to a research question. Hence, this part serves as an interactive portfolio and scaffold repository.

For intermediate results and items to be discussed, e.g. when selecting a specific item from various sources, the Collected Content part offers a kind of clipboard functionality. Items can be moved from there to Documents, and thus become "finalized" for further processing. This feature is of crucial importance when learners collaborate with peers and need to conclude on some results to reach a milestone in a research project, in particular completing the research questions (through Manifestation).

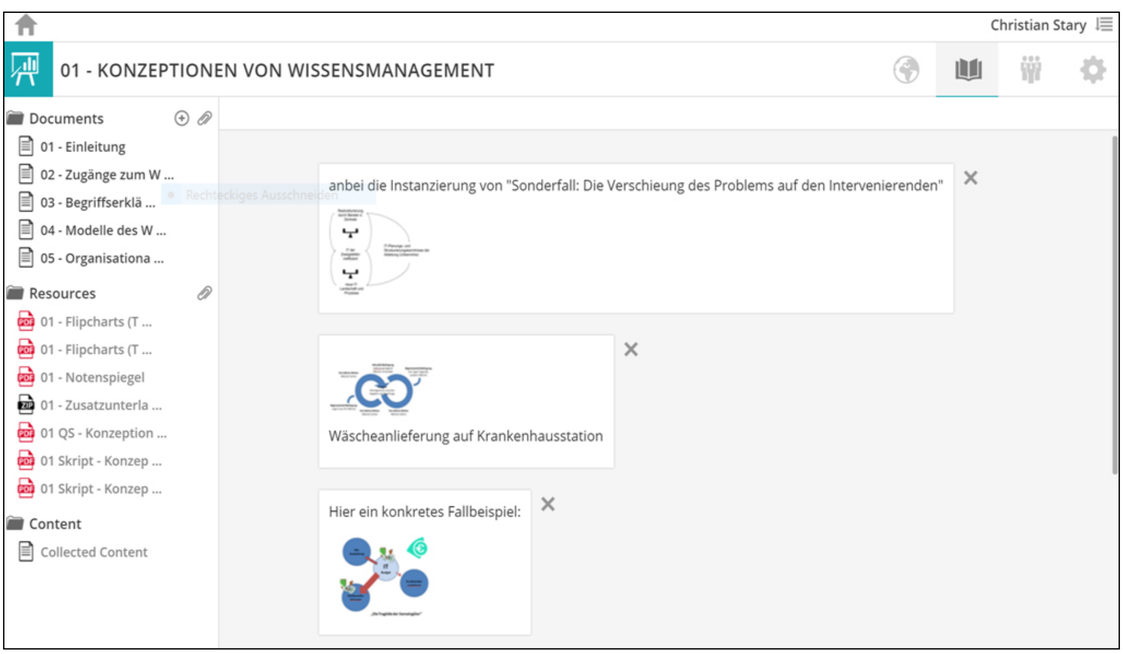
The workspace in Figure 7 shows Collected Content with examples of emerging content as part of the sample case intertwining Knowledge Management and Systems Thinking, in order to understand contextual inquiry in Business Process Management. After providing scaffold I in the Document part, students have explored Systems Thinking and created use cases, such as a causal chain diagram according to Senge (1990) in the middle for stationary healthcare. The facilitator released them as illustrative material for all learners. In this way, learners can learn from other use cases and find out whether they have understood the concept of Systems Thinking. The facilitator ensured the correctness of the Collected Content.

Overall, cognitive apprenticeship with scaffolding can be supported as follows:

1. *Modeling*: products with subsequent assignments, presentations of guiding information can be part of Documents, as they have educational value and need to be tagged. Additional material can be provided as part of Resources.
2. *Coaching*: guidance and supervision in the execution of the task can be provided by private peer-to-peer or public interactions, varying from 1:1 interactions to group discussions. However, students have control on setting information public or working privately.
3. *Scaffolding*: both the provision of scaffolds by facilitators or expert(s) in individual steps and the withdrawal of the facilitator/expert from the process ('fading'), depending on the respective learning situation, can be triggered by composing interactions. A link to Documents or direct inclusion into interactions gives access to scaffolds for students when needed.
4. *Articulation*: practicing the learned skills and abilities in varied situations and under changed conditions can be provided through additional assignments provided in Documents.
5. *Reflection*: comparing and reviewing of solutions, products, and learner results, as well as feedback from experts, can be provided at any point in time. It depends on the learner making information public through interactions.
6. *Exploration*: the autonomous transfer of the learned in new situations and contexts can happen at any point in time. When the learner has become an expert, the privileges are transferred from experts or the facilitator to the learner. Then content in terms of Documents and Resources, as well as Collected Content, can be published at any time.

The facilitator can take private notes when following the public interactions, in order to intervene on a social level through plain interactions, or on the cognitive level through scaffolding, or both. Hence,

Figure 7. Sample collected content



Source: author's own work.

the intervention depends on the learner control, i.e. setting information public through interactions, and the judgment of the facilitator at that point in time whether the learner could benefit from working with a scaffold. Scaffolds can either be tagged as such in the Documents part or be created along facilitation, starting in Interactions and later moved to Collected Content for timely and focused intervention.

Current Field Test

In this section, an ongoing evaluation is reported which should lead to inputs for further developments. The case is driven by research-based education in digital production. Business Informatics students have the opportunity to experiment with production technologies when creating a digital artefact that meets their own interest (cf. Stary, 2015; Kaar & Stary, 2019). The current field test addresses Additive Manufacturing and its embedding in engineering and construction tasks. The setting is structured according to the phases of design science-based research, with a strong focus on the process leading to a set of requirements for a solution. In this case, the solution is a digital artefact that is eventually manufactured by a 3D-printing device. Students can access the digital learning support platform as described above, while being guided by the introduced cognitive apprenticeship support measures.

As preparation, background material for the 3D construction, material science, engineering and production processes is provided for the Documents section (see Figure 7, navigation panel on the left). Additional background information can be made available in the Resources section of the learning support system (see Figure 7, navigation panel on the left), including industry standards and Industry 4.0 frameworks, such as RAMI (cf. Kaar, Frysak, & Stary, 2018). The Collected Content part serves as a container when a research question is applied as a baseline for further project work. To allow a kind of procedural scaffold, three threads of interaction are predefined: Initialization, Probing, and Manifestation. They become active for each student in that sequence after cross-checking the result of the currently active thread with the facilitator.

The overall goal of the research project is to provide learners with a background in digital production and introduce its complexity through experiencing 3D design/printing technologies and corresponding materials. 3D modelling and collaboration in teams also form part of that exercise. The initial trigger of the learning process is that students are asked to design and prototype an object or interactive installation (i.e. artefact) of their choice by means of Additive Manufacturing. Hence, in order to accomplish that task, a 3D printer needs to be used (finally). Students may integrate sensor systems, other digital artefacts and technologies; however, they need to find a balance between structuring the artefact into components that can be produced by a specific 3D printing device, the material characteristics for each component and its consumption for production, and the available design and production technologies.

Consequently, as part of setting up their research question, the students need to become aware of the interdependencies between artefact, technology, and material. The research question lays the groundwork for the learning contract according to the design science procedure, and it contains the project plan the students need to hand in. It not only has to comprise the project idea and the milestones, but also how they plan to investigate the production and assembly of the different parts after modeling and specifying each component of the artefact.

While working on specifying the research question for their artefact, the students need to understand the basic principles of Additive Manufacturing (processes). In a self-managed way they can study the learning material provided on printing technologies, production materials, process design, and 3D modelling. The students need to be informed on the basics of the various techniques, since each of them requires certain specifications, depending on the selected artefact the students wish to produce. The materials can also differ depending on the used technology. In 3D printing the material can be resins, thermoplastics, powdered material or others. Essential for 3D printing is the awareness of the three dimensions of width, height, and depth, in order to be able to create a model, and the capability of the available printing technologies in terms of what part of the artefact can be printed to which extension.

If the students need to help to grasp the complexity of their research, a scaffold of type I (Describe Existing Situation) helps, as the frame of reference can be conveyed in this way. It contains the steps to consider before an object can or should be printed. Once the student can identify a valid starting point, they might need support in formulating problematic elements forming the core parts of their research project, e.g. components of the artefact, in which case a scaffold of type II (Formulate Problem or Potential) can be provided by the facilitator. This indicates which relations need to be considered for digital production, and can be supplemented by a scaffold of type III (Capture Envisioned Situation) for forecasting success in production. All scaffolds are part of the digital learning support system and are activated by the facilitator when appropriate. They become visible in the interaction part of the active thread, and thus form part of the learner's individual workspace.

Conclusion

In this contribution, academic competence development has been addressed with respect to scientific work practice. The presented concepts focus on developing a research question in the context of the problem-based design science approach. Defining the research objectives and solution requirements has been facilitated by cognitive apprenticeship, including scaffolding. These educational means have been mapped to the digital learning support features of an intelligent content and media platform, demonstrating its feasibility and applicability.

The learning process is addressed from both a cognitive and a social perspective. The respective support features are grounded in interactions between the participants, either leading to content co-construction, input, or feedback provision. The portfolio-like documentation is part of semantic content management and includes the scaffolds and how to work with them when developing a research question. The use of the platform shows the context-sensitivity of the interactions, content management, and organizing of the learning tasks as major assets.

Future work will focus on empirical studies of various features to better understand co-creation and collaboration among learners (cf. Oppl, 2016). In addition, the use of video annotations will be explored, as they could become part of the interactions to become part of content-relevant threads. Finally, the research work following the specification of a research question is of interest, as the learners utilize the platform features for prototyping, demonstration, and evaluation, as defined by the design science framework. The portfolio structure then needs to capture results from each cycle to meet the identified requirements for a solution.

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Christian Stary holds a PhD (1988) and a Diploma (1984) in usability engineering from the Vienna University of Technology (TU Wien), where he completed his Habilitation (venia docendi) in 1993. He is currently a full professor in Business Information Systems at the JKU Department of Business Informatics-Communications Engineering. He also chairs the JKU Knowledge Management Competence Center. At JKU he is also Study Admission Chair. Christian Stary is the Chair of ICKM (International Council of Knowledge Management) and Austrian representative of the S-BPM steering committee. He is past president of SOL Austria (2012–2016). His research interests are work knowledge elicitation and modelling, learning support and organizational development. He has been principal investigator in international and national R&D projects in the mentioned areas, and has published around 300 refereed papers in journals, books and archival proceedings. ORCID: 0000-0001-9764-5021

We recommend

Trends in Learning Report 2019 based on the research from the Open University's Institute on Educational Technology.

The report goes in line with the research on innovation in education carried out each year by the Open University. It refers to workplace learning and is aimed at corporate L&D professionals. As stated in the foreword, it is intended to answer the question: How do you know if a trend in organizational learning is worth exploring and adopting?
Each year the researchers from OU IET try to identify important and emerging trends that are having an impact on workplace learning. In 2019 they highlighted five trends, described as follows:

1. Thinking and working out loud
   In essence, thinking and working out loud is working in an open, collaborative and visible way. It's all about building connections, sharing in sights and problems and collaborative ways of working.
2. Place-based learning
   Context is king with place-based learning. It is about making the link between potentially abstract concepts with actual information and challenges.
3. Action learning
   Learning is no longer about a course when you only learn stuff until the end of the course. This is about applying learning, reflecting and applying more learning – you use the information that you've got in an environment that allows you to apply it.
4. Learning with machines
   Learning with machines covers several aspects of tech-enabled learning. There's AI and intelligent learning, there's the use of algorithms as a mechanism for instruction and there's humans interacting with robots.
5. Playful learning
   Playful learning is about experimentation, exploration and curiosity. It is as much a state of mind and an environment, as an actual medium of play, so while it can be role play and gamification.

The main parts of the report are five sections of the same structure, each corresponding with one trend. It starts with a brief description "About this trend," followed by the answer to the question "What impact is the trend having on workplace learning?" and "The expert view." The section ends with "Tips for L&D" and the "Resources" containing useful links for further reading.

More information at **http://www.open.ac.uk/business/apprenticeships/blog/trends-learning-report-2019**