2024

About the Alignment of Learning Objectives and Interactive Elements in Video-Based Learning: A Mixed Methods Approach

Maximilian Raab
University of Bamberg, Germany, maximilian.raab@uni-bamberg.de

Julian Weidinger
University of Bamberg, Germany, julian.weidinger@uni-bamberg.de

Nico Hirschlein
University of Bamberg, Germany, nico.hirschlein@uni-bamberg.de

Jan-Niklas Meckenstock
University of Bamberg, Germany, jan-niklas.meckenstock@uni-bamberg.de

Lisa Thron
University of Bamberg, Germany, lisa.thron@uni-bamberg.de

About the Alignment of Learning Objectives and Interactive Elements in Video-Based Learning: A Mixed Methods Approach

Research Paper

Maximilian Raab[1], Julian Weidinger[1], Nico Hirschlein[1], Jan-Niklas Meckenstock[1], and Lisa Thron[1]

[1] University of Bamberg, Chair of Industrial Information Systems, Bamberg, Germany
{maximilian.raab,julian.weidinger,nico.hirschlein,jan-niklas.meckenstock,lisa.thron}
@uni-bamberg.de

Abstract. Aligning lecture contents with learning objectives, as well as the integration of interactive elements, can increase the efficacy of video-based learning. However, their integration, i.e., the alignment of learning objectives with interactive elements, has not yet been systematically explored. Currently, integrating interactive elements is driven more by personal beliefs than evidence-based strategies. We address this research gap with a mixed-method study in the context of an information systems course. Based on the students' subjective perception, we investigated the alignment between learning objectives and interactive element types, as well as the underlying rationale. Our results indicate that quizzes are most suitable for different purposes, annotations are never unsuitable but only needed on higher complexity levels, and navigation features are merely nice-to-have. The systematic understanding of interactive elements offers valuable guidance for educators and scholars, contributing to best practices in online education.

Keywords: video-based learning, interactive elements, learning objectives, alignment, mixed methods

1 Introduction

Video-based learning (VBL) transforms education by providing novel methods to engage students and facilitate their learning processes (Palaigeorgiou et al., 2019). The COVID-19 pandemic has further raised the significance of VBL with an increased use of video lectures (Pal and Patra, 2020). Its benefits include increased learner autonomy, motivation, and satisfaction (e.g., Chen, 2012, Sablić et al., 2020). Still, VBL can also imply drawbacks like passive learning experiences, lack of human interaction, and low cognitive engagement with video content (Palaigeorgiou and Papadopoulou, 2019). To mitigate these, several interactive elements have been proposed. Using such elements in VBL can foster self-regulated learning, engagement, critical thinking, and learning performance (e.g., Palaigeorgiou et al., 2019, Raab et al., 2023, Weinert et al., 2021).

To implement comprehensive teaching approaches, educators are encouraged to align courses, lessons, and resources with the intended learning objectives. Orientation is given through frameworks like the Revised Bloom's Taxonomy (RBT). Within it, learning objectives specify what students are expected to know, comprehend, or be able to accomplish after engaging with a particular educational resource like a video lecture. The RBT is commonly utilized in traditional classroom settings (e.g., Brok, 2019, Oliveira, 2012). In the context of VBL, the RBT has meanwhile been utilized to guide flipped classroom setups (Siva-Kumar, 2023, Zainuddin et al., 2019) and assist educators in designing purposeful lecture content.

Both, aligning lecture contents with learning objectives, as well as integration of interactive elements, can facilitate VBL. However, the alignment of learning objectives with interactive elements has not yet been systematically explored. It remains unclear which element type particularly supports students pursuing a certain learning objective. Currently, the use of interactive elements is mostly driven by educators' personal experiences rather than evidence-based strategies. This often results in an arbitrary, excessive, or non-targeted use of interactive elements (Brame, 2016). To allow a purposeful design of VBL, insights into the suitability of distinct interactive element types are needed. Hence, research needs to assess the alignment of interactive element types and learning objectives in VBL as well as the underlying rationale for their alignment.

To address these issues, this paper answers the following research questions: ***RQ1****: How well do different interactive element types align with distinct learning objectives in video-based learning?* ***RQ2****: What is the rationale behind this alignment?* We followed a mixed methods approach including a quantitative study and a design thinking workshop. It focused on three prominent interactive element types: *quizzes*, *annotations*, and *navigation* features, which have each been subdivided into three subtypes. In the quantitative part, elements of these subtypes were integrated into sections of video lectures. Students rated the perceived alignment with the respective contents, which had been a-priori categorized according to the underlying learning objective. Using ANOVA analyses, we compared the alignment ratings for these learning objectives. The workshop provided additional insights into the rationale behind the alignment of the interactive elements and the overall design of VBL.

Our study provides a novel perspective on VBL. It complements existing research with a proposal on how to align interactive elements with specific learning objectives. The results show that students appreciate the inclusion of interactivity in VBL – regardless of the element type or the learning objective. However, the insights also show how nuanced students rate the alignment of element types for contents following distinct learning objectives. Overall, quizzes were rated best, followed by annotations and navigation features for most learning objectives. In detail, quizzes appear as the most suitable for different purposes, annotations seem never unsuitable but only needed on higher complexity levels, and navigation features were seen as merely nice-to-have. Based on the presented insights, the study provides an evolutionary step for VBL, in which the advantages of interactive elements get combined with the objective-oriented design of learning resources. The resulting understanding of interactive elements can benefit educators and scholars and advance discussions on best practices in online education. It finally provides avenues for future research and improvements of VBL tools.

2 Theoretical Background and Related Work

2.1 Interactive Elements in Video-based Learning

The advent of VBL through interactive videos in education has paved the way towards more learner-centered education (Sablić et al., 2020). Pleasant educational experiences with improved learning performance can especially be attributed to interactive videos enriched with different interactive element types (Palaigeorgiou et al., 2019, Wachtler et al., 2016). Among them, *quizzes*, *annotations*, and *navigation* features are prevalent (Palaigeorgiou et al., 2019). They are well-known by VBL consumers, easily implementable with tools like H5P, and provide different modes of action.

Quizzes serve as a valuable formative assessment tool (Zainuddin et al., 2020). They challenge students' knowledge and promote information recall. Thus, studies indicate a positive effect on learning performance (e.g., Palaigeorgiou et al., 2019, Vural, 2013, Weinert et al., 2021). Regarding subtypes, quizzes can differ in terms of their method of answering. Answers can be *selected* in form of multiple-choice quizzes. In *input* quizzes, answers must be manually entered for cloze or calculation tasks. Finally, answers can be *assigned* to pre-defined objects or terms in drag-and-drop style quizzes.

Annotations and signaling mechanisms draw students' attention to critical information, thus facilitating information processing. Therefore, annotations contribute to improved learning performance (e.g., Althwaini and Mahmoud, 2021, Palaigeorgiou et al., 2019). Subtypes of annotations can differ in terms of the additional stimulus they provide. *Highlighting* is the first subtype, where existing content gets additional marking in a time-controlled way. Examples include pointers and text markings. Beyond that, *add-ons* can provide additional content in the form of pop-ups. Finally, *motivation* cues try to address the students directly to keep them engaged and motivated.

Navigation features enable students to personalize their learning (Meixner, 2014, Palaigeorgiou et al., 2018). This approach supports self-regulated learning, thereby positively impacting learning performance (Cattaneo et al., 2015, Palaigeorgiou et al., 2018). Navigation features can differ in terms of their respective direction. Features to *repeat* already-seen content may be used to ensure that students are on track. Conversely, navigation can be used to *skip* content that is already known. Finally, *external* resources and further material can be the destination of advanced navigation.

2.2 Revised Bloom's Taxonomy

To guide the design of educational courses and resources (e.g., video lectures), literature recommends focusing on learning objectives. Several taxonomies have been proposed to delimit such objectives. Bloom's taxonomy is among the most established and prominent ones and has been revised in recent years (Anderson and Krathwohl, 2001). This RBT provides a detailed and well-defined delimitation along the cognitive process as well as the knowledge dimension.

The *knowledge* dimension classifies learning objectives according to subject matter, reflecting information about a certain field. *Factual knowledge* encompasses the key elements of a discipline, such as terminology. *Conceptual knowledge* is more intricate, enabling students to articulate concepts, or frameworks in their own words. *Procedural knowledge* details a sequence of steps or subject-specific methods to conduct a task. *Metacognitive knowledge* encompasses the cognition of one's learning process.

The *cognitive process* dimension includes six levels specifying what is to be done with or to a piece of content for learning purposes. *Remember* involves recognizing and recalling. *Understand* requires determining the meaning of instructional messages by interpreting or classifying information. *Apply* demands the execution of known procedures in novel situations. *Analyze* involves breaking content into parts and understanding their relationships. *Evaluate* necessitates making judgments based on knowledge of applicable criteria. *Create* entails reorganizing elements into a novel, coherent whole. The complexity of each level varies, with *remember* being less complex than higher cognitive processes such as *create* (Anderson and Krathwohl, 2001, Krathwohl, 2002).

The RBT's two-dimensional perspective creates a taxonomy table, with each intersection of the two dimensions forming a distinct *learning objective*. Thereby, it offers a concise representation of courses and resources (Krathwohl, 2002, Oliveira, 2012).

2.3 Previous Research on Interactive Videos and RBT

Prior research in digital education has shown that VBL improves learning performance when compared to traditional classroom instructions (e.g., Merkt et al., 2011, Zhang et al., 2006). Thereby, interactive element types have been studied, emphasizing their largely beneficial influence on learning (e.g., Althwaini and Mahmoud, 2021, Cattaneo et al., 2015, Raab et al., 2023, Vural, 2013). Previous studies also showed that the RBT has practical uses in implementing comprehensive teaching approaches that align educational resources with intended learning objectives. The RBT thereby effectively assists educators in designing lecture content (e.g., Brok, 2019, Oliveira, 2012, Siva-Kumar, 2023). Furthermore, the usage of the RBT may guide VBL in flipped classroom setups (e.g., Siva-Kumar, 2023, Zainuddin et al., 2019).

While both aspects are well understood individually, the alignment between interactive elements and learning objectives has not yet been systematically researched. By now, the usage of interactive elements in VBL is primarily driven by personal experiences, often resulting in a non-targeted use of interactive elements (Brame, 2016). Educators lack clarity regarding which interactive element supports students in pursuing a certain learning objective. For a more deliberate design of interactivity in VBL, insights into the suitability of different interactive elements are needed. We thus provide a thorough understanding of which interactive elements align best to aid the teaching of distinct learning objectives based on students' perceptions.

Our study is inspired by the task-technology fit (TTF) theory, which investigates the fit between the characteristics of a task and the features of a technology used to perform or support that task (Goodhue and Thompson, 1995). TTF appears relevant in education as digital technologies play a key role in facilitating the learning experience (Alyoussef, 2021, Cheng, 2019). The center of TTF theory denotes the *Fit* between task and technology (Goodhue and Thompson, 1995). The impact of the technology (i.e., interactive element) on the learning experience, as a means of perceived fit, depends on how well it aligns with the requirements of the task (i.e., teaching the learning objective).

3 Mixed Method Approach

3.1 Quantitative Study

In an empirical study, we employed statistical analyses to explore how well different interactive element types align with the respective learning objective. The study covered three weeks in the 2023 summer semester. The content was pre-defined as 68 slides (sections) from the lecture notes. We recorded videos featuring the slides and a referent screen next to them. Each video section incorporated one interactive element. Information systems (IS) master students rated the alignment with the respective contents.

To classify the contents, two researchers (coders) independently analyzed each section. A coding manual instructed them on how to identify learning objectives based on the slide content and the referent's spoken explanations. Thereby, we applied Anderson and Krathwohl (2001), such that a learning objective is described by a verb (cognitive process) and an object (knowledge). For example, a section teaching a "definition of objectives for ERP system deployment" has been classified as *remember-factual* as students need to *recall* (cognitive process) *basic definitions* (knowledge). After independent coding, the two coders achieved consensus on 62 of the 68 sections, resembling a Cohen's Kappa of 0.890 (Landis and Koch, 1977). The remaining six sections were discussed in a roundtable session until a consensus was reached. Overall, we did not observe sections teaching *metacognitive* knowledge or the cognitive processes *analyze*, *evaluate*, and *create*. There is an accumulation at the *understand-conceptual* intersection (see Table 1). However, we found sections for each remaining learning objective.

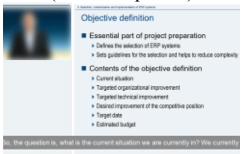
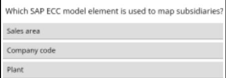
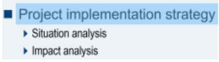
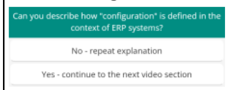
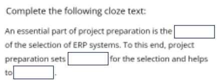
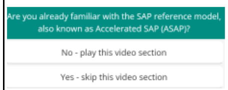
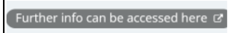
Table 1. Distribution of interactive element types with respect to learning objectives

Knowledge level	Cognitive process dimension																											Σ
	Remember									Understand									Apply									
	Quiz			Anno			Navi			Quiz			Anno			Navi			Quiz			Anno			Navi			
	S	I	A	H	A	M	R	S	E	S	I	A	H	A	M	R	S	E	S	I	A	H	A	M	R	S	E	
Factual		1		1					1			1			1	1	1		1				1					**9**
Conceptual	1*	1	1	2	1	1	1	1	1	4	3	3	3	3	3	3	3	3	1		1	1	1		1	1	1	**45**
Procedural			1		1						1				1			1	1	1	1	1	1	1	1	1	1	**14**
Σ	**15**									**35**									**18**									**68**

Note: **Quiz**zes (**S**elect, **I**nput, **A**ssign), **Anno**tation (**H**ighlight, **A**dd-on, **M**otivation), **Navi**gation (**R**epeat, **S**kip, **E**xternal); digits = number of video sections; * = video section removed due to technical issues

The course provided videos for each week's lecture, covering the topics of production management and ERP system selection, customization, and deployment. Each video's basic setup included standard play-pause-speed buttons, a table of contents, and a scrubbable timeline. Each video section additionally incorporated one interactive element implemented in H5P (https://h5p.com). The elements were delineated along the types and subtypes described in section 2.1 and are summarized in Table 2. The nine subtypes were randomly assigned to the 68 video sections. To maintain even distribution, we exchanged single sections if needed. As displayed in Table 1, we tried to feature each element type at least once per learning objective. Only *navigation* could not be used in *apply-factual* and *remember-procedural* due to the low number of respective sections.

Table 2. Exemplary implementations for each interactive element subtype

Video section	Quizzes	Annotations	Navigation
Referent screen + slide + spoken explanations (closed captions)  Learning objective: *remember-factual*	Select 	Highlight 	Repeat 
	Input 	Add-on 	Skip 
	Assign 	Motivation 	External 

Students were invited to the voluntary study via the course platform. Participants received a small number of bonus points for their exam score (up to 1.5 out of 90 points). Each student viewed the same interactive videos. After each video section, students were asked to rate the perceived alignment of the interactive element with the learning content on a 7-point Likert scale: *"The interactive element aligns well with the learning content"*. During analysis, we had to remove records of one section due to technical issues. We also excluded data sets when students finished a video in less than half of the runtime and due to straight lining, suggesting a lack of serious effort. Our final dataset comprised 2,121 records for 67 video sections.

To answer our research questions, we took an explorative stance. Thus, to identify statistically significant differences in the subjective alignment between the three interactive element types and the nine learning objectives, we conducted a multi-factor (two-way) ANOVA with the alignment rating as the dependent variable and the interactive element type and the learning objective as the two independent variables. If the interaction term is significant and to understand in more detail how the interactive element types align with each of the nine learning objectives, we conducted one-way ANOVA analyses with the alignment ratings as the dependent and the interactive element type as the independent variable. While these analyses reveal differences among group means, Tukey HSD post hoc tests inform about the pairwise comparisons of each type.

3.2 Workshop

The second element of our mixed-methods approach was a design thinking workshop with students of the same IS master course. It helps understand *why* different interactive elements align with specific learning objectives. Again, volunteers were recruited via the course platform and the only extrinsic motivators were pizza and beverages. Design thinking is especially suited to understand complex problems and find innovative solutions (Brown, 2008, Plattner et al., 2011). The focal problem to be addressed was to improve the integration of interactive elements in VBL. The workshop was organized along the Double Diamond method (Design Council, 2023). In the problem phase, participants jointly *discovered* and *defined* their experiences and problems with VBL. For the ideation phase, participants were assigned to two groups. Both were provided with the same nine familiar video sections, each reflecting a distinct learning objective, unknown to the participants. After analyzing them, the groups discussed how well element subtype(s) would align with each learning content and why. The groups *developed* ideas and *delivered* interactive element prototypes. Finally, results were jointly discussed.

Data was collected in several ways. For each group, a non-intervening observer took notes of the discussions, photos of whiteboards, paper prototypes, etc. Also, we recorded each group and transcribed their conversations. Two researchers inductively and iteratively developed categories and coding rules from the data. These are applied to analyze the developed ideas and delivered prototypes regarding their alignment. After independent coding, the results were compared and discussed to resolve conflicts and summarized in a roundtable session (Mayring and Fenzl, 2019).

4 Results

4.1 Quantitative Study Results

We had 49 individual participants over the course of the three-week study period (20 female, 29 male, average age 26.2 years). The left-hand side of Table 3 summarizes the mean alignment ratings of element types with respect to the individual learning objectives. We highlighted the values in a heatmap-like coloring ranging from red for the minimum value of all our analyses (4.222) to green for the maximum value (6.500). The findings indicate that students overall saw *quizzes* as the best aligning interactive element type, followed by *annotations* and *navigation* features. Due to the low number of video sections coded as *remember-procedural* and *apply-factual*, we cannot provide data for all interactive element types there. These apparent insights are backed by the multi-factor ANOVA results, which indicate significant main effects for interactive element types ($F(2, 2096) = 6.04, p < 0.001$), learning objectives ($F(8, 2096) = 83.84, p < 0.001$), and a significant interaction between both, ($F(14, 2096) = 2.22, p < 0.01$).

Table 3. Mean alignment ratings (left) and one-way ANOVA plus Tukey HSD results (right)

Learning objective		Element type			One-way ANOVA	Tukey HSD		
Cognitive process	**Knowledge level**	**Quiz**	**Anno**	**Navi**	**F-Value**	**Quiz – Anno**	**Quiz – Navi**	**Anno – Navi**
Remember	Factual	4.963	4.926	4.857	$F\,(2, 79) = 0.03^{ns}$	0.105^{ns}	0.037^{ns}	0.068^{ns}
	Conceptual	6.258	4.829	4.630	$F\,(2, 261) = 22.42^{***}$	1.429^{***}	1.628^{***}	0.199^{ns}
	Procedural	6.393	5.321	–	$F\,(1, 54) = 7.56^{**}$	1.071^{**}	–	–
Understand	Factual	6.385	4.444	4.934	$F\,(2, 124) = 12.43^{***}$	1.940^{***}	1.450^{***}	-0.489^{ns}
	Conceptual	5.927	4.898	4.960	$F\,(2, 894) = 34.93^{***}$	1.029^{***}	0.967^{***}	-0.062^{ns}
	Procedural	6.077	4.821	4.714	$F\,(2, 92) = 9.86^{***}$	1.255^{**}	1.363^{***}	0.107^{ns}
Apply	Factual	6.033	5.600	–	$F\,(1, 58) = 1.26^{ns}$	0.433^{ns}	–	–
	Conceptual	5.323	5.177	4.923	$F\,(2, 212) = 0.97^{ns}$	0.145^{ns}	0.400^{ns}	0.254^{ns}
	Procedural	6.357	5.585	5.231	$F\,(2, 322) = 19.50^{***}$	0.772^{***}	1.126^{***}	0.354^{ns}

^{ns} = non-significant, * p<0.05, ** p<0.01, *** p<0.001, **Quiz**zes, **Anno**tation, **Navi**gation

The right part of Table 3 displays the one-way ANOVA analyses with alignment ratings as dependent and interactive element type as independent variable for each learning objective. For instance, it shows a significantly differing alignment of element types for *understand-conceptual*. The pairwise comparison via Tukey HSD reveals that the alignment of *quizzes* significantly exceeds the ones of *annotations* and *navigation* in this case. Similar results can be seen for most other learning objectives. Only for *remember-factual*, *apply-factual*, and *apply-conceptual*, we could not report significant differences. Thus, *quizzes* mostly outperformed the two other element types. Comparing the alignment of *annotations* and *navigation*, we found no significant differences.

Besides the aggregated perspective on element types, we also took an in-depth look at their respective subtypes. To obtain meaningful values with the level of detail in this dimension, we had to aggregate on the learning objective dimension. Thus, we present the mean alignment ratings of element subtypes separately for each cognitive process and knowledge level in Table 4. We had to remove a video section's record embedding multiple-choice quizzes and cannot report data for the subtype *quiz-select* concerning *remember*. The results show that each element subtype has a positive alignment rating (above 4 on the 7-point Likert Scale). The colored cells further indicate that the *quiz* subtypes have a better alignment compared to each annotation and navigation subtype. Overall, it appears that the alignment of most element subtypes improves with higher levels of cognitive process and knowledge. Due to page limitations, we cannot provide ANOVA and Tukey HSD analyses for all dimensions of this detailed view.

Table 4. Mean alignment ratings for interactive element subtypes

Element type		**Quizzes**			**Annotation**			**Navigation**		
Element subtype		Select	Input	Assign	Highl.	Add-on	Motivat.	Repeat	Skip	External
Cognitive process	Remember	–	5.723	6.321	4.860	5.018	4.933	4.963	4.222	4.782
	Understand	5.902	5.906	6.157	4.954	5.433	4.432	5.203	4.849	4.742
	Apply	5.889	6.500	5.886	5.356	5.530	5.436	5.000	5.015	5.232
Knowledge level	Factual	6.033	4.963	6.385	4.926	5.600	4.444	5.067	4.806	4.857
	Conceptual	5.734	5.961	5.980	4.965	5.237	4.462	5.115	4.757	4.804
	Procedural	6.395	6.286	6.269	5.464	5.612	5.179	5.214	5.105	5.091

4.2 Workshop Results

During the workshop, eight participants (5 female, 3 male, average age 25.5 years) praised VBL for its flexibility of location and time. Yet, they also criticized the lack of social contacts, potential boredom, and slow progress, i.e., in lengthy videos. Generally, the integration of interactive elements was seen as beneficial in encouraging students to completely watch the videos. Next, we illustrate how participants recommended to utilize each *interactive element subtype* across the nine video sections, which each reflected a distinct *learning objective*. Thereby, we also address RQ2 of this study.

Quizzes were the most frequently implemented element type. Overall, *quizzes* also appear to be the best-aligning interactive elements in VBL. For each video section, one form of a quiz was suggested at least once. Thereby, students liked their challenging nature (information recall and reflection) and the need for active participation. The subtype *quiz-select* was suggested mostly for sections on the lower levels *remember* and *factual*. They were found especially suited to query definitions or comparably limited contents. However, students also criticized them as potentially boring. *Quiz-input* was often rated as somewhat difficult due to the lack of predefined answer options. Yet it was deemed suitable for higher complexity tasks. Only for the *apply-procedural* section, both groups implemented this subtype. Instead of a cloze task, it was used in form of a calculation task with the solution submitted via an input. Overall, *quiz-assign* was seen as suitable in all sections, with only slight losses on the *procedural* level. Students enjoyed their playful character, the option to link different aspects and include graphics. They found it useful to cover more complex content compared to *quiz-select*.

Annotations were similarly often implemented and perceived as useful, well-aligned additions. For eight of the nine sections, at least one group suggested some kind of annotation. Students especially liked their guiding character (drawing attention to critical information) and praised the option to complement existing or complex content. *Annotation-highlight* was suggested mostly on the higher levels *apply* and *procedural*. It was found suitable to guide viewers through long or complex content and to connect related content from text, figures, and tables. *Annotation-add-on* was mostly suggested for sections on the *factual* level but discussed for all others, too. They were typically used to provide graphical processions of the content or to complement it with practical examples or additional information. Notably, students preferred action buttons for optional add-ons over pop-ups. Finally, *annotation-motivation* was rarely implemented. One group only discussed it for a single section, and the other suggested it mostly on the *understand* level. They found it useful to direct the viewer's focus, thereby keeping up their engagement with complex contents and loosen up text-heavy or long sections.

Navigation features were seen considerably less positively and often discarded in favor of other element types. Students liked the idea of increased individuality (self-regulated learning) but did not see sufficient value in these features. Only *navigation-repeat* was frequently considered beneficial. One group discussed it for one section, the other for multiple ones, especially on the *understand* level. They recommended it only for highly relevant content to check if the viewer is ready to continue. *Navigation-skip* was seen even more skeptically and only discussed for individual sections in both groups. Most students agreed they were too worried about missing relevant content if they skipped a section, even if they had previously gained knowledge about the skippable content. Therefore, the feature would be unnecessary and rather distracting. *Navigation-external* was suggested by only one group for a single section. Students mentioned that external resources had low value and may be confusing because of the context switch. Instead, they rather suggested to retain the original video context, while for complementary content, they preferred *annotation-add-on* within the video.

5 Discussion

5.1 Key Findings

Our results provide several insights into the alignment between learning objectives and interactive element types. Every interactive element subtype was positively evaluated (above 4) across all RBT levels, underscoring their broad alignment. The workshop participants highlighted the universal benefit of interactivity, too. This confirms extant literature promoting interactive elements in VBL (Palaigeorgiou et al., 2019, Wachtler et al., 2016). Beyond that, we showed that most interactive elements' alignment increases with the learning objective complexity. For instance, interactivity seems more useful in supporting students to *apply procedural* than to *remember factual* knowledge.

Comparing the interactive element types, the quantitative results indicate a significant dominance of *quizzes* as the best-aligning. Between *annotations* and *navigation* features, no significant difference was apparent. The workshop results might somewhat strengthen the role of *annotations* as they received the mostly same positive approval as *quizzes*. We assume that *annotations* have likely received lower ratings during "run time" in the quantitative study due to their passive character, fostering less direct engagement. In the workshop during "build time", students often appreciated the theoretical and practical usefulness of *annotations* (e.g., Althwaini and Mahmoud, 2021). Despite the still positive but low alignment ratings for *navigation* features, workshop participants often neglected them in favor of other types that appeared more valuable.

Diving into the distinct interactive element types, we also revealed differences in the alignment of their respective subtypes. These detailed insights from both the quantitative study and the workshop have been summarized in Table 5. Interestingly, certain subtypes like *quiz-select* appear especially suited for lower complexity levels. Therefore, they contrast the overall picture of increasing alignment with higher complexity. Despite the equal underlying effect, e.g., formative assessment for *quizzes* (Zainuddin et al., 2020), this points towards deviations within the element types. It appears that an interactive element's precise presentation and mode of action might be comparably important to assess its alignment with distinct learning objectives.

Table 5. Alignment of interactive element subtypes with respect to learning objectives

Knowledge level	**Cognitive process dimension**																										
	Remember									**Understand**									**Apply**								
	Quiz			Anno			Navi			Quiz			Anno			Navi			Quiz			Anno			Navi		
	S	I	A	H	A	M	R	S	E	S	I	A	H	A	M	R	S	E	S	I	A	H	A	M	R	S	E
Factual	+	o	+	o	+	-	o	-	-	+	o	+	o	+	-	o	-	-	+	o	+	+	+	-	o	-	-
Conceptual	+	o	+	o	o	-	o	-	-	+	+	+	o	o	-	o	-	-	o	+	+	+	+	o	o	o	o
Procedural	+	o	+	+	o	-	o	-	-	o	+	+	+	o	o	o	o	o	o	+	+	+	+	o	o	o	o

Note: **Quiz**zes (**S**elect, **I**nput, **A**ssign), **Anno**tation (**H**ighlight, **A**dd-on, **M**otivation), **Navi**gation (**R**epeat, **S**kip, **E**xternal); + = very well-aligned, **o** = well-aligned, **-** = aligned, but not as useful as other subtypes

The above findings highlight the alignment of interactive element types with distinct learning objectives in VBL (***RQ1***). Section 4.2 and our discussion also shed light on the rationale behind this alignment (***RQ2***). Beyond that, the workshop results provide further insights into VBL. First, complexity is not only perceived in terms of cognitive processes and knowledge but also in terms of content formatting. Slides with text, figures, and tables might call for more interactivity than slides with only short key points. Second, participants recommended considering the context of multiple slides to better align interactive elements with the broader learning objectives of lessons, chapters, or courses. However, our study design required video sections for individual slides. Third, a certain variety of interactive elements within videos is suggested, rather than solely relying on, e.g., the best-aligning *quiz-assign*, to ensure optimal engagement. Combining multiple elements was also suggested but with caution not to overwhelm learners.

5.2 Implications for Academia and Educational Practice

Our study holds several implications. From an academic perspective, we account for a novel combination of educational research, VBL, and the integration of interactive elements. Using taxonomies like RBT is recommended to guide the development of video lectures (e.g., Siva-Kumar, 2023, Zainuddin et al., 2019). Yet, research lacks the consideration of learning objectives in implementing interactive elements in VBL. Our study is the first to address this research gap by systematically investigating the alignment of distinct element (sub)types for contents following distinct learning objectives. This offers novel insights for educational research in higher education. Our approach also facilitates the identification of interactive elements that support students in pursuing a specific learning objective. This provides an initial step towards an evidence-based framework for the objective-oriented design of interactive video lectures. Given that *annotations* and especially *quizzes* show not only better alignment but also greater learning performance than navigation features (e.g., Raab et al., 2023), it could be inferred that a higher alignment may also be indicative of the element type's effect on learning. Future research should explore this assumption.

Our study also corroborates previous studies, emphasizing the largely beneficial influence of interactive elements in VBL (e.g., Cattaneo et al., 2015, Raab et al., 2023). However, most studies examined the effects of interactive elements as a whole. They arbitrarily combine different element types, neglecting their individual effects (e.g., Jacob and Centofanti, 2023, Kartimi et al., 2023). Some studies at least differentiate on the level of element types (Raab et al., 2023), which still resembles a rough distinction. Our study adds an additional layer by dividing element types like *quizzes*, *annotations*, and *navigation* into three subtypes each. This enabled us to show how nuanced students perceive alignment. Due to apparent differences even on this level, we advocate for a more distinctive selection and analysis of interactive elements in VBL.

Summing up, our mixed-methods design helped us gain a more intricate understanding of *how* and *why* different interactive element types, including their subtypes, align with the respective learning objectives. Overall, we showed that distinct kinds of quizzes are most-suitable for different purposes, annotations are never unsuitable but only needed on higher complexity levels, and navigation features are merely nice-to-have. Beyond that, our exploratory approach may give inspiration for future research endeavors. They include a complexity dimension of content formatting, the context of multiple slides, and the variety and combination of multiple interactive elements.

From a practical perspective, our results offer guidance for the objective-oriented design of interactive videos. Previous research shows how the RBT helps educators develop lecture content, such as educational videos in flipped classrooms (e.g., Siva-Kumar, 2023, Zainuddin et al., 2019). However, using interactive elements in VBL often relies on personal experience, with vague recommendations on optimal timing (e.g., Jacob and Centofanti, 2023, Kartimi et al., 2023). In this regard, our study provides new recommendations and rationales on when specific interactive element subtypes are suitable for content with distinct learning objectives. Consequently, when educators employ RBT to create learning resources, our findings additionally facilitate the transformation of educational videos into well-aligned interactive videos. This approach supports students' needs better than arbitrary element selection (Brame, 2016). It represents an evolutionary step for VBL, combining the benefits of interactive elements with objective-oriented design. Due to the generalizability of both aspects, we expect our results to be transferrable beyond the considered IS course. Also, VBL system vendors can utilize our insights to improve existing elements and design new ones. Their tools could also support the categorization of video sections according to RBT, leading to decision support systems that recommend suitable interactive elements for specific learning objectives. Overall, we advance discussions on best practices in VBL.

6 Limitations and Concluding Remarks

The results are not free of limitations. Regarding interactive element types, we concentrated on the three most prominent ones with their respective subtypes. Less often used element types could not be included. Regarding video sections, we used existing video lectures. This resulted in a realistic sample but limited the even distribution across learning objectives, such that the frequency of video sections for *understand conceptual* was above average. This follows the RBT, which also states it as one of the most common learning objectives (Anderson and Krathwohl, 2001). Still, it prevented us from collecting data for all possible combinations of learning objective and element subtype. For the classification of video sections, we decided to use the RBT as the most common framework. However, other frameworks or alternative approaches like the ones discussed at the end of section 5.1 can add interesting insights. Finally, our quantitative results are based on a limited sample of one master's course in the IS context. Given the universally applicable nature of the RBT and interactive elements in video lectures, they appear rather generalizable. However, we could not obtain enough data for significance tests for all combinations of learning objective and interactive element subtype.

Despite these limitations, we hope to provide a valuable contribution to the field of VBL. The provided understanding of interactive elements can benefit educators and scholars and advance discussions on best practices in VBL, as our results give guidance for the objective-oriented design of interactive video lectures. We provide recommendations and a rationale on which interactive elements are suitable for a given learning objective. Our findings thus provide a starting point for future endeavors in this domain.

7 Acknowledgements

This study has been funded by the "Innovation in der Hochschullehre" foundation as part of the "Digitale Kulturen der Lehre entwickeln (DiKuLe)" project.

References

Althwaini, S. N. and Mahmoud, S. M. (2021). 'The Effect of the Number of Hints Accompanying Content in Interactive Videos on Achieving Some Learning Outcomes for Female Students in Hail Schools', *International Journal of Advanced and Applied Sciences* **8**(3), 120-129.

Alyoussef, I. Y. (2021). 'E-Learning Acceptance: The Role of Task–Technology Fit as Sustainability in Higher Education', *Sustainability* **13**(11), 1-15.

Anderson, L. W. and Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives,* Longman. New York.

Brame, C. J. (2016). 'Effective Educational Videos: Principles and Guidelines for Maximizing Student Learning from Video Content', *CBE - Life Sciences Education* **15**(6), 1-6.

Brok, D. (2019). A Framework for Teaching Conceptual Modeling and Metamodeling Based on Bloom's Revised Taxonomy of Educational Objectives, *in* 'Proceedings of the 52nd Hawaii International Conference on System Sciences'.

Brown, T. (2008). 'Design Thinking', *Harvard Business Review* **84**(6), 84-92.

Cattaneo, A., Nguyen, A. T., Sauli, F. and Aprea, C. (2015). 'Scuolavisione: Teaching and Learning with Hypervideos in the Swiss Vocational System', *Journal of e-Learning and Knowledge Society* **11**(2), 27-47.

Chen, Y.-T. (2012). 'The Effect of Thematic Video-Based Instruction on Learning and Motivation in E-Learning', *International Journal of the Physical Sciences* **7**(6), 957-965.

Cheng, Y.-M. (2019). 'How Does Task-Technology Fit Influence Cloud-Based E-Learning Continuance and Impact?', *Education + Training* **61**(4), 480-499.

Design Council (2023). 'The Double Diamond - a Universally Accepted Depiction of the Design Process'.

Goodhue, D. L. and Thompson, R. L. (1995). 'Task-Technology Fit and Individual Performance', *MIS Quarterly* **19**(2), 213-236.

Jacob, T. and Centofanti, S. (2023). 'Effectiveness of H5p in Improving Student Learning Outcomes in an Online Tertiary Education Setting', *Journal of Computing in Higher Education*.

Kartimi, K., Chandra, E. and Riyanto, O. R. (2023). 'The Influence of H5p Interactive Video on Stereoisomer Understanding in Terms of Learning Style', *Jurnal Pendidikan IPA Indonesia* **12**(3), 451-459.

Krathwohl, D. R. (2002). 'A Revision of Bloom's Taxonomy: An Overview', *Theory Into Practice* **41**(4), 212-218.

Landis, J. R. and Koch, G. G. (1977). 'The Measurement of Observer Agreement for Categorical Data', *Biometrics* **33**(1), 159-174.

Mayring, P. and Fenzl, T. (2019). Qualitative Inhaltsanalyse, in Baur, N. and Blasius, J. (Eds.) *Handbuch Methoden Der Empirischen Sozialforschung.* Springer VS. Wiesbaden, pp. 633-648.

Meixner, B. (2014). 'Annotated Interactive Non-Linear Video - Software Suite, Download and Cache Management', *Fakultät für Informatik und Mathematik.* Universität Passau.

Merkt, M., Weigand, S., Heier, A. and Schwan, S. (2011). 'Learning with Videos Vs. Learning with Print: The Role of Interactive Features', *Learning and Instruction* **21**(6), 687-704.

Oliveira, M. (2012). Using the Revised Bloom's Taxonomy to Scaffold Student Learning in Business Intelligence/Business Analytics, *in* 'Proceedings of the 20th European Conference on Information Systems'.

Pal, D. and Patra, S. (2020). 'University Students' Perception of Video-Based Learning in Times of Covid-19: A Tam/Ttf Perspective', *International Journal of Human-Computer Interaction* **37**(10), 903-921.

Palaigeorgiou, G., Chloptsidou, I. and Lemonidis, C. (2018). Computational Estimation in the Classroom with Tablets, Interactive Selfie Video and Self-Regulated Learning, *in* 'Proceedings of the Interactive Mobile Communication Technologies and Learning', pp. 475-486.

Palaigeorgiou, G. and Papadopoulou, A. (2019). 'Promoting Self-Paced Learning in the Elementary Classroom with Interactive Video, an Online Course Platform and Tablets', *Education and Information Technologies* **24**, 805-823.

Palaigeorgiou, G., Papadopoulou, A. and Kazanidis, I. (2019). Interactive Video for Learning: A Review of Interaction Types, Commercial Platforms, and Design Guidelines, in Tsitouridou, M., A. Diniz, J. and Mikropoulos, T. (Eds.) *Technology and Innovation in Learning, Teaching and Education.* Springer, Cham, pp. 503-518.

Plattner, H., Meinel, C. and Leifer, L. (2011). *Design Thinking - Understand – Improve – Apply,* Springer Berlin, Heidelberg.

Raab, M., Weidinger, J., Hirschlein, N., Meckenstock, J.-N., Thron, L. and Ulbricht, E. F. (2023). Understanding the Effectiveness of Interactive Elements in Video-Based Learning: An Experimental Study, *in* 'Proceedings of the 18th International Conference on Wirtschaftsinformatik'.

Sablić, M., Mirosavljević, A. and Škugor, A. (2020). 'Video-Based Learning (Vbl) - Past, Present and Future: An Overview of the Research Published from 2008 to 2019', *Technology, Knowledge and Learning* **26**(4), 1061-1077.

Siva-Kumar, A.-K. (2023). 'Augmenting the Flipped Classroom Experience by Integrating Revised Bloom's Taxonomy: A Faculty Perspective', *Review of Education* **11**(1), 1-28.

Vural, Ö. F. (2013). 'The Impact of a Question-Embedded Video-Based Learning Tool on E-Learning', *Educational Sciences: Theory & Practice* **13**(2), 1315-1323

Wachtler, J., Hubmann, M., Zöhrer, H. and Ebner, M. (2016). 'An Analysis of the Use and Effect of Questions in Interactive Learning-Videos', *Smart Learning Environments* **3**(13), 1-16.

Weinert, T., Benner, D., Dickhaut, E., Janson, A., Schöbel, S. and Leimeister, J. M. (2021). 'Unterstützung Digitaler Bildungsprozesse Durch Interaktive Gamifizierte Lernvideos – Wie Innovative Lernvideos Motivation Und Lernerfolg Steigern Können', *HMD Praxis der Wirtschaftsinformatik* **58**(6), 1483-1503.

Zainuddin, Z., Hermawan, H. D., Nuraini, F., Prayitno, S. M. and Probowasito, T. (2019). 'Flipping the Classroom with a Lms: Designing a Technologybased Learning Model', *Journal of Education and Learning* **13**(3), 309-317.

Zainuddin, Z., Shujahat, M., Haruna, H. and Chu, S. K. W. (2020). 'The Role of Gamified E-Quizzes on Student Learning and Engagement: An Interactive Gamification Solution for a Formative Assessment System', *Computers & Education* **145**, 1-15.

Zhang, D., Zhou, L., Briggs, R. O. and Nunamaker, J. F. (2006). 'Instructional Video in E-Learning: Assessing the Impact of Interactive Video on Learning Effectiveness', *Information & Management* **43**(1), 15-27.