An Assessment of Learners' Needs Regarding Learning Videos and Immersive Learning Environments

Ingrid Wahl[1,2*], Stefanie Kuso[3] & Barbara Wimmer[4]

[1] Department of Communication, University of Vienna, Austria

[2] Business Administration & Psychology Bachelor, FernFH Distance-Learning University of Applied Sciences, Vienna, Austria

[3] Aging Services Management Bachelor; FernFH Distance-Learning University of Applied Sciences, Vienna, Austria

[4] E-Learning & Web-Support Center; FernFH Distance-Learning University of Applied Sciences, Vienna, Austria

Abstract

Background: Learning videos are widely used in education and theory-based design principles are established. To derive design recommendations for learning material, however, potential users should be involved. Immersive learning environments (e.g., augmented reality, virtual reality) are new and there are no recommendations for their use yet.

Objective: This paper focuses on the learners' perspectives and explores learners' needs regarding learning videos and immersive learning environments, to examine their fit with established design principles and to derive additional design recommendations. Furthermore, we aimed to identify suitable application contexts.

Methods: In total, 14 current and former students participated in two online focus groups. They were asked about their usage habits regarding learning videos and what are potential areas of immersive learning material for their studies. Thematic analysis was used to identify relevant themes.

Results: Results indicate that some of the established design principles might be frequently violated, as they are often mentioned. Additional recommendations concern mostly the user interface, but also didactics, and instructions. Learning videos are mainly used for demanding and dry subjects, when a different approach is needed, or to catch up on lacking previous knowledge. Being someone else, being somewhere impossible, and being involved were identified as suitable applications for immersive technologies.

Conclusion: Experience with immersive learning technologies is scarce among students, nonetheless they have ideas about how immersive learning environments could support their learning activities. The recommendations presented should be implemented and their effect on learning outcomes should be empirically tested.

Keywords: immersive learning, designing principles, multimedia learning, virtual reality, augmented reality

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1 Introduction

When videos emerged as elearning tools, they promised advantages compared to text-based elearning, as they offer the possibility to display dynamic contents, to vividly illustrate situations and procedures, and to illustrate things that are otherwise difficult to observe (Petko & Reusser, 2005). The vast developments in information and communication technology provide learners with even more possibilities to change perspectives and to interact with learning materials, allowing them to fully immerse in learning environments.

Immersive learning environments (ILE) are mostly implemented as virtual reality (VR) or as augmented reality (AR). VR uses a head mounted device which in its simplest form allows viewers of a video to look in all directions or in a rather advanced form allows the wearer to engage in complete computerized presentations of real or invented worlds. For AR also electronic devices such as smart phones are used in which the real world is enhanced (i.e., augmented) with computerized contents. Examples for the successful implementation in immersive learning range from learning environments in which co-located and remote learners can interact with each other (VR; Gautam et al., 2018) to AR laboratories for teaching mechanics (Kaufmann & Meyer, 2008). ILE are more positively evaluated and learners feel a greater sense of presence than with learning videos (Makransky et al., 2021; Makransky & Petersen, 2019). Also, when students are asked to enact the behavior they should learn in virtual learning environments, they have a better procedural knowledge and can transfer their knowledge better compared to learning videos (Makransky et al., 2021). However, to support learners achieving their learning goals with ILE, these environments need to be carefully designed.

For creating well designed multimedia learning content, various design principles are established by scientists and practitioners. But these principles mainly focus on theoretical assumptions and are only tested experimentally following the development process (Mayer, 2002; Mayer & Moreno, 1998, 2003; Narayanan & Hegarty, 1998). Furthermore, there are no ILE-specific principles available until now. Only when learners are consulted in advance, important features related to learners' needs can be implemented that might be overlooked if only relying on the designers' views. Thus, user-centered design is crucial, i.e. to consider learners' perspectives and needs regarding the design of videos and ILE from the beginning of the development process.

2 Theories on Multimedia Design

Different theories on designing multimedia content for learning and for different media formats emerged over the years. The most prominent theories are the cognitive theory of multimedia learning and its expansion, the cognitive-affective theory of learning with media. The theory of multimedia learning has three assumptions: (a) audio and visual information is processed in two different channels, (b) each channel has a limited capacity, (c) humans are active learners through paying attention to relevant incoming information, organizing this information into coherent mental representations, and integrating the obtained information with previous knowledge (Mayer, 2005; Mayer & Moreno, 1998). For interactive content (i.e., dialoguing, controlling, manipulating, searching, and navigating) the cognitive-affective theory of learning with media suggests four additional assumptions, namely that (d) long term memory consists of past experiences and general knowledge, (e) motivational factors influence cognitive engagement, (f) metacognitive factors regulate cognitive processing and affect, and (g) learners' prior knowledge influences learning outcomes (Moreno & Mayer, 2007).

Another important theory, which specifically focuses on learning dynamic and complex processes like machines or algorithms, is the cognitive process model of multimedia comprehension (Narayanan & Hegarty, 2002). The cognitive process model states that learning should follow four steps. First, complex processes should be decomposed into simpler parts, second, a static mental model through mentally representing the relations between each part should be generated, third, potential causal relationships should be identified, and fourth, a dynamic mental model by mental simulation and inference should be constructed. Prior knowledge and spatial comprehension are assumed to facilitate learning complex processes (Narayanan & Hegarty, 1998).

From these theories and driven from practice (see Cuendet et al., 2013), design principles for learning with multimedia have been developed. Especially, design principles derived from the cognitive theory of multimedia learning and the cognitive-affective theory of learning with media have been found to be valid in a meta-meta-analysis (Noetel et al., 2021). The design principles can be grouped according to whether they concern user interface, didactics, or the instruction of learning material. Figure 1 provides an overview of the derived principles and includes a brief explanation for each and the next section describes how multimedia should be designed according to the principles.

3 Multimedia Design Principles

Design Principles Concerning the User Interface

Especially for educational videos specific principles should be followed concerning the design of the user interface, so that neither the audio nor the visual channel is overloaded and less cognitive resources are bound (Mayer, 2005; Mayer & Moreno, 1998). When videos, for example, show graphics and explanatory written text at the same time, the visual channel is crowded while the audio channel is left empty. Thus, videos should use both pictures and speech to prevent overloading one channel. This applies also when showcasing animations as providing verbal descriptions rather than on-screen text prevents the visual channel from overloading. Accordingly, it is recommended to accompany animations only with verbal descriptions and leaving out on-screen texts (Brame, 2015; Mayer, 2002; Mayer & Moreno, 1998, 2003). Also, in augmented learning environments, it is advised to use less rather than more visualizations and functionalities (Cuendet et al., 2013).

Furthermore, corresponding words and images should be presented in close spatial and temporal proximity to each other. This allows learners to concentrate on the learning material instead of having to search for additional information, thus tying up fewer cognitive resources. To prevent diverting learners' attention from the actual learning material it is suggested to also omit unnecessary images and sounds. This is even true when the additional but unnecessary material is interesting. To further reduce learners' cognitive load and to allocate their attention, the learning material should contain cues on how to select and organize it (Brame, 2015; Mayer, 2002; Mayer & Moreno, 1998, 2003).

Design Principles concerning Didactics

Didactics principles have been developed to guide learning activities, especially for interactive content (Brame, 2015; Mayer, 2002; Mayer & Moreno, 1998, 2003). Pedagogical agents (e.g., cartoon characters), for example, can help directing the cognitive process and therefore help with the selection, organization, and integration of newly learned material. It is further suggested to ask learners to reflect on their actions during the meaning making process to assist them in organizing and integrating new information. To reduce learners' cognitive load, explanations why answers are correct or incorrect should be provided. For the

same reason, learners should have the possibility to control the pace of the learning material's presentation (e.g., next buttons) so that smaller chunks of the learning content can be stored in their working memory (Mayer, 2002; Mayer & Moreno, 1998, 2003).

When learners need to understand dynamic and complex processes, further didactic principles should be applied to guide their learning. Interlocking components are best explained by stating each component separately beforehand, so that the individual parts are already known and the cognitive load of learning the complete material is decreased (Brame, 2015; Mayer, 2002; Moreno & Mayer, 2007). Similarly, it is suggested to use verbal and visual cues to decompose complex processes into small parts so that each part is understood individually before learning the complex process. To support learners in recalling prior knowledge, both verbal and visual cues should be provided and spatial and logical connections between different parts of a process should be explicitly explained (e.g., different perspectives of a machine to show spatial relations). In case that different verbal and visual explanations mean the same thing, this should be stated explicitly (e.g., visually highlighting the parts verbally described). Also, verbal and visual explanations should be implemented to assist learners to understand how each part of a process influences the other parts. Before learners view the actual animation of a complex system, they should be encouraged to mentally simulate the process to improve comprehension. In case that basic knowledge cannot be presupposed, then these basics should be clarified in a separate section and referenced in the main explanation (Narayanan & Hegarty, 1998, 2002).

Design Principles concerning Instruction

There are also a number of principles for instructors that should be taken into account, especially when using media-centered ILE such as AR. Although multimedia learning material is integrated into regular learning activities, the person teaching should still be the focus of the class, not the multimedia use. Instructors should be made aware of learners' progress and dynamics through the ILE being used. Having access to information about learners' progress in ILE allows them to help when needed (Cuendet et al., 2013). For instructions and explanations, it is recommended, to use a conversational style as learners try harder to understand information presented in this form (Brame, 2015; Mayer, 2002; Moreno & Mayer, 2007).

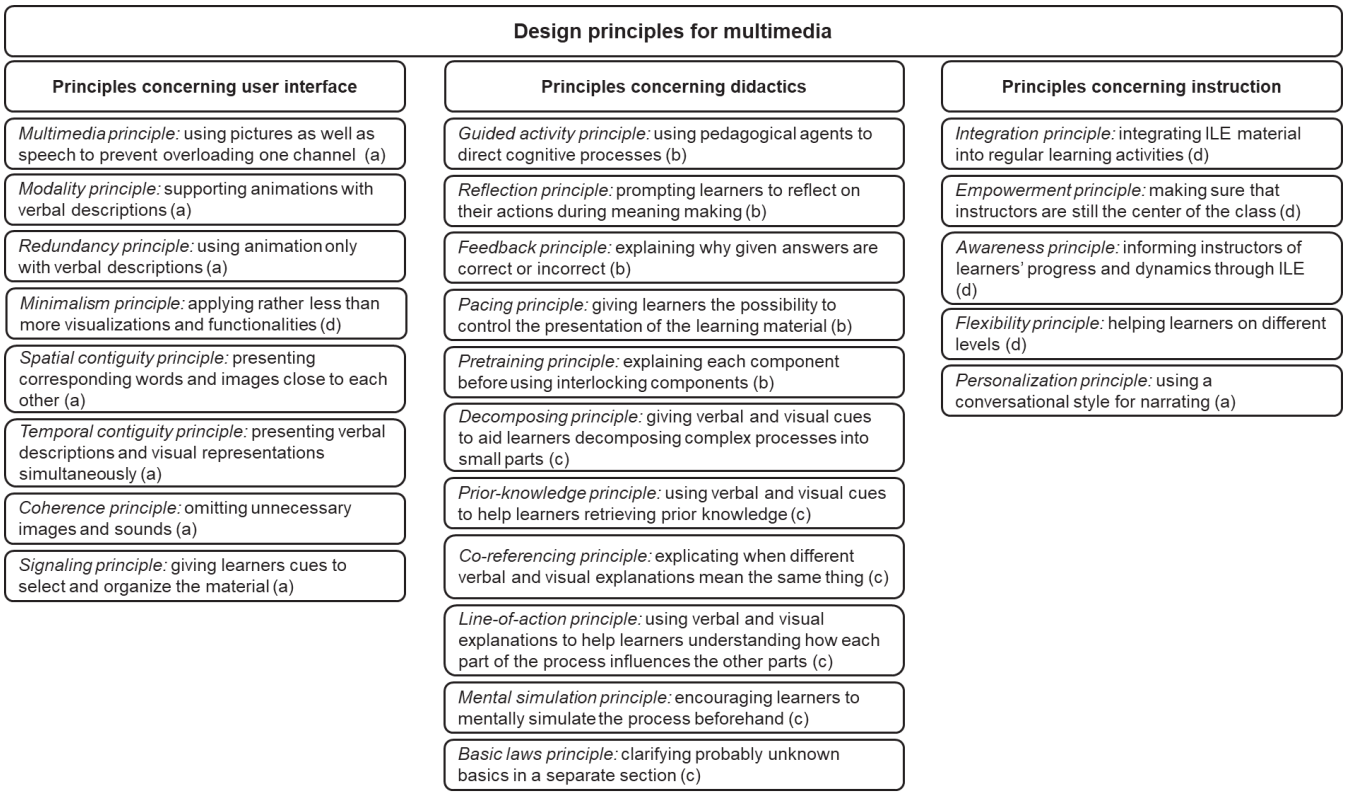

Figure 1. Learning principles.
Note. originate from a) the cognitive theory of multimedia learning (Mayer, 2002; Moreno & Mayer, 2007); b) the cognitive-affective theory of learning with media (Moreno & Mayer, 2007); c) the cognitive process model of multimedia comprehension (Narayanan & Hegarty, 1998, 2002); d) practice (Cuendet et al., 2013).

Previous research mainly neglected learners' perspectives and derived design principles from theory and from practice; however, learners are the experts of their learning and can provide useful insights into what improves and what hinders their learning. Therefore, at the beginning of a three-year development project on immersive learning at a distance learning university of applied sciences, the focus was on students' needs regarding learning videos and ILE. The aims of the study at hand are, firstly, to examine the fit with established design principles. Secondly, to identify new recommendations derived from learners' reported needs. And thirdly, to carve out when learners perceive learning videos and ILE as useful.

4 Method

4.1 Participants, Recruitment, and Sampling

Participants were recruited via postings in the general information forums of each study program at our university and via postings in the university's Xing alumni network. Each of the two online focus groups consisted of seven students with different study progress (n=12) as well as alumni (n=2) from different study programs with an age range between 21 and 49 years. 13 participants were female and one male. Participants received 25 Euro for their participation.

4.2 Online Audiovisual Focus Groups

To examine important aspects of learners' needs regarding learning videos and ILE, students using these online sources for learning are considered experts. Also, the future ILE should be designed for the needs of the distance learning students. Thus, students currently studying or alumni of our university were suitable participants. ILE are a new and complex topic needing more elaboration, accordingly focus groups should be used to gain a better insight (Powell & Single, 1996). As the targeted students are dispersed over a large distance and focus groups using video conferencing offer a similar data richness as face-to-face focus groups, online focus groups were used (Abrams et al., 2015; Kite & Phongsavan, 2017; Woodyatt et al., 2016).

4.3 Procedure

The online focus groups were conducted and videotaped at the end of March 2019 using the Skype for Business™ video conferencing tool. A semi-structured online focus group guide was developed by the research team including questions on (a) how videos are used for studying, (b) which application areas for ILE students could imagine to be used for teaching, and (c) how ILE should be designed to assist learning (see Appendix A). After the questions on video use a video introducing different forms of ILE (i.e., VR, AR) was showcased, so that participants had a common understanding of ILE. Both focus groups were held by the same interviewer who was also in charge of recording; a second interviewer took notes and did not intervene. The focus groups lasted 107 and 94 minutes.

4.4 Analysis

The online focus groups were transcribed verbatim by the interviewer, who took notes during the sessions, excluding non-verbal reactions from the participants. Nvivo 11 was used to organize and code the transcripts. Thematic Analysis (cf. Braun & Clarke, 2012) was applied, as the aim was to identify a broad range of emerging themes in the context of experiences and needs regarding the actual and potential use of videos and ILE. For an unrestricted analysis, the design principles known from the literature were neglected and a purely inductive procedure was applied to determine themes. Further, a semantic approach was taken to find the themes, as experiences and needs were already brought to the surface with the instructions of the focus groups. First, two researchers read and marked important passages of the transcript independently. Second, they individually reflected on existing key aspects in the transcripts. Third, they discussed the identified key aspects, formed suitable categories, and established a coding framework (see Appendix B). Fourth, they discussed and coded the transcripts together, using and adapting the developed categories. Fifth, they again discussed the developed categories and merged them to meaningful themes. Sixth, the emerging themes regarding needs were systematically compared to existing principles or used to identify new recommendations from a learners' perspective.

5 Results

Four central themes were identified through the thematic analysis: First, needs that match the design principles reported in the literature; second, new design recommendations from the learners' perspective; third, the appropriate context for learning videos; fourth, the appropriate context for ILE. These central themes and subthemes are also presented in Table 1.

5.1 Learners' Needs Matching the Design Principles from the Literature

Although they were not explicitly asked for in the online focus groups, participants reflected on some of the established design principles for multimedia learning; however, by far not all were mentioned. In accordance with the principles on user interface (i.e., *coherence principle, minimalism principle)*, participants think that learning videos should be simple and not overloaded or shrill. The rest of the previously established design principles

concerned didactics. Learners found real life or animated agents guiding through the learning material suitable (i.e., *guided activity principle)*. The *pacing principle* was mentioned insofar as learners want to be provided with short and structured learning videos, allowing them to switch between different materials in their own pace and finding the needed information effortless. Further, step-by-step instructions explaining difficult material were also found eligible (i.e., *decomposing principle*). In line with the *prior-knowledge principle*, learners addressed the advantage of seeing materials from different perspectives and that processes are visualized. As learners asked for explanations using practical examples, also the *line-of-action principle* was addressed. Moreover, the *basic laws principle* was regarded as useful as learners suggested to incorporate trivial but important explanations in the learning material. Table 2 presents participants' quotes reflecting the previously established design principles.

5.2 Recommendations from a Learners' Perspective

Furthermore, participants verbalized needs that could be transformed to new recommendations concerning user interface, didactics, and instruction from the learners' perspective. Mostly recommendations regarding the user interface were verbalized. Participants stated that they "do not watch longer than five minutes," "it is better to have more, but shorter videos" and "the shorter, the better" videos are. From this the *brevity recommendation* was derived. Further, participants prefer when videos are "capsuled in more videos" so that "you have short videos per topic" as "often you just want to know something about a very specific topic". On these statements the *focus recommendation* is based. Also, the simplicity of the technical accessibility was mentioned by participants. A statement reflecting this was, "easy to use with any PC, laptop, no matter the age [of the device], no matter the operating system". This was condensed to the *accessibility recommendation*. Participants also indicated that it is important "that you can tell from the naming of the video what the video is about." From this the *marking recommendation* originates. Further recommendations consider the didactics of the learning material. Learners reported on the importance to use "the same technical terms" in the videos in regard to all learning materials to "avoid misconceptions." This was termed the *conforming recommendation*. Further, the presentation of "an overview at the beginning" with "a chapter-by-chapter structure" was discussed. From these statements the *structure recommendation* was derived.

The only recommendation on instruction was that most participants positively emphasized that learning videos should use humor while explaining. Examples were videos "which were really hilarious to watch and you also learned something". One participant stated, "I have examples in my head, that I for sure will never forget [laughs], because they had a certain wit about them." These ideas were summarized as the *merry recommendation*.

5.3 Context for Learning Videos

Most participants reported to frequently use learning videos. They use videos when they feel that a specific learning subject is demanding (e.g., "theoretical things, which I do not understand that well"), for "dry subjects" or when a different approach to a specific subject is needed (e.g., "as a different approach to the topic, because it makes it easier to access difficult topics"). A few participants also indicated to reduce lacking previous knowledge through videos (i.e., "to acquire the basic knowledge, which has already been presupposed").

5.4 Context for ILE

In contrast to learning videos, participants had little or no experience with ILE; however, in general the use of augmented or virtual reality in the learning context was expected as enrichment. Participants stated that ILE should only be applied when they aid and facilitate learning. Suitable application areas regard (1) *being someone else*, (2) *being somewhere impossible*, and (3) *being involved*.

Being someone else means to change the point of view with other people to learn about their experiences (e.g., "putting oneself in the perspective of an elderly person and having to reflect which challenges arise"). Also, *being someone else* plays a role when social situations should be experienced and trained. When using ILE, learners can gain realistic hands-on practice in different fields such as "personal development," "sales," "marketing," or "conflict management" without having to face any negative consequences. A statement regarding recruitment was "so you can better imagine, how it actually works if you have never been a participant in an assessment center."

Being somewhere impossible signifies studying places where people cannot normally be, for example, "the human brain" or "network engineering." With ILE, learners could move freely in these three-dimensional spaces and decide for themselves from which angles they want to view the learning material. This would improve their understanding of these places. A participant put it in the following words, "Everywhere where you have to imagine something vividly, such as the brain, network technology, because there are objects or bodies behind them that you can simply remember or imagine better in 3D."

Being involved means to make causes and effects visible and therefore more tangible. ILE could, for instance, allow learners to change a parameter and automatically display the following consequences. A statement reflecting this was, "Perhaps it would be more tangible, than just a chart […] If you can really control it yourself, and say, I now increase the price by €5 for a product, to what extent will that decrease the buying behavior."

Table 1. Central themes and their characteristics

Central theme	Characteristics	Concerning
Previous design principles	minimalism principle	User interface
	coherence principle	User interface
	guided activity principle	Didactics
	pacing principle	Didactics
	decomposing principle	Didactics
	prior-knowledge principle	Didactics
	line-of-action principle	Didactics
	basic laws principle	Didactics
Recommendations from a learners' perspective	brevity recommendation (i.e., shorter than five minutes)	User interface
	focus recommendation (i.e., one topic per video)	User interface
	accessibility recommendation (i.e., easy technical accessibility)	User interface
	marking recommendation (i.e., clear naming)	User interface
	conforming recommendation (i.e., consistency of wording to other learning materials)	Didactics
	structure recommendation (i.e., overviews at the beginning)	Didactics
	merry recommendation (i.e., include humor)	Instruction
Context for learning videos	demanding subjects	
	dry subjects	
	need for a different approach	
	lacking previous knowledge	
Context for immersive learning environments	being someone else (i.e., real life experiences which evoke empathy)	
	being somewhere impossible (i.e., exploring unreachable places)	
	being involved (i.e., making contents tangible by allowing to change parameters and following the corresponding consequences)	

Table 2. Interview quotes reflecting previously established designing principles and context of application

Principle	Area of application	Translated quotes
Minimalism	Learning with AR	One should not be overstimulated by things like that. But focus just on content, brevity, on digestible units.
Coherence	Educational videos	Of course, it must not be too much additional, not too many effects. That is, that there is not too much around it in the video, but that the focus is really placed on what I want to convey and that in a way that the brain can easily process it.
Guided activity	Learning with interactive media	Some sort of avatar guiding you through or interacting with someone, who explains things, where you have the feeling that you are not sitting there alone.
Pacing	Learning with interactive media	If the topics are so complex, that you sometimes have to pause again, rewind, pause, rewind, so that you really understand it, then of course a longer video is more of a hindrance in my opinion. Encapsulated in several videos […] that not everything is in one piece, but that you have short videos on the topics, because then you can orientate yourself and work through things much better. If I don't have to search within a video where this example starts, I really have 5, 6, 7 videos and can then watch exactly that on the topic in question. You can just click through there in the video, […] there you really have the topics, like chapter headings, and on the right you can watch the respective videos, so this is very convenient.
Decomposing	Multimedia learning	Each calculation example was dealt with in a single video, dealt with in detail, with an insight into the Excel lists, and that was very good for recalculating and understanding, including the individual calculation steps.
Prior-knowledge	Multimedia learning	Network technology, for example, would certainly be practical if you could walk through a server room and find out what a switch is, what a router is, the different cables and so on. You could certainly get a better idea if you walk through it. When it comes to new product development or product management, where you can then better visualize certain processes.
Line-of-action	Multimedia learning	I can also imagine it in marketing, e.g. the cycles, such as the product cycle or other possibilities, are better or more concretely presented. Which might also be a way to show a value chain for an entire company. I could also imagine that you could experience a virtual walk-through, so to speak.
Basic laws	Multimedia learning	That you then look for additional help in the form of videos, which you can then simply watch again […] perhaps with examples that make it a bit clearer.

6 Discussion

The aim of the present study was to explore learners' needs and perspectives regarding learning videos and ILE. Results indicate that the application of principles concerning user interface and, to an even greater extent, didactics should be improved in the future. Additional design recommendations address user interface, didactics, and instruction. For demanding and dry subjects, for getting a different approach, or when facing a lack of previous knowledge learning videos are suitable. ILE, on the other hand, were seen eligible for being someone else, being somewhere else, or being involved with the material.

Some of the previously established design principles (Mayer, 2002; Mayer & Moreno, 1998, 2003; Narayanan & Hegarty, 1998; Cuendet et al., 2013) were reflected in the online focus groups. Both of the mentioned user interface principles (i.e., *minimalism and coherence principle*) state that the learning material should not be overloaded with unnecessary content. Concerning didactics, the mentioned principles should either help learners to direct their attention to the important content of the learning material (i.e., *guided activity, decomposing, prior-knowledge, and line-of-action principle*) or enable them to obtain information on their own terms (i.e., *pacing and basic laws principle*). As the design is only to support learning, it should be unconscious and unnoticed; however, being aware of a design could indicate that it either interferes with learning or that it is notably well integrated.

The new found recommendations can also be grouped in terms of user interface (i.e., brevity, focus, accessibility, and marking recommendation), didactics (i.e., *conforming and structure recommendation*), and instruction (i.e., *merry recommendation*). The user interface *recommendations of brevity* and *focus* are consistent with the *minimalism principle* of Cuendet et al. (2013) and the coherence principle of Mayer (2002; Mayer & Moreno, 1998, 2003), which also suggest omitting unnecessary content and focusing on the essentials. What is new, however, is that it is expanded to the length of the videos and their thematic content. The other two recommendations for user interface do not refer to any established design principles and seem to be rather logical and insignificant; however, they were frequently mentioned by learners, and therefore indicate issues with technical accessibility and findability which should be addressed when designing learning material. The *conforming recommendation* on didactics extends the *co-referencing principle* (Narayanan & Hegarty, 1998, 2002) in that it includes learning material which is currently not at hand. Providing learners with an overview and structure at the beginning of the learning material seems to be obvious, but videos in particular do not usually contain tables of contents. Structuring the leaning material is in line with the *pacing principle* (Mayer, 2002; Mayer & Moreno, 1998, 2003), as it also enables learners to control the presentation of the learning material to some extent. For instructions, the *merry recommendation* and the *personalization principle* (Mayer, 2002; Mayer & Moreno, 1998, 2003) strike the same chord, as the use of a conversational style and the inclusion of humor in descriptions often go hand in hand.

What all the recommendations found have in common is that they aim to mitigate the cognitive load on learners so they can focus on what they actually need to learn. This is prompted by both the cognitive theory of multimedia learning (Mayer, 2005; Mayer & Moreno, 1998) and the cognitive-affective theory of learning with media (Moreno & Mayer, 2007).

Although participants were asked about learning videos and ILE, their responses can be extended to the design of other learning materials. Written learning material should likewise be brief, focused, consistent with the wording used in other materials, and provide an overview. The recommendations derived from learners' responses, however, seem to be especially useful for learning videos.

Learners use learning videos in special difficult learning situations and contexts. It can be assumed that videos are used to avoid the cognitive load of reading learning material as they are easier to understand.

The use of ILE enhances the context of application compared to videos, which already provide the possibility to display dynamic contents, vividly illustrate situations and procedures, and illustrate things that are otherwise difficult to observe (Petko & Reusser, 2005). ILE, and virtual reality in particular, can be applied meaningful in areas where they provide learners with the most realistic experiences without actually living in a situation and facing its consequences. Students, for example, can take on a role and be someone else to evoke empathy with a person, or they can explore normally inaccessible places on their own from different perspectives and get an unrestricted view. The context in which the application of augmented reality makes sense, is where contents can be made tangible through involving learners. Students, for example, can change certain parameters and easily compare actual results, which helps them to understand complex relationships and consequently immerses them in the learning situation more than just watching someone else. Thus, ILE are better equipped for these contexts than videos or text-based learning materials.

7 Limitations and Future Prospects

The participating learners had none or only remote experiences with ILE. A first step to overcome this shortcoming was to provide a video showcasing different examples of ILE. Although videos might help to understand the concept of ILE, they could also influence participants' answers. Furthermore, without actual experience it might still be difficult for participants to anticipate how ILE could be designed. This could explain why the principles suggested by Cuendet (2013) were not mentioned in the online focus groups. Future research on learners' needs in ILE should also consult learners with more prior experiences. Furthermore, the sample consisted mainly of women, which might have influenced the results. Therefore, further studies should include more male students.

The recommendations from a learners' perspective suggested in this paper are not based on learning theories, are not tested empirically, and base only on two exploratory online focus groups. Thus, only first impressions of learners' needs when learning with videos and ILE can be derived. Learners are the experts of their learning experiences; however, it is possible that they perceive special features to support their learning outcomes, while in fact those features might not be effective. Therefore, future research is necessary to further explore the new recommendations and examine whether they objectively support learning outcomes.

Students already have experiences with educational videos and use them as part of their studies or as additional learning resources. Therefore, it is easier to determine which design principles and recommendations they perceive as important and helpful. ILE are not yet common, which makes it harder to get experience-based information of design needs. This lack of information makes it even more crucial to develop ILE from the beginning with the participation of potential users. Considering learners' needs regarding design and learners' expectations concerning areas of application could make the utilization of immersive learning material more appealing to them.

Although online focus groups offer a similar data richness as face-to-face focus groups, technical problems can arise and the moderator could have less control over the discussed topics (Abrams et al., 2015; Kite & Phongsavan, 2017; Woodyatt et al., 2016). As participants were familiar with online learning, technical problems could be neglected, and minor problems did only arise for one participant. Since one of the aims of the online focus groups was to generate ideas for the use of ILE, there was no need for a high control of the discussed topics and the advantage of reaching students living in remote areas outweighed.

Providing learners with well-designed videos and ILE can help them to better understand learning contents. The theory driven principles already provide designers with an informative basis on creating ILE. The newly found recommendations could additionally help meeting learners' needs in such environments.

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Contact information

Ingrid Wahl: ingrid.wahl@univie.ac.at
Stefanie Kuso: stefanie.kuso@fernfh.ac.at
Barbara Wimmer: barbara.wimmer@fernfh.ac.at

*Correspnding author

Correspondence concerning this article should be addressed to Ingrid Wahl, Department of Communication, University of Vienna, Kolingasse 14–16/6.60, A-1090 Vienna, Austria,
Email: ingrid.wahl@univie.ac.at, Telephone: +43-1-4277-48319
ORCID-ID: https://orcid.org/0000-0002-9618-0207

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Appendix A: Semi-structured online focus group guide

Question	Pursued objective	Rephrasing
To begin, let's do a quick round of introductions: What's your name and what major are you studying or have you studied?	Get to know the sample	What is your name and what are you studying? Please introduce yourself.
How do you use video in your studies?	Video use	When do you resort to videos? What do you particularly like to learn with videos? What do you use videos for? How do you use video in learning?
Show the explanatory video about AR/VR		
Where do you see areas of application for augmented or virtual reality in teaching?	Generating ideas	What learning content do you think could be taught with augmented or virtual reality? Think perhaps of a course that could be developed further with an educational video. How do you think this could be implemented? For which content could you implement learning videos with augmented or virtual reality? In which areas of teaching would augmented or virtual reality be applicable for you?
How would the above examples need to be designed to help you learn?	Use and design AR/VR for learning	What does a virtual reality video need to contain for you to use it for learning? How can you imagine learning with the above content? How would you use your ideas in actual learning? How would you integrate these ideas into your learning?
What else would you like to say about the topic?	Conclusion	What else can you think of on this topic? What content have we not yet addressed that you would like to discuss? Is there anything else you'd like to comment on in terms of augmented or virtual reality or video?

Appendix B: Coding framework

Video	
Theme	**Code**
Topic	Complex Theoretical Dry subject No prior knowledge
Bad examples	Only at the surface Only lecture
Good examples	Colorful Animated Hilarious In step with actual practice Easy to follow Tutorial
Important features	Useable as podcast Correspondence to other learning material Short overview at the beginning Meaningful naming Provide video descriptions
Time of use	Get an overview Introduction to topic Answer a specific question Difficulties with understanding Summary Repetition before the exam
Length and content	Less than 5 Minutes Many but short videos Only longer if really important Only one topic Table of contents for navigation
Advantages in comparison to written learning material	Faster learning than written learning material Support or addition to written learning material Make connections Find another approach Possible to learn while doing other things Possible to learning when less concentrated
AR/VR	
Should not (be)	too flashy contain paraphernalia
Should (be)	short coherent structured divided to small sections focused on the essentials humorous playful technically easily accessible use avatars provide practice increase understanding
Application area	Immersion in situation Spatial representation of things Virtual space in which you can move around Adoption of other perspectives Experience consequences after changing parameters Gamification Live experience Tangible Vividly

Call for Papers

Beyond Media Comparison: Investigating When and How Learning with Augmented and Virtual Reality Works

Guest Editor

Josef Buchner (josef.buchner@phsg.ch)

Augmented Reality (AR) and Virtual Reality (VR) are two contemporary technologies gaining momentum in educational research and practice. For both, empirical studies reporting effects on different learning outcomes increase year by year (e.g., Arici et al., 2019; Radianti et al., 2020). However, more recently, researchers criticize that the research types applied in these studies are focusing on the question *if* learning with AR or VR works and do not investigate *when* and *how* learning with these technologies works (e.g., Buchner et al., 2022; Garzón et al., 2020; Makransky & Petersen, 2021; Zumbach et al., 2022).

A typical method addressing the if-question is the comparison of an AR/VR application to "traditional" teaching or media. For example, in a recent metanalysis on the impact of AR on learning, 83.6% of the included studies (n = 134) compare AR to non-AR instruction (Chang et al., 2022, p. 7). This type of research is known as media comparison study (Mayer, 2019) and has been under criticism for more than forty years, since Clark, Kozma, and others discussed the influence of media on learning (Clark, 1983; Hodges et al., 2020; Kozma, 1994; Mishra et al., 2009).

With this *Digital Psychology* special issue, we encourage researchers to report study results beyond the media comparison paradigm that represents a technology-centered/thing-oriented view on learning in the digital age (e.g. Mayer, 2020; Reeves & Reeves, 2015).

Type of Articles

We seek for original empirical investigations as well as meta-analysis and systematic reviews taking on a learning-centered perspective addressing questions about *when* and *how* learning with AR/VR works. Letters and Commentaries are also welcome. For eligible manuscript categories see the *Digital Psychology* author guidelines (https://ejournals.facultas.at/index.php/digitalpsychology/about/submissions)

Such work might, for example, investigate (but are not limited to):

- Influences of different learning strategies/learning designs
- Influences of learning strategies/learning designs on different learning outcomes (e.g., cognitive/affective)
- Influences of moderating/mediating variables when learning with AR/VR (e.g., age, prior knowledge, cognitive load, immersion experience, AR/VR experience, …)

If you are interested in submitting a manuscript to this *Digital Psychology*'s Special Issue entitled "Beyond media comparison: Investigating *when* and *how* learning with Augmented and Virtual Reality works"**,** please read the *Digital Psychology* submission guidelines (https://ejournals.facultas.at/index.php/digitalpsychology/about/submissions) carefully.

Contact

If you have further questions, please contact Guest Editor Josef Buchner (josef.buchner@phsg.ch).

Manuscripts can be submitted via the *Digital Psychology* website (please indicate the special issue "Beyond Media Comparison"): https://ejournals.facultas.at/index.php/digitalpsychology/about/submissions

Deadlines

Submission of papers: 15th July 2023
Expected Publication: in October 2023

Publication Fee – Open Access

The Special Issue will be available as an open access publication. The publication fee is € 449,– per article.

Guest Editor Short Bio

Dr. Josef Buchner (Orcid: 0000-0001-7637-885X) is Head of Research and Development at the Institute for ICT and Media, St. Gallen University of Teacher Education. He worked as a teacher and researcher in Austria, Switzerland, and Germany. His research focuses on educational technology, instructional/learning design, multimedia learning, and teacher education in the digital age. He is the co-chair of the Media Education division of the Austrian Society for Research and Development in

Education (ÖFEB) and serves as reviewer for several international journals in the field of learning, instruction, and educational technology. Further information can be found here: https://www.phsg.ch/de/team/dr-josef-buchner

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