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Engaging Students through Interactive Learning Videos in Higher Education: Developing a Creation Process and Design Patterns for Interactive Learning Videos

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Abstract:

The use of learning videos has grown dramatically in the last decades. However, there is also increasing criticism against the use of learning videos concerning the harmful effects on the learning process, such as a decrease in motivation, engagement, and learning success. Although interactive learning videos can be helpful in supporting students' learning process, the design of such videos is still challenging for instructional designers. To overcome these challenges, we follow a Design Science Research (DSR) approach and develop a design pattern-based process to support the development of interactive learning videos. To this end, we engage in multiple DSR cycles where we conduct a systematic literature review, collect practical and theoretical requirements, as well as develop and evaluate our artifact in two cycles. Finally, we codify our results into design patterns and a creation process for interactive learning videos. With our contribution, we make design knowledge for such learning materials accessible by including tangible and applicable practices during our interactive learning video creation process. Our contribution aims to support developers and educators in designing more effective learning videos.

Keywords: Interactive Learning Videos, Design Pattern, Design Science Research.

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1 Introduction

In 2021, about 30% of videos watched worldwide were educational (DataReportal, 2022). This demand has grown in recent decades (Andel et al., 2020). In higher education, the COVID-19 pandemic has encouraged using videos as supplement lectures (Breslyn & Green, 2022; Kurian et al., 2021).

However, there is also increasing criticism against the use of learning videos concerning the harmful effects on the learning process, such as a decrease in motivation (Chatti et al., 2016), engagement (Mohammadhassan et al., 2022), and learning success (Brame, 2016). These effects can be a particular issue in higher education, where learning videos are oftentimes simple recordings of the lecture and even worse a simple recorded presentation of the slides (Bétrancourt & Benetos, 2018). These materials rarely meet the requirements of well-designed learning videos.

One way to overcome this challenge is to use elements to foster interactions in the video (Brame, 2016; Roth & Koenitz, 2019). These elements, like quizzes and question marks, can positively influence motivation and engagement (Liao et al., 2019) by focusing learners' attention on essential information (Huh et al., 2019). The encouragement of interaction within videos can help to design a more active learning process that fosters learners' engagement (John et al., 2022; Seo et al., 2021).

Although interactive learning videos can be helpful in supporting students' learning processes, the design of such videos is still challenging for instructional developers (Ploetzner, 2022) for three reasons. First, the number of different interaction elements can overwhelm instructional developers. Developers do not know which elements should be used in different situations to support their students (Wachtler et al., 2016). Second, many instructional developers use too many interactive elements in videos (Mohammadhassan et al., 2022; Wachtler et al., 2016) which can negatively impact learning because the interactions distract (Koć-Januchta et al., 2020). Third, various characteristics can influence the effects of interactive elements (i.e., duration, type of video, and the complexity of the content). These factors can influence the effectiveness of the interactive elements to better support learning processes. Mohammadhassan et al. (2022) and Shoufan (2019) investigated how the interactive elements have a significant impact on students' learning processes and, therefore, suggest considering these factors in the design process. However, designing interactive learning videos remains a challenge due to a lack of guidance for instructors in the development process (Ploetzner, 2022).

Following the design science research approach by Peffers, Tuunanen, Rothenberger, and Chatterjee (2007), we develop a design pattern-based process for creating interactive learning videos and corresponding patterns to provide design knowledge for learning materials. Our ultimate design goal is the derivation of interactive learning videos that support learners in their learning processes. Thus, we derive design patterns (DP) for each process phase by including tangible and applicable practices during our digital learning material creation process. Our process aims to support video developers to create well-designed interactive learning videos that ultimately can support the individual learning processes of students. This is important because the diversity of students' learning processes must be taken into account in both the preparation and post-processing phases of the videos (Campbell et al., 2020). Hence, the research question (RQ) of our study is:

RQ: How can learning processes be supported by interactive learning videos?

To answer our RQ, we first analyze previous literature about the creation processes of learning material. Furthermore, we reveal practical requirements for the creation process and interactive learning videos in general by conducting a qualitative evaluation in a business informatics course. In two iterative development cycles, we want to examine design knowledge and codify it into design patterns and creation processes to allow video developers to integrate interactive elements in their videos. Through rigorous evaluation, we show that well-designed interactive learning videos can support the learning process.

2 Theoretical Background

In this section, we outline the most important theoretical constructs and theories which guided our study. First, we outline the characteristics of interactive learning videos under the consideration of cognitive load and highlight how interactive learning video designs influence learning processes. Second, we shed a light on the design and development of learning materials in consideration for our case of interactive learning videos.

2.1 Interactive Learning Videos

Designing interactive videos can be a challenge since interaction can also be an obstacle to the learning process. Too much interaction can overwhelm learners and increase cognitive load, negatively affecting the learning process (Koć-Januchta et al., 2020). According to the cognitive load theory of multimedia learning, this can occur for three reasons (Mayer & Moreno, 2003). First, interactions can split the attention of learners. On the one hand, students must focus on the information in the video. On the other hand, students must solve learning tasks within the interactive elements (Koć-Januchta et al., 2020). Second, the cognitive capacities of learners are limited (Sweller et al., 2019). The amount of information a person can cognitively handle over time is limited. Third, the learners must actively process the presented data by selecting the relevant information, restructuring them, and integrating them into the previous knowledge to learn meaningfully (Koć-Januchta et al., 2020; Mayer & Moreno, 2003). An example of these limited cognitive resources is the myth of the six minute rule, which postulates that learning videos should not be longer than 6 minutes to maintain engagement and not cognitively overburden the learners (Guo et al., 2014). Other researchers noticed that this length might differ from this through an intelligent and target group-dependent design of the videos (Shoufan, 2019). With this in mind, the structure of learning videos and context-aware design is central to supporting learners' self-directed learning process.

In this context, the correct selection and composition of interaction elements over the learning video are relevant for whether the interactive learning video is beneficial to the learning process of students. Interactive elements that are well aligned with the learning process can help prevent potential shortcomings in the design of the actual video. Interactive elements can be easily modified and updated, reducing the effort of redesigning the learning materials when necessary. The implementation of interactive elements into learning videos is still being explored. For example, several research papers address the proper positioning of interaction elements from each other so as not to overwhelm learners (Schoeffmann et al., 2015; Wachtler et al., 2016). Other researchers focus on the right amount of interactive elements to avoid a cognitive overburden of learners (Skulmowski & Xu, 2022). As the two meta-analyses by Ploetzner (2022) and Noetel et al. (2021) reveal, the effects of interactive elements on learning process effectiveness are still somewhat unclear and need to be further investigated. In particular, the process of developing interaction elements and integrating these elements into the videos influences the design of interactive learning videos, and, thus, affects the quality of the learning process.

2.2 Design of Digital Learning Materials

The design of high-quality learning materials for digital learning environments is a major challenge. Against this background, assessing the quality of the provided learning materials is of great significance. There are various models and techniques that should help assess the quality of learning materials. One possibility to examine the quality of learning materials is the ARCS (Attention, Relevance, Confidence, and Satisfaction) model by Keller (1987), which should help instructional developers design motivational, engaging learning materials. Other researchers try a more specified way to assess the quality of the various learning materials. Focusing on the case of learning videos, research centers on visual and content characteristics and the understandability of video developers (Pandey et al., 2022; Shoufan, 2019). Other researchers try to assess the quality of learning videos from different perspectives, like from the learners' perspective or the number of likes and dislikes on video platforms like YouTube (Tadbier & Shoufan, 2021). In this context, a recent study has examined the significance of engagement in the design of learning videos. Seo et al. (2021) have determined that learners' engagement depends on the learning context in the videos. Hence, an engaging design of interactive learning videos can be important to enhance their quality.

However, the development of such engaging and high-quality learning videos that consider learners' cognitive capabilities can be challenging because of different factors that influence the quality. To support the development process, the ARCS model offers several strategies to increase learners' attention to the learning material, increase the perceived relevance of the material, and develop learning materials with an appropriate level of difficulty to promote learners' confidence and thus increase their satisfaction (Keller, 1987).

There are different models to support the development of learning videos in general. Especially the ICSDR (identify, connect, conceptualize, develop, review, reflect, and revise) model by Campbell and Cox (2018) which has become increasingly relevant in support of the development process of learning videos. For example, Sitthiworachart, Joy, and Mason (2021) use the ICSDR in a blended learning environment in a business course. The model describes a way to gather information, structure and prioritize it, develop

concepts for the video, and consider them in the creation process of the video. Thus, it supports developers and students to gather and structure their thoughts to consider different contextual factors in the design of the learning videos. However, existing process models like the ICSDR do not reflect the complexity of the design of interactive videos as a new type of learning content that supports students in their learning process. Other approaches like the *Video Learning Canvas* (Ebner et al., 2021) try to support developers at the beginning of the development process by providing guidance on how to identify and structure the relevant context information for the videos. This guidance is oftentimes necessary, because developers have a lack of experience, especially at the conception phase of video development (Campbell et al., 2020). However, to the best of our knowledge, existing processes and recommendations do not reflect the necessary guidance for a structured development process for interactive learning videos. When considering the valuable findings of existing approaches to capture the essence of how to design learning videos in an interactive way, we acknowledge that there is a variety of findings that are not integrated and might also be conflicting. Thus, we tackle this research and practice-based problem with our design approach (see Section 3 for an overview) to offer actionable guidance for video developers.

3 Methodological Fundamentals

The project has been adapted to our research agenda, following the DSR approach proposed by Peffers et al. (2007). We follow this approach because it provides a sufficient method and guidance for organizing and conducting design research that emphasizes (i) how the presented design works to solve the outlined problem and (ii) how the proposed design effect can be replicated to assist instructional designers in creating their own interactive learning videos. The overall procedure is shown in Figure 1.

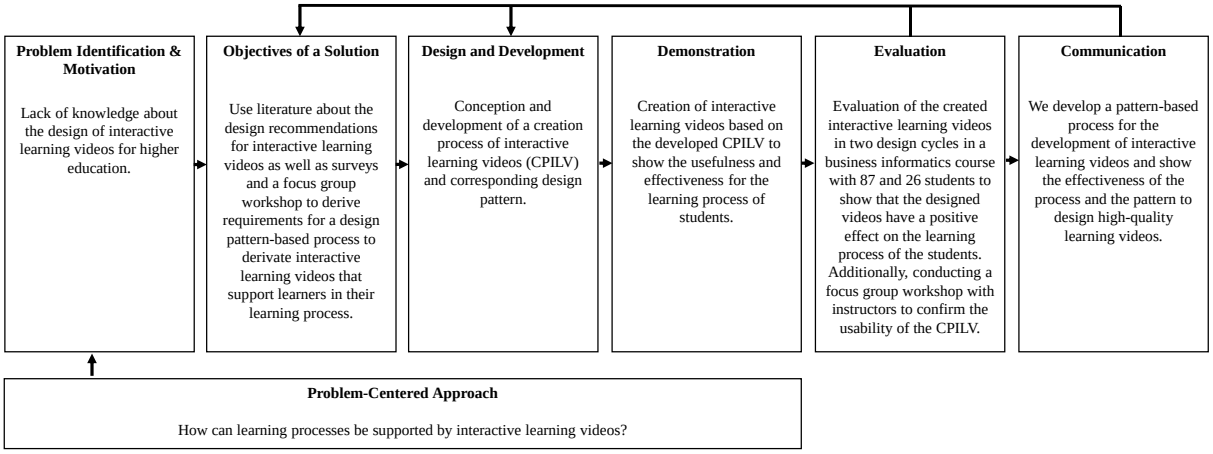

Figure 1. Design Science Research Approach for this Study (Adapted from: Peffers et al. (2007))

Designing the creation process for interactive learning videos (CPILV) is advocated by the DSR approach. Specifically, we follow a problem-centered approach that relies on students' feedback to develop a process that supports the creation of interactive learning videos. To inform the design and development, we carry out a systematic literature review (see also Section 4.1). Within two design cycles, we developed our artifact in an interactive process (Figure 2).

We used the Framework for Evaluation in Design Science – or FEDS (Venable et al., 2016) and followed the human risk and effective strategy to rigorously evaluate our artifact and demonstrate the utility of our solution for developing interactive learning videos. We are evaluating the process and design patterns with short and longer tutorial videos to demonstrate their usefulness to developers and students in different scenarios, and to show that CPILV's usefulness in real-world situations will be sustained over time (Venable et al., 2016). The evaluation approach of the CPILV is twofold. On the one hand, we evaluate the usability of the process for instructional designers to create interactive learning videos. On the other hand, and more importantly, we focus on the evaluation of the effects of the developed interactive learning videos. These videos were developed within the CPILV. In doing so, we evaluate how our artifact affects real learning. We can demonstrate that the designed CPILV is suitable for creating better interactive learning videos by showing that the designed interactive learning videos are motivating, and engaging, and lead to higher satisfaction with the learning process.

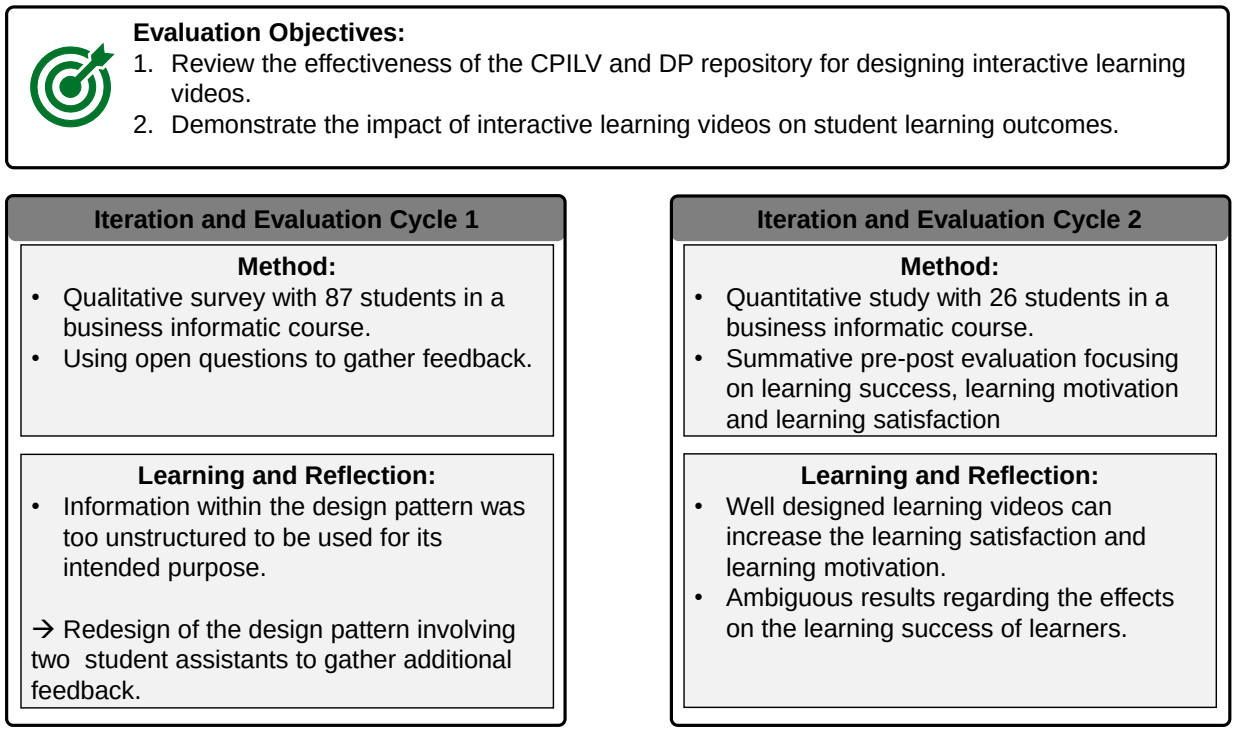

Figure 2. Overview of the Evaluation Approach

To communicate our results, we need a simple and comprehensive way to convey design knowledge into actionable recommendations to help video developers create their interactive learning videos. The solution to this problem should be the integration of the design knowledge we have into our process. A possible solution for this problem comes from the field of system development. DPs document proven solutions to recurring problems (Gamma et al., 1994). These DP contain templates to codify design knowledge in a clearly arranged form and represent established instruments to make complex knowledge accessible and applicable (Alexander, 1979). As such, DP is a well-established way to facilitate the codification of proven design solutions and apply them to recurring problems to make them usable for the future and accessible to a non-expert audience. Pattern representation helps codify design knowledge. DP provides a kind of template that follows the same structure for the entire DP repository to make design knowledge applicable and reusable for the future. The DP template (Figure 3) helps us to codify the design knowledge that is derived to support the instructors in the development process. Within this template, the design knowledge can be structured in a way that is more accessible to the instructors. We develop our CPILV based on the literature and the practical needs of students. We make the developed design knowledge accessible through a DP repository. This is the basis for the design of our CPILV and our pattern repository artifact.

4 Development of the CPILV and Design Pattern Repository

We use literature and practical requirements from students to develop our CPILV and make the developed design knowledge through a DP repository accessible. On this foundation, we designed our CPILV and pattern repository artifact in the following.

4.1 Derivation of Practical and Theoretical Requirements

The first step in our development process is to identify practical needs. Therefore, we conducted a survey of 103 students in a business informatics course to gather suggestions for improving existing interactive and non-interactive learning videos. The exemplary learning videos have been equipped with various elements of interaction, such as simple quizzes, crossroads, or integrated images, although their arrangement is based solely on the assumptions of the teacher (Weinert et al., 2020). For example, students can comment on an existing (interactive) learning video and make suggestions for a better implementation of the interaction elements, and students criticize the unstructured integration of the interaction elements.

We conducted a focus group workshop with five undergraduate and graduate industrial engineering and engineering students (m=4, f=1) to further explore possible requirements. We used this focus group approach to extend the open-ended survey and gain a deep understanding of practical and theoretical requirements. During the workshop, participants were asked to develop their ideas for making a good learning video, evaluate existing interactive learning videos, and suggest improvements. With the help of Briggs and Vreede's (2009) brainstorming elements, the arising categories of criticism were determined, prioritized, and embedded with the survey in the concluding requirements. We conducted a systematic vendor analysis, which can be found in Appendix A, to further explore the possibilities and functionalities of interactive learning videos. Thus, we follow the procedure that is described by Webster and Watson (2002) and Vom Brocke et al. (2009). Based on our findings, we used the following search string: ("interactive") and ("pictures" or "videos" or "material") and ("learning" or "training" or "theory"). For our systematic literature review that aimed at the theoretical requirements elicitation, we used eight databases: ACM DL, AISeL, IEEEXplore, JSTOR, SSRN, ScienceDirect, SpringerLink, and EBSCOhost. We included only peer-reviewed articles in our search. We were able to identify 1,581 papers. Following the approach of Webster and Watson (2002), we analyzed the title, abstract, and keywords of each paper. After the initial review, 235 studies remained, which we then analyzed in full text. As a result, 27 papers were identified including the backward and forward search. The overall search process for our systematic literature review can be seen in Figure B1 in the Appendix. Table 1 provides a brief overview of some of the existing design recommendations.

Table 1. Existing Design Knowledge for Interactive Learning Video Development

Study	Goal and Context of the Study	Interactive element focus	Design Considerations for Interactive Video Development
Quadir et al. (2022)	Affection of different types of interaction on learning outcomes in blog-based courses.	Multiple-Choice; Hyperlinks;	- Focus their attention on the video by combining various interactive elements. - Use links to additional material to provide the learners with background information.
Brame (2016)	Identification of design principles for the development of effective learning videos.	Annotations/ Bookmarks; Crossroads; Open questions	- Interaction elements can be used to segment information feed to avoid cognitive overload. - Interactive elements are used to give users more control of their learning process to foster self-organization.
Yu et al., (2021)	Design of an automated rapid scene indexing system for learning videos	Annotations/ Bookmarks; Quizzes	- Quizzes can help to structure the learning process and enable a self-assessment by learners.
Wachtler et al. (2016); Wachtler and Ebner (2015)	Investigation of the usage and effects of interactive learning videos,	Open questions; Multiple Choice Questions	- Do not place the interaction elements within a too short time (<2:20min). - Combination of different interactive elements to focus their attention on the learning video.
Sauli et al., (2018)	Usage and design of hypervideos.	Quizzes (Single Choice, Multiple Choice); Annotation; Links	- Combination of different interactive elements to focus their attention on the learning video. - Using interaction elements like links to foster collaboration among students.
Cattaneo et al., (2019)	Development of a conceptual model for hypervideo instruction.	Hyperlinks; Multiple Choice; Annotations	- Provide a structured process for learner context and video creation when developing interactive elements.
Weinert et al. (2020)	Development of design guidelines for interactive videos.	Hyperlinks; Multiple Choice; Single Choice;	- Focus on the learning objectives of the video and make these learning objectives self-assessable for the learner. - To avoid cognitive load, non-essential information such as background information should not interrupt the learning video.

4.2 Design and Development of CPILV and Design Pattern Structure

Our analysis reveals that previous development reference processes like the process model proposed by Campbell and Cox (2018) or the video learning canvas (Ebner et al., 2021) are not sufficient for the development of interactive learning videos. For example, our results indicate that the interactive elements are often not in line with the overall learning goal of the video. This seems to be supported by the

students' statements: "*I don't really understand the learning content, even though the learning objective is mentioned*[1]." The lack of an unstructured preparation phase for the development of interactions could be an important reason for this. Another reason for this may be cognitive overload on the part of the learner, indicating the need to address these cognitive limitations. Considering this, we propose to develop a process model which can support the development of interactive learning videos. To develop our CPILV, which can be seen in Figure 3, we use the derived requirements (see Appendix C) and follow the proposed DSR process. In the following, we have a closer look at the process model. After that, we will describe the integrated design patterns in more detail.

4.2.1 Creation Process for Interactive Learning Videos

In general, our CPILV is divided into four phases, which are based on the typical development phases of educational videos (Campbell & Cox, 2018; Cattaneo et al., 2019). These phases are the *preparation phase*, the *production phase*, the *post-production phase*, and the *decision phase*. In the *preparation phase*, the foundation for the video development is established. Thereby, relevant information is gathered which is important for the subsequent production phase like the previous knowledge of learners. In the *production phase* the video is filmed based on the ideas and concepts from the preparation phase. Thus, the transfer of knowledge between the preparation and the development phases is the most common problem in the development process of non-interactive video creation (Campbell et al., 2020). During the *post-production phase*, the videos are revised, and possible errors can be fixed. In addition, during this stage interactive elements are integrated into the video. In the *decision phase*, the entire interactive learning video is reviewed for errors and, if necessary, iteratively revised by jumping back to earlier phases. These phases are accompanied by a design pattern repository, which is intended to help instructors with concrete design knowledge in each of the creation phases. These design patterns are briefly described in the following and are sorted in the phases.

The *preparation phase* is supported by DPs one to four. Instructors begin by brainstorming (DP1) about the video's potential, focusing on the video's themes, goals, and context. After this *brainstorming phase*, the instructional developers conceptualize and cluster the ideas generated in the *brainstorming phase* (DP2). In the next step, developers can use storyboarding and flowcharting (DP3 and DP4) to create a learner's journey that combines the video content and interactive content into interactive learning videos. This step involves planning potential entry points for interactive elements and their characteristics. For example, consider where to implement an interactive hint or quiz, how to phrase it (including its content), and how to present it. These steps are essential for understanding the learner's perspective in the learning process and for taking this into account in the design of the learning material (Moore, 1989). Additionally, there is much discussion in the literature about different types of learners and the implications for the design of interactions (Brame, 2016; Koć-Januchta et al., 2020). Against this background, it seems even more important to deal with the target group in a structured way.

The next phase, the *production phase*, focuses on producing the base learning videos. After producing, (i.e., filming and editing the video material), the videos are reviewed and revised during the next step. Thereby instructional developers could draw on DP3 and DP4 to revise their base video material until a satisfactory level is reached.

As soon as a satisfactory result is achieved, developers can move to phase three, the *post-production phase*. In the first process step of this phase, the pre-selected interactive elements are implemented as planned (e.g., interactive hints or quizzes) and embedded into the video. Afterward, the resulting interactive learning video is reviewed and potentially revised as the base videos. This sub-process of review and revision is essential to reflect and gather feedback on the interactions and the video lecture itself (Campbell & Cox, 2018). In this phase of CPILV, developers can draw on DP5, which is concerned with making learning videos interactive. The phase ends when an excellent interactive learning video is designed.

The last phase is the *decision phase*. In this phase, the entire result is assessed (i.e., a set of learning videos). If the overall results are not satisfactory, developers can backtrack to the preparation phase and make adaptations in another iteration (DP6) in the creation of interactive learning videos. This also highlights the iterative nature of CPILV. If a satisfactory overall result is achieved, the process ends. Developers can now publish their novel interactive learning videos. Additionally, instructional developers

[1] All quotes are translated from German into English.

can expand the existing DP repository by adding potential learning to the repository and expanding the design knowledge of interactive learning videos.

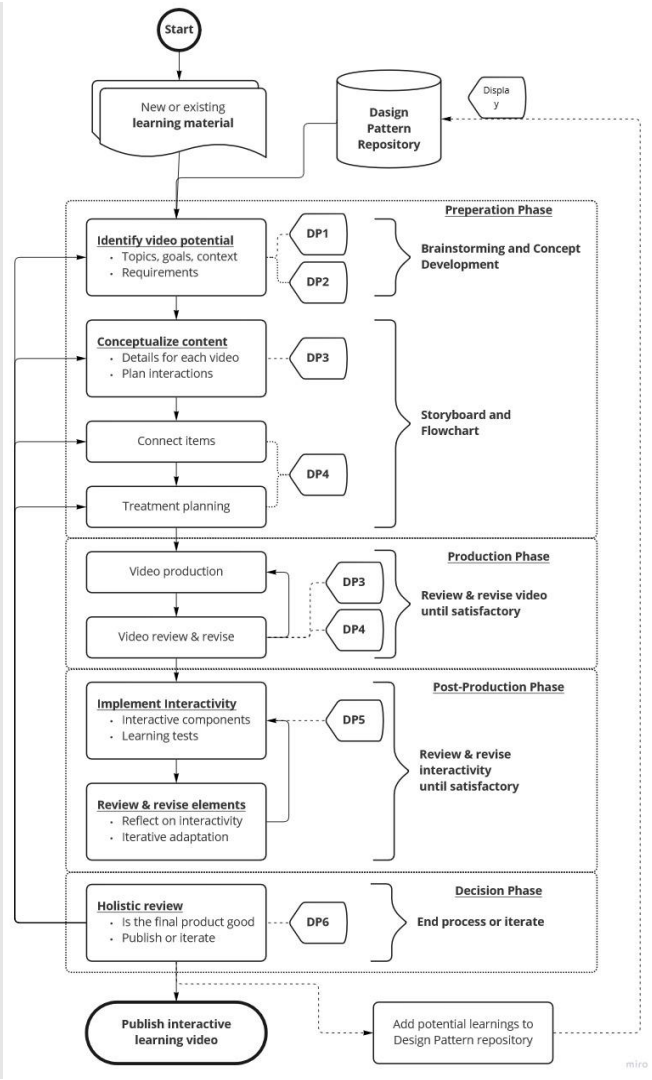

Figure 3. The Creation Process for Interactive Learning Videos (Final Version) with a Design Pattern Repository

4.2.2 Design Pattern for Interactive Learning Videos

Our CPILV features a set of DPs that supports developers throughout the creation process. In this subsection, we elaborate on the DPs we consolidated in a DP repository. We followed the design pattern template by Dickhaut, Janson, and Leimeister (2020) to develop the DP catalog. To create a first pattern version, we adapt the DP template that addresses the specifics of the design knowledge of the new discipline. We conducted an expert focus group workshop (n=5) with instructional developers and researchers in education to derive and evaluate a set DPs. Thus, we used ThinkLets to structure our workshop and facilitate the discussion between the instructors and researchers (Briggs & Vreede, 2009). Thereby, the participants discussed the first version of the DP in order to identify problematic or ambiguous instructions. To support the instructional developers, each DP features characteristic elements and supportive descriptions, and instructions to help them create interactive learning videos. We further develop these patterns in two iterative development phases (see Figure 1). Thus, we present an exemplary DP to explain the general structure of the pattern. The development process leading to the final pattern structure is described in more detail in Figure 4 and explained below.

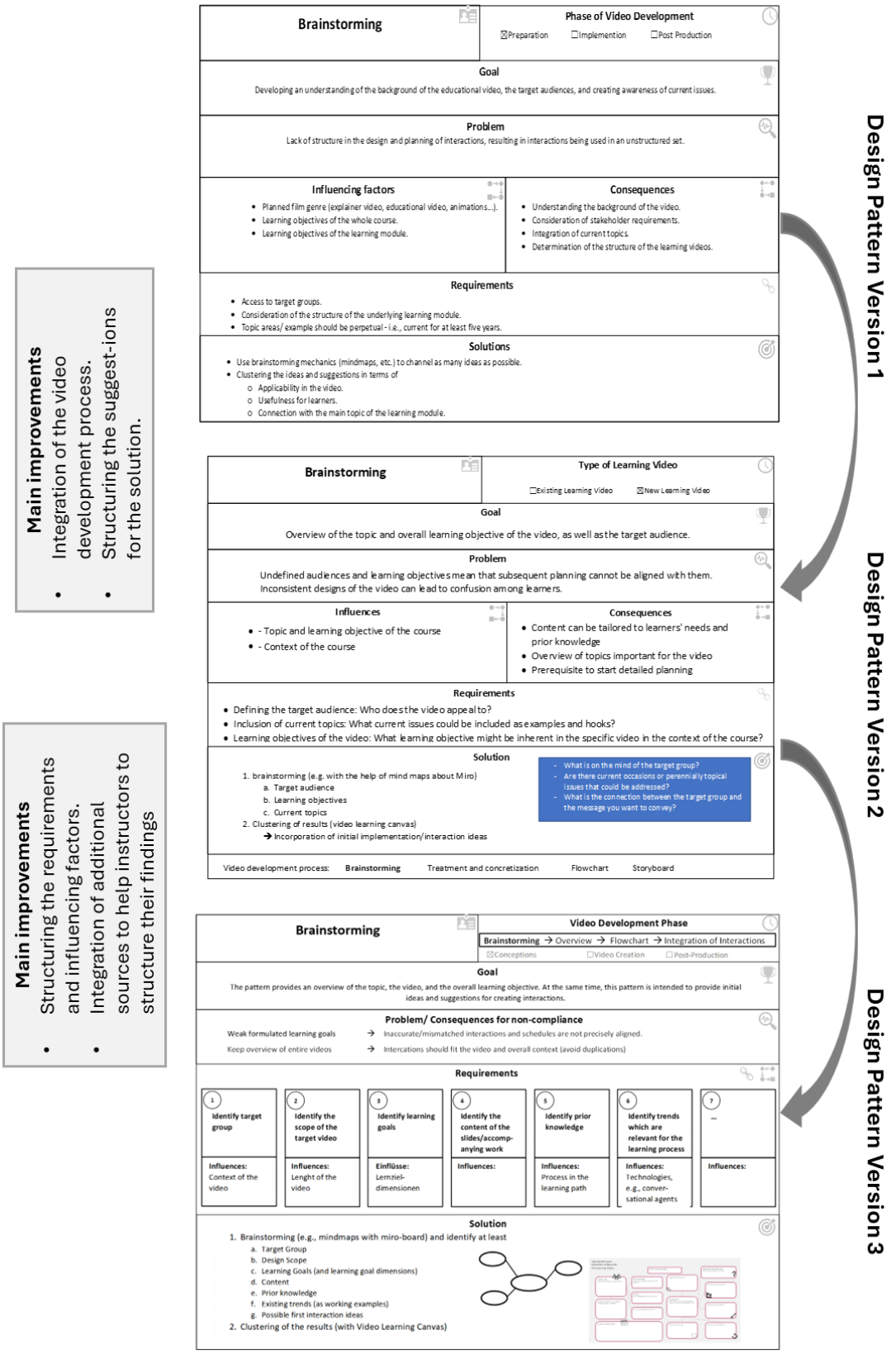

Figure 4. Design Adaptations of the Design Pattern[2]

[2] The final patterns can be seen in the appendix D.

In the first revision (DP Version 1), we have adapted the instructions to support a better understanding of the proposed solution approach. For example, in the case of the brainstorming pattern, we provide guidance through questions, which target to reveal important information for designing interactions. Furthermore, the provided information seems to be too general to operationalize it. Therefore, we have revised the patterns by making the information available for the instructors using more straightforward wording and descriptions. Additionally, we have implemented a new design element to give instructors a better overview of the entire development process.

To increase the understandability of the provided information in the patterns, we have further revised our DP to the *second design version* (see Figure 4). First, we have implemented a better structure of the different influencing factors and corresponding requirements shown in the pattern. This was done because some students felt that the conditions of their performance were not reflected in the design of the interactive elements. Furthermore, we have integrated additional sources to support instructional developers in the creation process. For example, we have implemented a video learning canvas template to structure the brainstorming results in terms of the *brainstorming pattern*. These additional sources were implemented into the DP in various forms, like the proposed structuring elements or giving additional information about the possible interaction elements within the videos. The final pattern structure is now described in more detail in the example of the interactivity pattern.

To describe the exemplary DP, the DP receives a unique name and a clear description of the purpose and application of the DP. The exemplary DP5 is the *Interactivity* DP (see Figure 4). First, the DP is classified in terms of its application during the video development phase (i.e., in the preparation of the video or the post-production). Furthermore, the pattern explains the following stages in the development phase. Further, the DP is then characterized by the goal and problem it attempts to solve. Additionally, the pattern explains what consequences may arise when the pattern is not considered.

This pattern focuses on guiding developers in the post-production phase to integrate the interactive elements in the videos (Cattaneo et al., 2019). The goal of this DP is to guide them in the structured development and integration of interactive elements based on the previous considerations in the preparation phase (Campbell et al., 2020; Cattaneo et al., 2019). As seen in practice, previous considerations and interactivity ideas were oftentimes not integrated into the actual learning video, thus, the interactivity pattern reminds developers of the planned interactions in the flowchart and storyboard pattern (DP3 and DP4), ultimately leading to successful learning processes. Furthermore, many instructional developers tend to implement too many interactions within the video, thus, leading to a cognitive overload of learners as described in the theoretical background. To guide them in this process, so they do not get trapped in these pitfalls, the DP includes requirements and corresponding influencing factors which should be considered in this video development phase. For example, only one mandatory interaction should be implemented every 10 minutes (Wachtler & Ebner, 2015).

The DP should help developers implement their interactive elements with a few best practices (e.g., implement longer learning tests at the end, shorter mid sequence, or provide an overview of achieved scores on an overview screen at the end of the video). At the bottom of each pattern, the solution approach is outlined. All DP in our catalog follows this schema. Thus, we present the main patterns briefly below and highlight their ultimate impact on the learning processes of learners. Moreover, all patterns in the repository can be seen in Appendix D.

DP1 *Brainstorming* is the beginning of the preparation phase. The goal of the pattern is to support developers in the structural identification of relevant information about the target group, the learning goals of the video, and first ideas for possible interactions, thus, providing an outline of learning processes. Furthermore, the pattern provides a structure to conceptualize this identified information to make it accessible in the subsequent phases (Campbell et al., 2020).

DP2 *Treatment & Ascertainment* is part of the preparation phase. Its goal is to formulate concise structure and concepts and plan the interactions for the learning videos. It addresses the problem of matching interactive elements to the concept of each learning video based on the factors determined using DP1 (Cattaneo et al., 2019). Consequently, DP2 is influenced by the topic and scope of the video, technical capabilities, and planned interactions. The consequence of this DP is to adequately communicate relevant information structured in main and auxiliary information and paired with appropriate interactions during a student's learning process. Therefore, its requirements are to declare the relevant main and auxiliary information, select interaction elements, and plan their implementation.

DP3, the *Flowchart Pattern*, is part of the preparation phase and builds on the results of DP1 (*Brainstorming Pattern*). This pattern supports the development of the interactive elements by providing a holistic structure for planning, conceptualizing, and merging the interactions into an entire learning unit of disparate learning videos and helping students to link the interactions in a meaningful way.

DP4 *Storyboard* builds on DP3 (see the description of DP3 above). This DP takes a holistic view of the whole video, including all interactions and contents, in marking the learner's learning journey. Thereby, DP4 addresses the issue of a potentially lacking overview of the learning video and provides valuable tools to create a guiding thread throughout the whole video (Campbell et al., 2020). This DP is best combined with the earlier presented DP3 *Flowchart*.

To give instructional developers more guidance when creating the interactive part of their learning video, we dedicate DP5 *Interactivity* to this cause (see Figure 5). Overall, the interactivity pattern represents an integral and central building block in the entire process. Especially, many developers may not have experience creating interactive video content, which can cause significant issues with learning processes; thus, we provide additional guidance to solve this problem (Weinert et al., 2020). DP5 should help developers implement their interactive elements with a few best practices (e.g., implement longer learning tests at the end, shorter mid sequence, or provide an overview of achieved scores) on an overview screen at the end of the video. It brings together all the preliminary considerations (DP1 – DP4) regarding the interaction elements as well as the actual sequence of the learning video to provide the developer with ideas for designing the interaction elements. The pattern is intended to show designers various options and their limitations in which they can independently design their interactive learning videos.

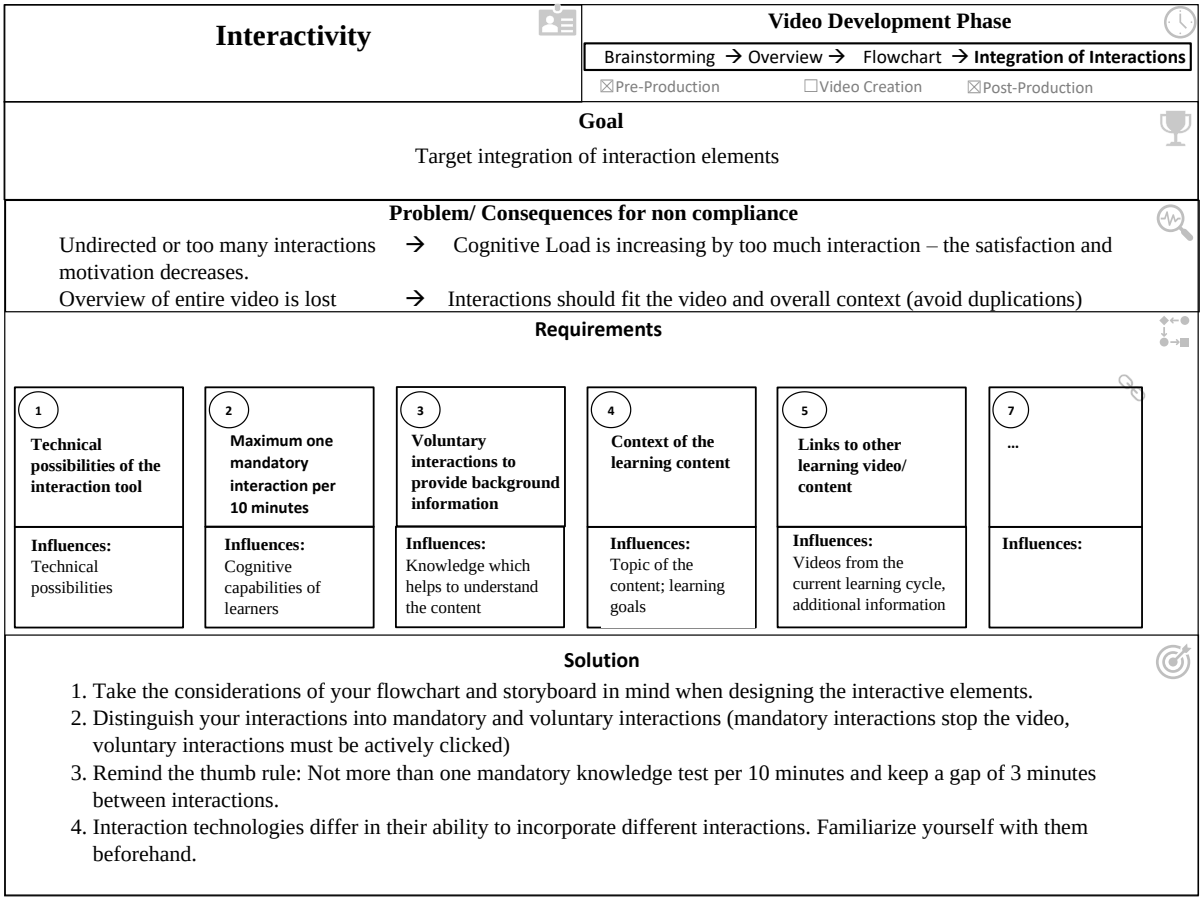

Figure 5. Final Interactivity Pattern (DP5)

Unlike the other DPs, DP6 *Holistic View* has a unique role in the process. It basically translates the termination criterion by assessing the overall interactive learning video. In doing so, it tackles the issue of potential shortcomings in learning materials that can exist and go unnoticed, particularly with novice instructors or time constraints. By providing guidance to assess the final product as a whole and gather valuable feedback (i.e., a small pre-test) this problem can be solved.

This proposed DP catalog should be valuable to content developers of learning videos to achieve their desired outcomes. The DP core generally consists of a solution that describes the tangible design knowledge to solve a recurrent problem to achieve certain goals by exploiting certain influence factors. In our case, the implementation of interactive elements in learning videos. Nevertheless, instructional developers are encouraged to consider relevant literature and additional best practices and consult their target audience, brainstorming the content or planned interactivity.

4.3 Demonstration of the CPILV and the DP

We apply the CPILV in a business informatic course by addressing the challenges in developing interactive learning videos and focusing on the design of high-quality learning materials to demonstrate the usefulness of the process to support students' learning process. Learning videos in the addressed business informatics course are commonly used throughout the video-based flipped classroom concept. To demonstrate the usefulness of our CPILV, we developed interactive learning videos and revised them after each iteration of the process. After each of the two development stages, we evaluated the designed interactive learning videos in the course.

We integrate the interactive elements in short and long videos to demonstrate our work and its generalizability. Thus, we define short learning videos as less than 10 minutes and long videos as more than 10 minutes long (Lagerstrom et al., 2015). We make this distinction because many existing learning videos in higher education are longer than 10 minutes (Shoufan, 2019). However, newly designed learning videos are often shorter than 10 minutes. Therefore, we also want to evaluate the effectiveness of interactive elements in shorter learning videos.

5 Evaluation of the Effectiveness of the CPILV to Design Interactive Learning Videos

In this section, we present the evaluation results to show the usefulness of our CPILV and the DP repository for the design of interactive learning videos to support the learning process of students. Thus, we present two evaluation cycles with shorter and longer interactive videos which we conducted in the design process (see Figure 2).

5.1 First Design Iteration

In the first evaluation cycle, we focus on a qualitative evaluation of the effectiveness of the CPILV and the DP repository for designing interactive videos that ultimately support the learning processes of students in a positive way. To evaluate the utility of the videos to achieve this goal, we designed six interactive videos following the CPILV process and the DP version 1 (Figure 4). The average length of the developed videos was six minutes. Exemplary screenshots of the videos and implemented interaction elements are depicted in Figure 6. We conducted a formative evaluation of the interactive learning videos that were created using our CPILV method. We focused on identifying problems and opportunities for improvement for the created videos, the CPILV, and the design pattern repository. We involved two student assistants and three research assistants in the evaluation.

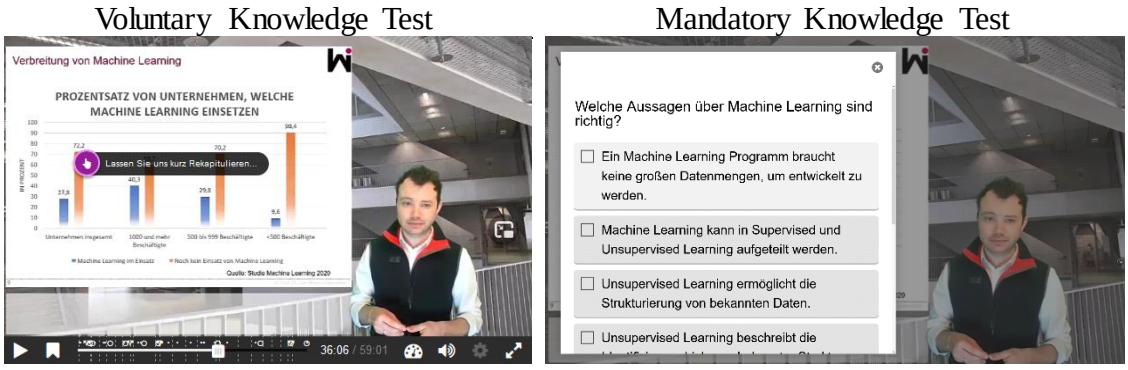

Figure 6. Developed Interactive Learning Video with Integrated Interactive Elements in the First Design Cycle

In the formative student evaluation, the participants use the interactive learning videos in a learning cycle of the flipped classroom of the Business Informatics course. The learning videos explain the usage of the Business Process Model Notation (BPMN) and the fundamentals of machine learning.

To implement the interactions, two research assistants followed the CPILV to design meaningful interactions for the students. After each primary information, mandatory knowledge tests were implemented. They used different interaction elements to check the participants' knowledge, such as multiple-choice tests or text blocks. In addition, other voluntary interaction element tests were implemented to allow participants to self-assess their learning process. We also included a final learning test that was designed to help learners summarize the learning content and allow them to test their knowledge at the end of the learning process.

To gather feedback, we collected qualitative responses through a student survey. We asked the students what they liked about the interactive learning videos (i.e., perceived benefits) compared to the non-interactive learning video in the course. At the same time, we also asked them what they did not like. The questions we used were formulated as open questions such as "*Do you like the learning videos? If yes, why? If not, why?*" and "*What are your thoughts about the interactive learning elements? Were they appropriate, or did they interfere with your learning? Why?".* In the evaluation process of this cycle, 87 students gave us feedback on the designed interactive learning videos.

5.1.1 Usefulness of the CPILV and DP Repository

The qualitative results of the evaluation of the short learning videos indicate that the proposed design of the interactive learning videos is perceived as sufficient to support the learning process with videos. The statements of the students support this observation. For instance, students enjoyed the implementation of short quizzes. One student emphasized "*In the learning videos, I really liked the interactions in the quizzes because you were more attentive due to the constant questions asked, and they served as memory aids"* (student #45). In particular, Quizzes were perceived as very beneficial and useful by students. For example, a student said *"The quizzes you could do during the video for reviewing your learning were great"* (student #15). In general, students very much enjoyed the diversification of the learning process that the interactive elements (e.g., quizzes) introduced, as one student described, *"The interaction opportunities have diversified the learning process"* (student #26).

These statements underline that the students perceived the interactive elements within the videos in a positive way. However, it seems that the interactive elements also influence the cognitive abilities of the learners. Some students described that the introduced interactive elements made the learning process more demanding, compared to previous learning cycles, as one student pointed out: *"Solving the tasks was significantly more demanding than the previous learning cycles"* (student #43). This also meant that students had to invest more time and effort, which some students did not like. For instance, one student said *"For me, the processing of the tasks was very time-consuming"* (student #61).

These statements reveal the problems that we faced in developing the interactive learning videos using the CPILV. Considering the subsequent work task when designing interactive learning videos can quickly become overwhelming in the development process. For example, it was difficult to incorporate the various ideas that we developed during the video preparation phase into the subsequent design process. These results have encouraged us to further revise our design pattern in the second design cycle.

Therefore, the results of the focus group workshop were of particular importance. In the workshop, six learning canvases, flowcharts, and storyboards were developed and analyzed for their ability to be converted into interactive learning videos. These results were further enriched with the results from the students' point of view. Students expressed their desire for more and varied interactions that allow them to reflect on their learning process. In particular, one student voiced a detailed opinion on that matter: *"I would integrate more interactions in the videos, so that you also already get a feeling for how your current standpoint is with the requirements and you can test yourself that way, so you're not completely alone when it comes towards the exam"* (student #31).[3] Students also highlighted the potential of interactive learning videos to activate their cognitive abilities for a longer period of time during the learning process as one student put it, *"It [The interactive learning video] would probably reactivate the concentration for a longer period of time"* (student #39).[4]

[3] Translated from German by the authors.

5.1.2 Learning and Reflection from Iteration 1

Considering the first evaluation of our developed CPILV and DP, we can conclude that both can help teachers produce interactive learning videos that are able to improve the learning process for students. Based on the feedback from the participants, we can confirm the usefulness, but we also had to acknowledge that some improvements are needed. In particular, some students mentioned that the structure of the interactive elements was rather confusing, mainly for two reasons. First, the tasks and the content displayed were not aligned. Second, the difficulty of the assessments was too low to have a significant impact on the students' learning process. After reviewing the CPILV and the DP, it was clear that the problems observed could have been avoided if the DPs in particular had been followed in detail by the instructional designers. Therefore, we revised the DPs with the help of two student assistants who were involved in the design process of the interactive learning videos. This process was characterized by intensive collaboration between the researchers, the developers, and the student assistants to identify and revise the problems in the patterns (see Section 4.2.2).

5.2 Second Design Iteration

In the second design cycle, we evaluated the effectiveness of the CPILV and the DPs from a *process* and *outcome* perspective. To evaluate the CPILV and the DP from the instructional developer's point of view, we conducted a focus group workshop with six instructors. These instructors were experts on the subject area of the business informatic course but had no or very little experience in video development. In the workshop, we focused on the *preparation phase* of the CPILV (see Figure 3) because we recognized that in the first cycle, developing ideas and translating those ideas into a structured flowchart was one of the triggers for interactions that did not match students' backgrounds (see Section 5.1). Based on the process and the DP, the participants developed their own ideas for the videos and interactions, conceptualized them, and created a flowchart and storyboard. Afterwards, the learning video canvas, the flowcharts, and the storyboards were analyzed on their understandability and feasibility by the first author of this paper. These findings were used to inform the design of our DP to further improve the interactive learning video creation process.

In order to further investigate the effects of the process and pattern on the outcome perspective from the students' point of view, we conducted a summative pre-post evaluation of the developed interactive learning videos with 26 students of the Business Informatics course and analyzed the influence of the interactive learning videos on the learning success, the satisfaction with the learning process as well as the motivation of the learners. Thus, we developed interactive learning videos following the CPILV model but focused on longer learning videos. To prepare for the assignment, learners need to watch a video that covers the following topics: the basics of BPMN, how to apply the notation in practice, and the fundamentals of machine learning. The video duration is 58 minutes.

Before starting our field study, we asked all participants to fill out a short pre-survey about their background information and demographics. We also assessed their satisfaction with the learning process compared to existing videos in the business informatics course, based on the instrument developed by Gupta and Bostrom (2013). We assessed the learning process satisfaction construct with a bi-polar measurement approach on a 7-point scale with five subconstructs (efficiency, coordination, fairness, understandability, and satisfaction). Moreover, we measured the motivational design of the learning material using the ARCS model (Li & Keller, 2018), which consists of four constructs: attention, relevance, confidence, and satisfaction. We assessed these constructs with a 5-point Likert scale to collect participants' responses. After completing the pre-survey, participants received the learning materials and the case study assignment. Prior to the experiment, we tested the assignment with two student assistants who are familiar with the learning content and now teach tutorials in the Business Informatics course.

In the first task, the participants had to analyze and interpret an existing human resource recruiting process, described as a real problem in an organization, and modeled with the BPMN. In the second task, the participants must develop a new business process based on their analysis, taking into account the possibilities of machine learning. Finally, in the third task, participants had to explain why their approach makes sense and what problems might arise with this new process. After the participants completed the tasks, which were designed to take about 120 minutes, they uploaded their assignments to the learning management system (LMS) and completed a post-survey that included our control variables as well as our constructs, in particular satisfaction with the learning process (Gupta & Bostrom, 2013), the quality of the instructional materials (Li & Keller, 2018), and the cognitive load (Klepsch et al., 2017).

5.2.1 Learning Process

To evaluate whether the CPILV and the DP repository have a positive impact on the design quality of the interactive videos, we evaluated the students' learning process in the third cycle of our DSR approach. Therefore, we conducted a pairwise t-test to examine the changes induced using the videos compared to the pre-post condition. The differences between the pre-post conditions are examined through their means. We present our results in Table 2 and discuss them below.

A total of 26 students completed the pre- and post-surveys. In the first step, we reviewed the data set according to the usual criteria (Field, 2013). After these preconditions were met, we analyzed the data. To test whether the designed interactive learning videos had a positive impact on learning satisfaction, we conducted a paired t-test to analyze the differences between the pre- and post-conditions. The results show that satisfaction with the learning process increased significantly, T(25)=-2.9; p=0.008; d=0.57. To further evaluate this effect, we examined our data and analyzed the motivational design of the learning material using the ARCS model. Since participants were familiar with the use of videos prior to the experiment, we also conducted a paired t-test. One of the four indicators showed significant differences between the groups, namely the relevance of the learning material T(25)=-2.75; p=0.011; d=0.54. The construct confidence with the learning material (T(25)=-2.04; p=0.052; d=0.4) has a non-significant tendency. The scores for attention and satisfaction were insignificant.

Table 2. Overview of the Tested Propositions

Construct	Subconstruct	Mean	SD	T-Value and P-Values
Satisfaction with Learning Process (Gupta & Bostrom, 2013)		3.67 Pre) 4.62 (Post)	1.30 (Pre) 1.13 (Post)	**T(25)=-2.898; p=0.008∗∗∗; d=0.568**
Motivational Design of the Learning Material (ARCS) (Li & Keller, 2018)	Attention	2,82 (Pre) 3,13 (Post)	0.834 (Pre) 0.93 (Post)	T(25)=-1.273; p=0.215
	Relevance	2.91 (Pre) 3.4615 (Post)	0.81 (Pre) 0.80 (Post)	**T(25)=-2.745; p=0.011∗∗; d=0.538**
	Confidence	2.71 (Pre) 3.14 (Post)	0.81 (Pre) 0.76 (Post)	T(25)=-2.038; p=0.052; d=0.4
	Satisfaction	2,41 (Pre) 2,78 (Post)	1.05 (Pre) 1.38 (Post)	T(25)=-1.084 p=0.289
Note: ∗ = p < 0.10; ∗∗ = p < 0.05; ∗∗∗ = p < 0.01				

5.2.2 Reflection and Learning from Iteration 2

Considering the results of Iteration 2, the impact of the interactive learning videos on the learning process was partially as we predicted. The designed process as well as the DP repository supported the developers in such a way that the created interactive videos had a positive effect on the learners' satisfaction. The positive impact on the perceived relevance of the learning material also suggests that the way the information is conveyed in the videos has a positive impact on the students' learning process. (Keller, 1987). In this context, we assume that the underlying CPILVs have a positive impact on the creation of interactive videos and thus support the learning process of the students. However, this indirect measurement of the fitness for the purpose of the process can be criticized and will be discussed in the next chapter.

6 Discussion and Contribution

In this section, we discuss the main findings of our study and place them in the overall context of the literature. We also present the theoretical and practical contributions of our work.

6.1 Discussion

In this study, we used a DSR approach to answer the question of how to support learning processes through the effective design of interactive learning videos. We conducted two design cycles to design a CPILV as well as a corresponding DP, which we evaluated in terms of the usability of the process and patterns for creating interactive learning videos that support students' learning processes.

There are several important findings from this study. First, the results show that the proposed design process led to the development of high-quality interactive learning videos that can effectively support students' learning process. As can be seen from the qualitative and quantitative results of the two evaluation cycles, the use of the designed interactive learning videos has a positive effect on the learning process. The qualitative evaluation results are consistent with the findings of other researchers who have shown that well-designed interactive learning videos can support learners' self-organization (Chatti et al., 2016). In particular, interactive elements such as crossroads allow students to decide which parts are relevant to their learning process and which details are irrelevant. This is in line with the design considerations of Sauli et al. (2018) and Cattaneo et al. (2019) (see Table 1), who recommend the use of links, annotations, and crossroads to help learners self-organize their learning in video-based learning.

However, when comparing the results of the two evaluation cycles, the interaction elements seem to have different effects on the learning process depending on the duration of the videos. For shorter learning videos, some participants said that the interactive elements were more distracting than helpful. For longer videos, participants did not mention this. This observation may be a consequence of the lack of structure in the design patterns, which led to an overcrowding of videos with interactions. We addressed this issue in the second design iteration. This would be consistent with the findings of Noetel et al. (2021), who did not find differential effects of interactivity as a function of duration. However, it is possible that these differential effects are because learners are challenged to follow the material, which is usually highly condensed and tailored to the viewer, in short, to solve interactions at the same time. In addition, as also noted by Wachtler et al. (2016), the short duration of videos makes it much more difficult to integrate interaction elements and maintain the necessary pauses between interaction elements (Wachtler & Ebner, 2015).

Therefore, for interactive videos of short duration, interactive elements such as multiple-choice questions at the end of each video may be an appropriate alternative to avoid overwhelming the learner. Other optional elements (hyperlinks with backup information) that do not interrupt the video may be more appropriate to increase interaction in instructional videos. Apart from the design challenges posed by the length of the learning video, the results in terms of learning performance and satisfaction are very similar between short and long interactive learning videos. Thus, our results confirm the work of Noetel et al. (2021), who showed that the length of the learning video did not moderate the effect of interactivity.

Specifically, in the case of longer learning videos, students reported that the interactive elements helped structure their learning process and allowed for self-assessment. These findings are supported by the qualitative results, which indicate that the implemented interactive elements were suitable for increasing learning satisfaction. Thus, our results show a significant medium effect (d=0.57) on students' satisfaction with their learning. In addition, we evaluated the quality of the learning materials using the ARCS model to verify that the quality of the learning materials is sufficient to support the learners in the learning process. Thus, one of the four sub-constructs of the model shows a significant effect. However, the satisfaction construct of the ARCS model was not significant, in contrast to the satisfaction with the learning process construct. The most likely explanation is that the two constructs measure different levels of satisfaction. On the one hand, satisfaction with the learning material in general, and on the other hand, satisfaction with the learning process, which refers not only to the individual learning materials, but also to the interaction with the video content, the interactions in the videos, and the associated tasks. In this context, the different scores can be explained as follows.

The designed interactive videos are perceived by the students as relevant to their learning process and they feel confident in using the interactive videos. This result can be attributed to two effects: First, the implemented interactive elements allow for better self-organization of the learning process by increasing students' flexibility by allowing them to repeat or skip certain parts of the video based on their knowledge level (Luo et al., 2018). These interactions lead to a degree of autonomy for students, which helps them gain confidence with the learning material. Second, this self-organization of the learning process makes the learning material feel more relevant to the learner. These results, together with the identified positive

results in terms of satisfaction with the learning process, can be seen as a confirmation that the designed interactive learning videos are sufficient to support the student's learning process.

In summary, the presented results show that the designed process is suitable to support the development of effective interactive learning videos. However, the evaluation process of the CPILV and the DP repository has some drawbacks. Although the proposed design process of the CPILV was carried out with an accompanying evaluation involving both authors and student assistants, the main evaluation was carried out directly with the videos developed through the process. This has the advantage of evaluating the underlying purpose of the process (i.e., the development of effective interactive learning videos to support student learning). However, to strengthen the findings, a more rigorous evaluation of the process itself would be necessary.

6.2 Contributions

The contribution of our paper is threefold. First, we provide an approach to the theory of design and action (Gregor & Jones, 2007) by providing an empirically evaluated design process for interactive learning videos. We developed and evaluated the process over two cycles to demonstrate the effectiveness of our process in supporting the design process of interactive learning videos. Additionally, the accompanying design pattern repository has supported the instructional developers in the development process of interactive learning videos. To demonstrate the usefulness of the process and the DPs, we used the process to create short and longer learning videos to show the applicability of the process in different usage scenarios. To complement our CPILV and to communicate our results to practice and research, we have developed DPs to complement our process. Through our qualitative and quantitative evaluations, we were able to show the effectiveness of the interactive learning videos designed for the learning process. Second, the adapted DP structure from Dickhaut et al. (2020) can be seen as a basis for communicating design knowledge in educational settings. Third, from a practical point of view, the developed CPILV supports instructional designers through the whole creation process of the interactive learning videos.

6.3 Limitations and Future Research

Although we have rigorously conducted our research, our research is not without limitations. First, we measured the effectiveness of the process only indirectly, by measuring the impact on students of the interactive learning videos developed from the process. Therefore, our results could be biased because the developer of the learning videos has prior experience that helps him to create good interactive learning videos. However, our process and the pattern are designed to support experienced and inexperienced instructors through the development process. Second, because we did not focus on individual interaction elements, we can only make statements about the general effects of interactive elements. However, this may be necessary because some elements could negatively affect the learning process.

As seen in the development of our CPILV, there are different interaction elements that may can be more appropriate to support the learning process. Therefore, and with these limitations in mind, we would recommend future research to examine the effects of individual interactions on the learning process with larger quantitative studies. Furthermore, we would like to further investigate the role of cognitive load in the use of interactive learning videos. As seen in different studies (Brame, 2016; Koć-Januchta et al., 2020), too many interactions can negatively affect the learning process. Since the assessment of the learners' cognitive load was not in the focus of our study, we would like to encourage the researcher to further investigate the influence of cognitive load on learning processes with interactive learning videos. An in-depth investigation of individual interaction elements or even different framework conditions would also be of great interest.

7 Conclusion

In this study, we have designed a DP-based process to support developers in the development of interactive learning videos. Within a two-cycled DSR approach, we developed a CPILV and a DP repository to support instructors. In the design cycles, we have evaluated the process and the DP within a business informatics course with developers and students. Our results show that the designed process is suitable to support instructional designers in designing meaningful interactive learning videos. Additionally, we were able to exhibit that the designed videos had a positive effect on the students' learning process. With our study, we can show that the thoughtful design of interactive videos is of great importance in

higher education. With our supporting process and the developed DP, we provide both practical guidance for the design of such interactive learning videos and theoretical insights for the extension of the research field.

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Appendix A: Provider Analysis

We follow the principles of data analysis suggested by Yin (2003). Thereby, we use two different search platforms (Google and Bing) to identify providers that offer interactive learning videos. An overview is shown in Table A1.

Table A1. Overview of the Identified Functionalities of Interactive Videos (Anonymous et al. 2020)

No.	Name of Provider	Identified interactive elements
1	ThingLink	Textual and visual elements, labels, links, crossroads/ tours to other videos.
2	Wirewax	Textual and visual elements, hotspots
3	Vidzor	Textual and visual elements, hotspots, crossroads, skipping, links
4	Storygami	Video elements
5	Metta	Textual and visual elements, audio elements, quizzes, leaderboards
6	Playposit	Quizzes, multiple choice questions, open response questions, surveys, fill in the blank, FORUMS
7	Touchcast	Textual and visual elements, documents, links
8	Wootag	Textual and visual elements, hotspots
9	Wideo	Textual and visual elements, audio elements, animations
10	Camtasia	Textual and visual elements, audio elements, quizzes, surveys
11	H5p	Textual and visual elements, crossroads, quizzes, multi choice questions, drag and drop, fill in the blank

Appendix B: Derivation Process of Theoretical Requirements

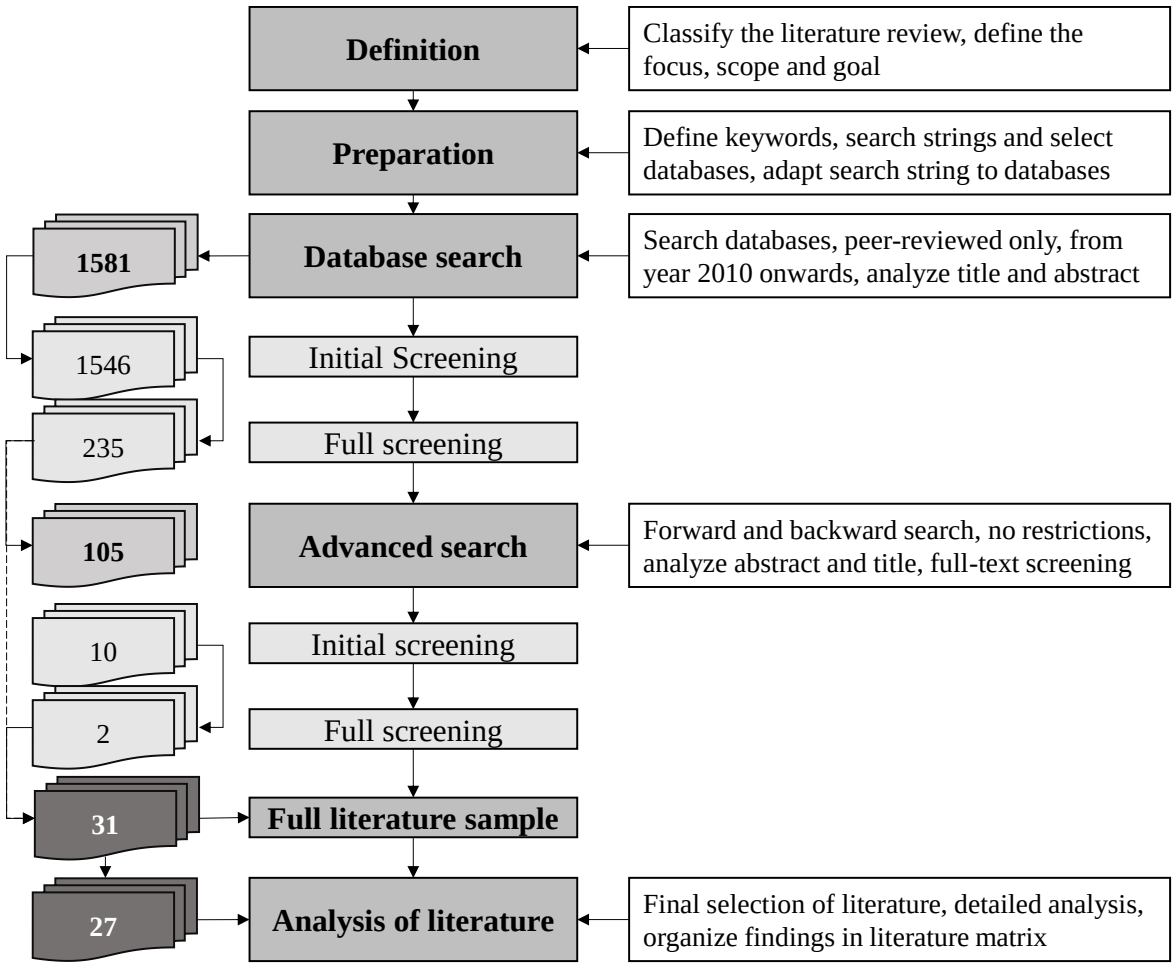


Figure B1. Systematic Literature Review Process

Appendix C: Design Requirements

Table C1. Design Requirements

Requirements	Explanation
Theoretical Requirements	
At the beginning of the video, the interactive elements should be explained (Brame, 2016; Mayer & Moreno, 2003)	The usage of interactive learning elements can be overwhelming for learners; therefore, it is necessary to inform learners about the interaction possibilities.
At the beginning of the video, the interactive elements should indicate the learning goals (Bloom et al., 1973))	Learning goals give structure to the learning process. Interactive elements can foster the understanding of these goals.
After an interactive learning control element, the interactive elements should promote the exchange between learners (Cattaneo et al., 2019; Krause et al., 2015)	Interactive elements can evaluate learners' knowledge. However, some questions may be difficult to understand, so an exchange between learners should be sought to promote understanding.
During the learning video, interactive questions should be placed after important parts of the video indicated by the learning goals (Brame, 2016; Lawson et al., 2006)	To ensure that the learners understand the important aspects of a video, mandatory interaction elements should be placed after each important part in the video.
During the learning video, the interactive elements should draw attention to the important aspects and avoid attention to unnecessary parts (Brame, 2016; Guo et al., 2014)	Interactive elements should accompany the information in the video and help to draw the attention of learners to the important parts in the video and not provide even more information that distracts the learner from the actual content.
Practical Requirements	
During the video, the interactive elements should support the self-organization of the learners by enabling jumping targeted in the video.	Interactive elements can help to structure the learning process by using guiding questions or crossroad elements to support a self-organized learning approach.
During the learning video, interactive elements should allow learners to compare themselves with each other.	The comparison between learners can foster competition between learners which can be helpful in motivating them.
At the end of the video, the interactive elements should enable a learning control, so that learners can self-control their learning progress.	Pointing out one's own performance at the end of the learning video can help learners see where their own weaknesses and strengths lie.
During the learning video, the interactive elements should indicate how to get feedback from the lecturer.	Even well-designed learning videos that have been adapted to the target group can overwhelm learners from time to time. At this point, interactive elements can promote exchange and provide easy access to the instructor.

Appendix D: Design Pattern Repository

Brainstorming

Video Development Phase

Brainstorming → Overview → Flowchart → Integration of Interactions

☒Pre-Production ☐Video Creation ☐Post-Production

Goal

The pattern provides an overview of the topic, the video, and the overall learning objective. At the same time, this pattern is intended to provide initial ideas and suggestions for creating interactions.

Problem/ Consequences for non-compliance

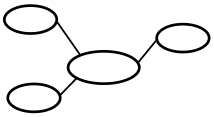
Weak formulated learning goals	→	Inaccurate/mismatched interactions and schedules are not precisely aligned.
Keep overview of entire videos	→	Intercations should fit the video and overall context (avoid duplications)

Requirements

1	2	3	4	5	6	7
Identify target group	**Identify the scope of the target video**	**Identify learning goals**	**Identify the content of the slides/accomp-anying work**	**Identify prior knowledge**	**Identify trends which are relevant for the learning process**	**...**
Influences: Context of the video	**Influences:** Lenght of the video	**Einflüsse:** Lernziel-dimensionen	**Influences:**	**Influences:** Process in the learning path	**Influences:** Technologies, e.g., conver-sational agents	**Influences:**

Solution

1. Brainstorming (e.g., mindmaps with miro-board) and identify at least
   a. Target Group
   b. Design Scope
   c. Learning Goals (and learning goal dimensions)
   d. Content
   e. Prior knowledge
   f. Existing trends (as working examples)
   g. Possible first interaction ideas
2. Clustering of the results (with Video Learning Canvas)



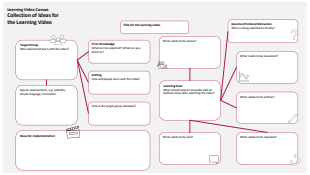


Figure D1. DP1 Brainstorming Pattern

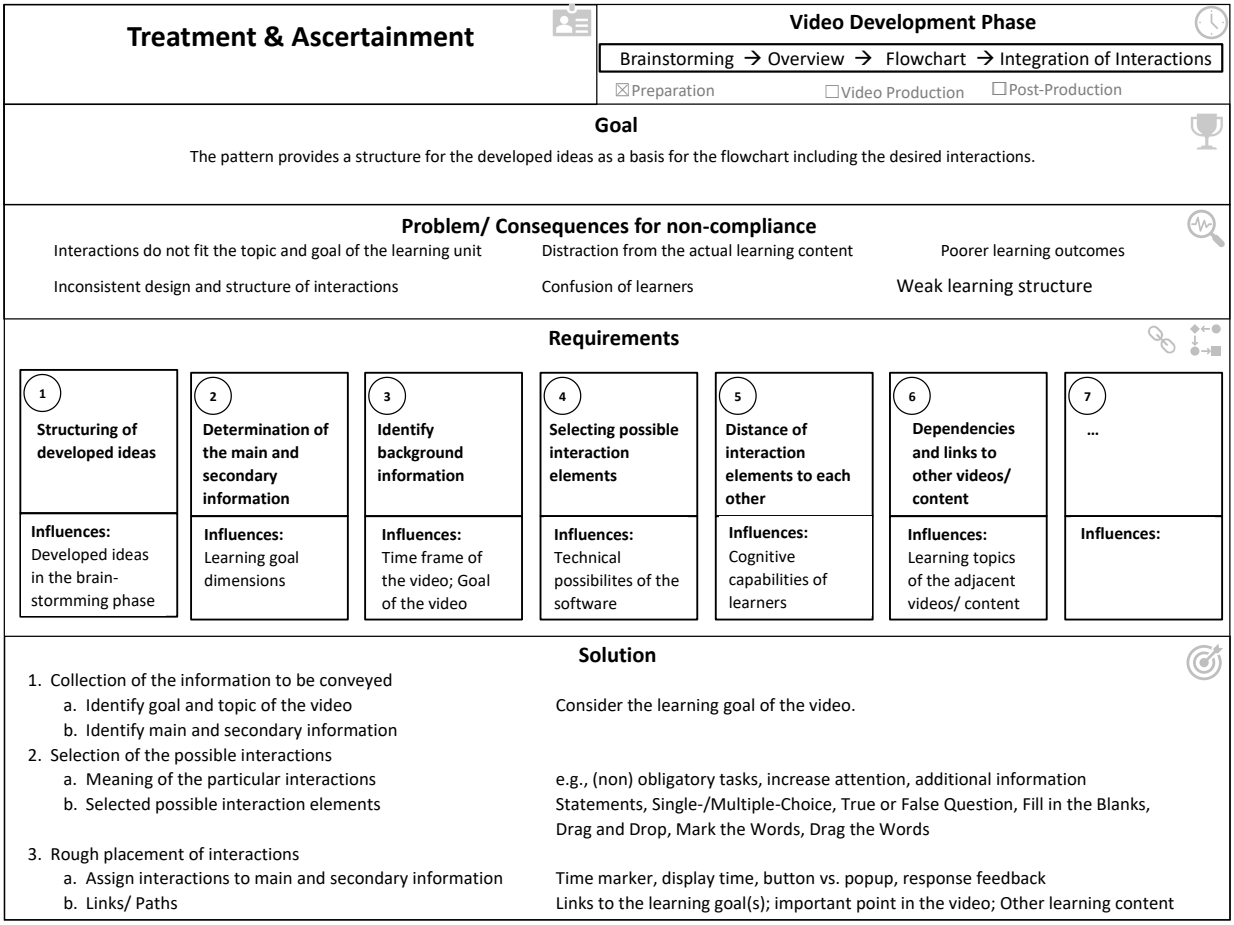


Figure D2. DP2 Treatment and Ascertainment Pattern

Flowchart

Development Phase of Learning Video

Brainstorming → Overview → Flowchart → Integration of Interactions

☒Conception ☐Video Creation ☒Post-Production

Goal

Concrete planning of the interactions in the video course with the help of a clear flowchart to get an overview of the sequence of planned interactions in the video.

Problem/ negative consequences for non-compliance

Too many interactions in a row → Increasing complexity and confusion of learners

Important information's are not recognizable → Information overflow

Requirements

1	2	3	4	5	6
Divide learning objectives into main and secondary information	**Assignment of the desired interaction**	**Check number of interactions in the video**	**Sensible arrangement of interactions through placement at slide**	**Response to the interaction**	**...**
Influences: Learning Goal Dimensions	**Influences:** Context of the video and interaction type	**Influences:** Time frame	**Influences:** Context of the video	**Influences:** Videos from the current learning cycle, additional	**Influences:**

Solution

1. Use the linked template for the flowchart.
2. Divide main and secondary statement of the learning goals.
3. List the sequence of the interactions in the flowchart.
   a. Consider possible interrelations with other implemented interactions in the video
   b. Don't overload the video with interactions - rule of thumb: don't implement more than one interaction in three minutes for self-assessment.
4. Plan reactions to user input (success/failure), for example, by building a interaction sequence.

Figure D3. DP3 Flowchart Pattern

Storyboard

Video Development Phase

Brainstorming → Overview → Flowchart → Integration of Interactions

☒Preparation ☐Video Production ☐Post-Production

Goal

A document with all necessary information about the procedure of the video production as well as planned interactions.

Problem/ Consequences for non-compliance

Speaker does not know where the interactive elements are implemented and thus cannot refer to them.

→Reduced usage of the elements.

→Red threat is hard to recognize.

Requirements

1	2	3	4	5	6	7
Orientation guide for post-production	**Connection between planned interaction and actual video**	**Avoidance of conflicts between speaker and post-production**	**Coordination of content, speaker and interaction**			...
Influences: Minimum or maximum length of the entire video	**Influences:** Planned Interactions; Complexity of content	**Influences:** Perceptions of the speaker; personal skills	**Influences:** Planned interactions	**Influences:**	**Influences:**	**Influences:**

Solution

1. Use the flowchart (DP3) to plan the individual scenes using the storyboard template.
   a. Keep in mind: Which information/ statements precede and follow which interaction? How long do learners have time to solve a interaction element? What image does the learner see in the background during this time?
2. Plan the position of the interaction elements - Plan speaker's reactions to the interactions.
3. Plan the text of the speaker before and after the interactions.

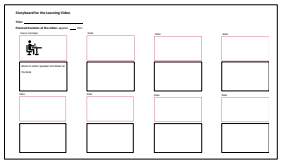


Figure D4. DP4 Storyboard Pattern

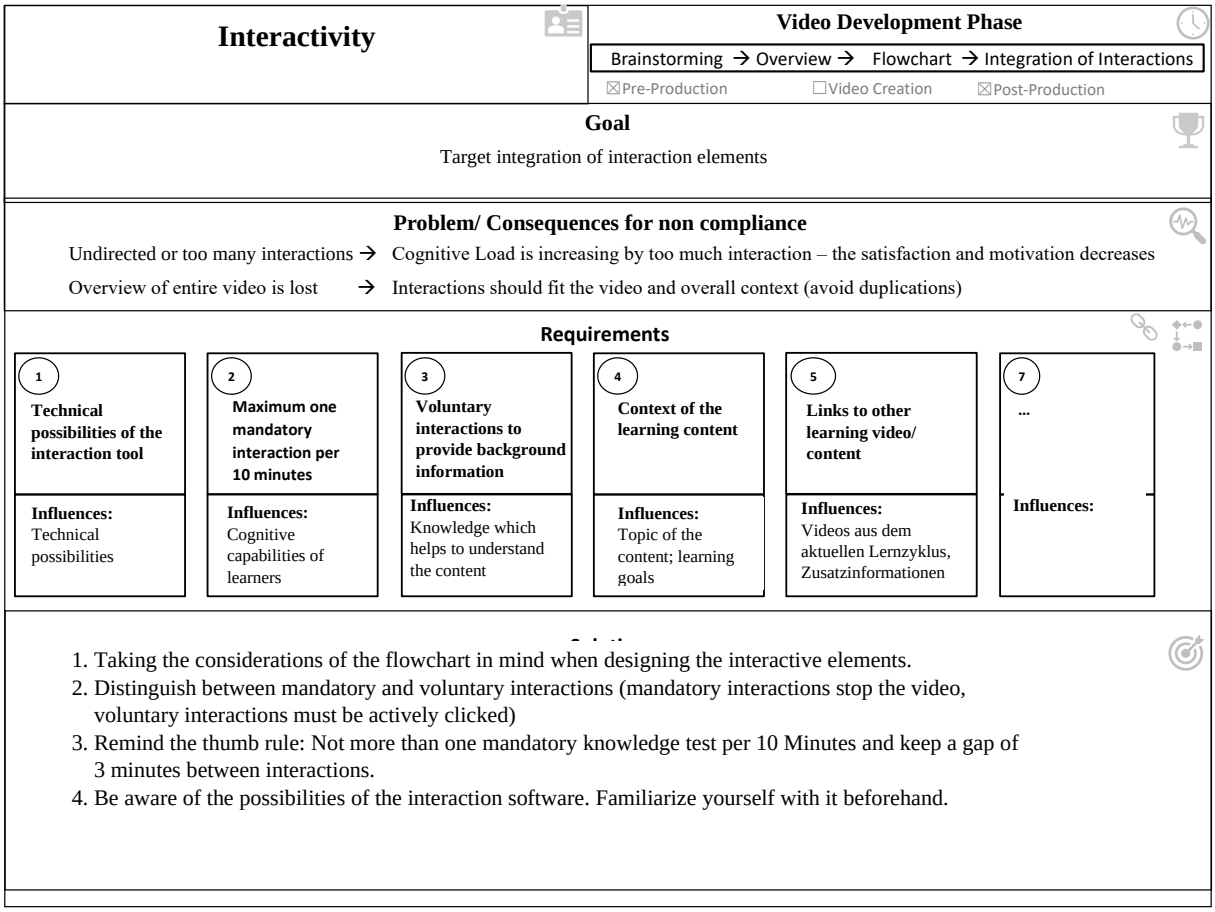


Figure D5. DP5 Interactivity Pattern

Holistic View

Video Development Phase

Brainstorming → Übersicht → Flowchart → Einbau von Interaktionen

☐Pre-Production ☐Video Creation ☒Post-Production

Goal

Provide a holistic overview of the interactive learning video to identify potential gaps

Problem/ Consequences for non compliance

Finished learning video exceeds the previously set parameters.

Unsolved problems in the design of the videos.

Requirements

1	2	3	4	5	7
Flowchart and Storyboard are at hand	Videos are finalized	Interactions are implemented			...
Influences:	**Influences:**	**Influences:**	**Influences:**	**Influences:**	**Influences:**

Solution

1. Compare the planned interactions in the flowchart and storyboard with the finished interactive learning video.
   a. Is something missing? If so, are there any reasons for this? If not, why do not implement the interaction?
2. Check that the mandatory interactions conform to the rule of thumb: One interaction per 10 minutes and spacing of interactions at least 3 minutes.
3. Check of consistency (i.e.): Are the selected questions and answers correct, do the time markers lead to the right sections, are the implemented links also up-to-date and working?

➔ In the best case: Involve other employees who had nothing to do with the video lecture and ask them for feedback. Involving students in a feedback session is also conceivable.

Figure D6. DP6 Holistic View Pattern

About the Authors

Tim Weinert holds a PhD from the University of Kassel in Information Systems. Tim has more than four years of experience in microlearning research and focuses on how to design interactive learning videos for higher education in line with the needs and interests of users. His research interest also focusses on designing co-creation systems for vocational training and higher education. His research results have been published in the European Conference on Information Systems (ECIS), the International Conference on Information Systems (ICIS), and journals like Computer Supported Collaborative Work (CSCW) or IEEE Transactions on Learning Technologies (IEEE TLT).

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