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Original Article

360° videos as a visual training tool – a study on subjective perceptions

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Abstract
Background*:* The development of digital media has led to new possibilities for digital aids in teaching and learning processes. Immersive playback media, such as virtual reality glasses and head-mounted displays, enable authentic digital training processes that are perceived as being close to reality; the potential of these media must be explored. As a link between video technology and immersive technologies, 360° video offers low-threshold training opportunities due to its resource-saving design (e.g., multi-perspective viewing options and immersive training experiences). ***Approach:*** Based on the potentials of 360° video as a teaching–learning medium in a non-specific educational context, the present qualitative study investigates the subjective perceptions the added value of 360° video technology from the perspective of users (N = 48), categorizes these perceptions and compares them with the results of the few explorative studies on 360° videos in the context of sports. ***Results:*** In particular, according to the subjects, the multi-perspective, all-round view of 360° video technology enables a differentiated view of movement from different perspectives for a very individually controllable learning process. According to the subjects, the different perspectives of the movement lead to a deeper understanding, which favors the acquisition of the movement. In contrast, the positive aspects of the easy handling and control of 360° videos mentioned in the literature cannot be confirmed without specific instruction. ***Conclusions:*** Our study was able to demonstrate the possibilities of 360° video technology as a visual training tool, especially if high-quality 360° video recordings are available and used within the framework of a methodological-didactic concept.
Key Words***:*** **360° video, digital motion learning, digital training, immersive technology**

Introduction

Virtual reality, 360° videos, augmented reality, as well as mixed and extended reality are becoming increasingly popular subjects of research in sports science. However, the use of digital media for mediation purposes, for illustration, or for analysis and reflection processes (Ruzicka & Milova, 2021) is not a new phenomenon. For example, classic video is used for video feedback through recording one's own movement (Mödinger et al., 2022) or reflection on recordings of game situations and tactical decision-making behavior (Koekoek et al., 2019). On the other hand, research is increasingly addressing the potential uses of immersive digital media, such as virtual reality (Faure et al., 2020), which can be used to program athletic training content to be perceived as realistic (Miah et al., 2020) and provide training opportunities in a digital training environment (Le Noury et al., 2022). In particular, 360° videos can be classified as a link between traditional video technology and virtual reality (Rosendahl & Wagner, 2023). Both immersive training possibilities (Rosendahl et al., 2022) and classical video applications for training purposes, such as illustration or observation of a targeted movement execution presented as optimal (Paraskevaidis & Fokides, 2020), can be easily designed with 360° videos. Nevertheless, the possibilities for training and other applications of 360° videos in sports are still poorly explored. However, the few studies on 360° videos in sports show a high application potential, be it for cognitive training content to improve attention and perception processes, to increase motivation, reflection skills, or even motor learning (Hebbel-Seeger, 2017; Kittel et al., 2020a; Rosendahl & Wagner, 2022). Drawing on the few exploratory studies of 360° videos in sports, this study presents the results of a qualitative interview following an intervention in which 360° videos were used as a visual training tool for independent movement acquisition.

Clarification of terms

In contrast to programmed virtual reality (VR) experiences, 360° videos are video recordings of the real environment, wherein the viewing perspective around the 360° video camera can be freely selected within the 360° video recording (Ranieri et al., 2022). This allows three rotating degrees of freedom within the digital application, so that the gaze perspective can be moved left and right, up and down, or by tilting (Griffin et al., 2021). In contrast to VR, which has six degrees of freedom, with translational movements forward and backward, sideways, and up and down (Griffin et al., 2021). This allows, for example, a freely selectable 360° all-around view, even around an observed object. Conversely, the all-around view in 360° videos is only around the camera viewpoint. Furthermore, action manipulation of the recorded action is not readily possible in 360°

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videos; in contrast, action manipulation is possible in programmed VR applications (Roche et al., 2021). While action manipulation and freedom of movement in VR contribute to a high degree of realistic sensation within digital applications, the environments are predominantly digitally generated. On the other hand, 360° videos are recordings of real-world environments, which in turn provide a high degree of authenticity and realism in training experiences (Rosendahl & Wagner, 2022); this can be enhanced by immersive playback media, such as head-mounted displays (HMDs) (Rosendahl & Wagner, 2023). Despite their proximity to VR, we agree with Roche et al. (2021) and argue that 360° videos should be classified as a distinct immersive video format (Rosendahl & Wagner, 2023).

State of research

The use of 360° video technology or immersive technology as a teaching–learning medium or training tool is rather rare in research (Pellas et al., 2021; Ranieri et al., 2022). For the non-specific education sector, there are few studies on the use of 360° videos as a teaching–learning medium (Pirker & Dengel, 2021; Ranieri et al., 2022; Rosendahl & Wagner, 2023; Snelson & Hsu, 2020); regarding their use as a teaching–learning medium in sports in particular, only one German-language literature review could be identified (Rosendahl & Wagner, 2022). The few studies on the use of 360° videos as a training tool in sports (Kittel et al., 2020a; Pagé et al., 2019; Panchuk et al., 2018; Paraskevaidis & Fokides, 2020; Rosendahl et al., 2022) are rather exploratory in nature. Due to the lack of definitional distinction from VR, the potentials of 360° video can also be identified in and derived from reviews of VR applications as a teaching–learning medium in non-specific educational settings (Kavanagh et al., 2017; Dhimolea et al., 2022; Pellas et al., 2021) and in sports (Farley et al., 2020). SWOT analyses of 360° video versus VR (Kittel et al., 2020b) and their use in teacher education (Roche et al., 2021) complement the reviews.

Due to the sports focus of this article, the sport-specific potentials of 360° video derived from the reviews by Rosendahl and Wagner (2022) and Farley et al. (2020) are presented and supplemented by the potential identified from the further reviews and SWOT analyses. Especially due to the fact that 360° videos are recordings of a real environment, they offer the potential for training experiences perceived as authentic and realistic (Farley et al., 2020; Kittel et al., 2020b; Roche et al, 2021; Rosendahl & Wagner, 2022; 2023), as well as, at the same time, particularly motivating and activating (Dhimolea et al., 2022; Kavanagh et al., 2017; Kittel et al., 2020b; Pirker & Dengel, 2021; Rosendahl & Wagner, 2022; 2023; Snelson & Hsu, 2020). Realistic 360° video recordings offer high reflective potential for analyses (Ranieri et al., 2022; Rosendahl & Wagner, 2022; 2023), which may be particularly useful for cognitive learning processes (Ranieri et al., 2022), for example, to improve perceptual skills or for decision making in game situations (Kittel et al., 2020b; Rosendahl & Wagner, 2022). Especially when using immersive playback media, such as HMDs, 360° videos create a realistic sense of presence within the digital application and also exhibit high immersion potential (Farley et al., 2020; Kavanagh et al., 2017; Kittel et al., 2020b; Pirker & Dengel, 2021; Rosendahl & Wagner, 2022; 2023). In addition, 360° videos also support technique training and movement acquisition through observation (Farley et al., 2020; Rosendahl & Wagner, 2022) and offer applications for performance enhancement (Pirker & Dengel, 2021; Ranieri et al., 2022). Pirker and Dengel (2021) were also able to identify a high application potential for teaching–learning processes due to the user-friendly design or handling of 360° video technology, confirming the findings of Kittel et al. (2020b) and Roche et al. (2021) on the resource-efficient design and application of 360° videos as a teaching–learning medium for knowledge acquisition. Furthermore, learning processes and learning speed can be individually controlled and designed with 360° videos (Rosendahl & Wagner, 2023).

Methods

The aim of this explorative study is to record the advantages and disadvantages of 360° video technology as a visual training support from the user's point of view and to compare these results with the potentials already known or assumed from previous research. The question is whether the added value and potentials of 360° video technology are also perceived by the users. As part of a randomized intervention study on the benefits of 360° videos as a visual training support, an open-ended questionnaire was used for this purpose. The questionnaire inquired about positive and negative aspects of 360° video post-intervention. Responses were deductively categorized according to positive and negative aspects of 360° video already known from the literature (Rosendahl & Wagner, 2022; Kittel et al., 2020b). New aspects not previously covered were inductively derived from the given answers and categorized. Finally, a numerical ranking of the identified positive and negative aspects of 360° video technology as a visual training support was performed and a ranking list was generated. Answers that could not be clearly assigned to a potential were assigned several times to the individual potential categories and counted for the numerical category ranking. As part of the intervention study on the usefulness of 360° videos and conventional training videos as a visual training support, subjects (N = 48) of the B.A. program Sport-Health-Leisure-Education of the Karlsruhe University of Education participated in the survey. Of these subjects, the responses of n = 48 could be included in the qualitative evaluation of the positive aspects of 360° video, and n = 44 also mentioned negative aspects and suggestions for improvement of 360° video as a visual training support.

Materials

The 360° videos used show short, approximately 20-second movement sequences of a total of eight fascial movement exercises from the "Fascia low intensity" program (Fessler & Müller, 2020). Each individual movement exercise was recorded using a specific recording design and set-up (Rosendahl et al., 2022). In a diamond formation around the 360° video camera (Fig. 1), four models performed the fascial movement exercises so that the movements of the recorded models could be observed in the 360° panoramic view (Fig. 2) from frontal and sagittal perspectives. In addition, auditory cues were integrated into the 360° videos. Written movement instructions, visualized using the 360° videos, were also used for independent movement acquisition. Subjects viewed the 360° videos on a laptop, smartphone, or tablet without using a HMD.

Figure 1: Recording design

Figure 2: Viewing perspectives in a 360° video recording in panoramic view

Results

A total of seven categories of added value and potentials of 360° video as a visual training support were generated and derived from the open question (Table 1). The deductively assigned added value categories (multi-perspectivity, fun & motivation, individuality, and operation) support the previously identified potentials from the various systematic reviews (Chapter 3). In contrast, the inductively reassigned potentials (variety, differentiation, comprehensibility) extend the findings on 360° video as a visual training support. Since the 360° videos were not viewed with an HMD, the two potentials already mentioned in the state of research section (immersion and authenticity or realism) were not relevant in our study and were accordingly not mentioned in the subjects' responses.

Table 1: Added value categories of positive aspects with exemplary keywords

Multi-perspective all-round visibility (n = 41)	**Easier to understand movement (n = 12)**	**Individuality (n = 11)**	**Differentiated observation (n = 11)**	**Demonstration of various movements (n = 5)**	**Fun & motivation (n = 3)**	**Handling / control (n = 2)**
deductive	inductive	deductive	inductive	inductive	deductive	deductive
• All angles • All perspectives • All views • Panoramic view	• Easier understanding • Complete insight • Movement easier to understand • Better to learn	• Individual camera • Individual control • Self-decide • Self-select • Customize viewing angle	• Differentiated • More details • Better overview • Accurate implementation	• Comparison of movements • Different movements • Comparison of the participants • Different executions	• More attractive • Good view • Inspiring	• Easy to use

By far the most frequently addressed potential category is the multi-perspectivity of the movements facilitated by the all-round view of the 360° videos (n = 41), followed by better understanding of the movements (n = 12), individuality (n = 11), and differentiated viewing options (n = 11). Subjects also positively perceived that, especially due to the specific design of the 360° video recordings, the different movement executions of different models could be compared within one video recording (n = 5). However, this was also commonly mentioned as a negative aspect (n = 14; Table 2), and in some cases, the recorded movements were even rated as faulty (n = 8). The number of participants who reported higher motivation and enjoyment resulting from the 360° videos as a visual training aid was rather low (n = 3). In addition, the number of positive perceptions of the control and operation of the 360° videos (n = 2) was significantly lower than the number of opposite, negative evaluations (n = 10).

Table 2: Categories of negative aspects with exemplary keywords

Different movement executions (n = 14)	**Handling / control (n = 10)**	**Video quality (n = 9)**	**Incorrect movement execution (n = 8)**	**Camera perspective (n = 7)**	**Different models (n = 6)**
• Uniform movement execution • Coordinated movement execution	• Too much sweep • Too much spinning • Handling	• Light conditions • Out of focus • Length	• Correct execution of the movements • Clean execution of the movements	• Top view is missing • Bottom view is missing • Unfavorable perspective	• Filming similar people • Filming only one person

The quality of the 360° videos in terms of length, video setting, and lighting conditions was also criticized (n = 9), although it was pointed out in advance of the study that the quality of the exploratory 360° video recordings should not be the focus of the evaluation. In addition, the lack of audio explanations was a source of negative evaluation (n = 6); however, it should be noted that audio explanations were present in the 360° videos, and it can be assumed that the subjects forgot to activate the audio track when viewing the 360° videos on the YouTube portal.

Discussion

Multi-perspective all-round visibility

The most frequently mentioned positive aspect of 360° video technology was the all-around view ("the possibility to see the exercise from any perspective and at any point in time"), which supports previous assumptions and findings about the potentials of 360° videos both in the non-specific educational sector (Pirker & Dengel, 2021; Rosendahl & Wagner, 2023) and in sports (Kittel et al., 2020a, b; Paraskevaidis & Fokides, 2020; Roche et al., 2021; Rosendahl & Wagner, 2022; Rosendahl et al., 2022). It can be seen that the possibility of observing movements from different angles in our specific recording design represents an important added value of 360° video ("from all sides you can observe everything best"); this was recognized by the subjects in comparison to conventional video technology ("view from behind and from the side to eliminate ambiguities"). However, it should also be noted that the free design of the viewing direction also brings with it the danger of confusion ("much too confusing") and that, in addition to clear work instructions, corresponding methodological-didactic concepts are also necessary. The all-round view in 360° videos, in combination with an HMD, can also be used for teacher education and instructor training, for example, to utilize the immersion potential in the context of simulated group instruction for training purposes (Kittel et al., 2020b; Pirker & Dengel, 2021; Rosendahl & Wagner, 2022; 2023).

Design and handling

Conventional training videos can also show different perspectives of movements, but this requires several camera systems for recording synchronous motion demonstrations or several video recordings for recording asynchronous motion representation, which subsequently have to be merged and designed by editing software; this requires additional effort and contrasts with the identified potentials of 360° videos as a resource-saving application design (Pirker & Dengel, 2021; Kittel et al., 2020b; Roche et al., 2021). With 360° videos, movements can be presented from different angles if the methodological-didactic conception and specific recording design are appropriate (Paraskevaidis & Fokides, 2020; Rosendahl et al., 2022). Despite the fact that the ease of use of 360° videos is mentioned throughout the literature (Pirker & Dengel, 2021; Kittel et al., 2020b; Roche et al., 2021), this was only confirmed by two subjects ("easy to use"). Significantly more subjects felt overwhelmed by the control ("you don't know what to look for or what is right"). The gaze direction control within the 360° video scenario was unfamiliar to some subjects ("too much waving and turning"). Paraskevaidis and Fokides (2020) suggest that negative perceptions of the suitability of 360° videos as a training tool are due to a lack of experience in using 360° videos and their controls. The negative evaluation as a training tool provides a possible explanation for Dhimolea et al.'s (2022) findings that short, infrequent uses of VR tend to be less successful, while more frequent use of VR as a teaching–learning medium leads to positive learning gains. Appropriate methodological-didactic steps (Rosendahl et al., 2022) can be taken to introduce subjects to the use and control of 360° videos and to counteract disorientation. Orientation aids, both auditory and with visual markers in the video itself, support gaze direction control. However, for a targeted design of 360° videos for a successful training benefit, it is also necessary that trainers and teachers have a qualification in media competence (Vogt et al., 2019).

Observation

Some subjects seemed to have difficulty selecting and adopting a suitable perspective for observation, which is already predefined in conventional training videos ("automatic rotation of the camera," "automatic change of perspective"). This confirms the assumptions of Rosendahl et al. (2022) that for successful use of 360° video technology as a visual training tool, an appropriate methodological-didactic concept has to be elaborated. While a preselected viewing direction in the training video can be controlled by auditory cues in the context of cognitivist learning theories for a purely observational learning of movements or for reflection and analysis processes (Ranieri et al., 2022; Rosendahl & Wagner, 2022, 2023), in terms of constructivist learning theories, user choice in viewing direction and the estimation of the optimal viewing angle for movement assessment is advantageous (Paraskevaidis & Fokides, 2020). Accordingly, which training objectives are to be achieved on which learning path should be clearly defined in advance when using 360° videos as a training tool.

Individuality

A great added value is seen in the individual design of learning processes through individual choice of the viewing direction ("unbound by the camera movement," "individual control"). Although the possibility of a free choice of perspective seemed overwhelming for individual subjects ("develop a method where you do not have to change the perspective yourself"), the majority evaluated individual control as beneficial for their own learning process ("you could decide yourself how long you look at which position," "subjective perception and

change of perspective during the exercise"). This confirms the potential of 360° video as an individual teaching–learning medium as identified in the review article by Rosendahl and Wagner (2023).

Differentiation and understanding

With 360° videos, observation of motions in the frontal and sagittal planes is made possible within a single video recording if the recording is appropriately designed ("axes can be seen better"). Due to the multi-perspective viewing option, a differentiated motion observation is possible, which seems to be useful for independent motion capture ("this allows to focus more on details," "can focus on individual body parts"). In order to make optimal use of this added value, care must be taken to ensure that the movements of the recorded models are as identical and synchronous as possible. Rosendahl et al. (2022) present a methodological-didactic training concept for the use of synchronous movement recordings within a 360° video scenario for given movement sequences in Taekwondo.

Video quality

Although subjects were informed in advance of the study that the 360° video recordings were exploratory and designed without the highest quality standards, the lighting conditions, blurriness, and video length were criticized. In addition to the central written movement instructions, the 360° videos were also available to the subjects as a brief visual representation aid. Accordingly, a methodological-didactic introduction of the target movement within the 360° video recordings was omitted and only the target movement was demonstrated visually. The recordings were made in a gymnasium, so quality comparisons with professionally recorded, studio-quality training videos are not meaningful. The recorded 360° videos are recordings in 4K image resolution that were made available to the test subjects via YouTube in a protected channel. When viewing the 360° videos on YouTube, the quality is not always set at the highest level but depends upon, among other things, the data transfer rate of the available Internet. We assume that when the subjects viewed the 360° videos during the seminar in the gymnasium, the highest possible image quality was not automatically retrieved on YouTube and, accordingly, a lack of video sharpness was observed in individual cases. Nevertheless, despite the lacking video quality, it can be stated that 360° video technology was generally evaluated as a positive visual training tool. For further research, it would be interesting to create studio-quality 360° videos in high resolution and make them available as a visual training tool.

Motivation

In contrast, the evaluation of 360° video as a motivating or activating teaching–learning medium and training tool was rather low ("more attractive for participants," "more inspiring"). However, this is highlighted in the research literature as a special potential of 360° videos (Dhimoelea et al., 2022; Kavanagh et al., 2017; Kittel et al., 2020b; Pirker & Dengel, 2021; Rosendahl & Wagner, 2022; 2023; Snelson & Hsu, 2020). We suspect that the open-ended task without specific guidance during the intervention might have unsettled or even overwhelmed the subjects. This would explain the negative perceptions of the individual camera control and viewing options in addition to the reserved evaluation of the motivational potential and would be in line with the findings of Paraskevaidis and Fokides (2020), who suggest that negative evaluations of 360° videos as a training tool may arise due to a lack of guidance and accompaniment during the task as well as a lack of experience using 360° videos. Both the lack of experience using 360° videos and our open task setting in terms of a constructivist learning approach would therefore be possible explanations for the low evaluation of 360° videos as a motivating and activating training tool in our study. This should be investigated in further research.

Variety of models

Deviations in the execution of movements by the models in the 360° video recordings were evaluated differently by the subjects. On the one hand, this provides opportunities for comparison of movement execution ("compare the movement sequences," "compare the participants"); on the other hand, deviations lead to confusion and misunderstanding during movement acquisition ("all subjects should execute the exercises in the same way" "the four subjects should execute the exercise in the same way, as it is confusing if the posture is different"). In the intervention, subjects had the task of learning the target movement with the help of written movement instructions and with visual training support through the 360° videos. In contrast to the study by Paraskevaidis and Fokides (2020), who recruited professional volleyball players for technique training and performance improvement in volleyball, our study recruited students for movement demonstration in our 360° video scenarios, who were familiar with the fascial movement exercises but were not tested for perfection. Accordingly, the included models differed in both physical condition and movement performance. We must critically note that for independent learning of a target movement presented as optimal, our material design was rather disadvantageous. Nevertheless, a different movement execution with different models within 360° videos could be used for analysis and reflection processes to clarify movement differences, to address different body states with different movement executions, and to train attention to differences and use it, for example, within an assessment for the identification of movement errors or for movement correction within sports teacher and trainer training.

Conclusion

With regard to the classification of 360° videos in the category of video formats, it can be stated that 360° videos expand the possibilities and potentials of conventional video technology. The results largely confirm

the potentials identified in the few reviews on 360° video as a teaching and learning medium. However, our survey of positive and negative aspects also showed that methodological-didactic concepts are necessary for successful use of 360° video as a training tool so that the potentials of motivation and activation and user-friendliness and usability identified in the literature come to fruition. With targeted guidance and accompaniment, 360° video technology can enable both cognitivist and constructivist learning processes. In addition, a need for professional, high-quality 360° video recordings as a training tool is apparent. Depending on the task, 360° videos can be used for multi-perspective demonstration of a movement execution that is considered optimal or for analysis purposes and movement comparisons. For further research, it is important to make greater use of these potentials for training and teaching–learning processes and to investigate them for possible increases in performance and learning.

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