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Enriched 360-degree videos in teacher education. Proposal of expert-based hotspots in 360-degree environments via eye-tracking and retrospective thinking aloud

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Enriched 360-degree videos in teacher education: Proposal of expert-based hotspots in 360-degree environments via eye-tracking and retrospective thinking aloud.[1]

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Abstract:
Classroom recordings (CR) can be beneficial for the competence development of student teachers regarding the formation of teachers' professional vision (TPV). Due to technical limitations, fixed-frame CR have so far only been able to depict a section of the lesson. 360-degree CR remove this technical limitation and thus create new possibilities for TPV development (especially *Noticing*). However, 360-degree videos can also overwhelm viewers. In order to use spherical CR purposefully for TPV education, guiding support is needed. This paper focuses on the research around the placement of optical aids (hotspots) in 360-degree CR.

[1] Translation of: Draghina, M., et al. (2023): Angereicherte 360-Grad-Videovignetten in der Lehrkräftebildung: Vorschlag expertisebasierter Orientierungshilfen in 360-Grad-Räumen mittels Eye-Tracking und Retrospective Thinking Aloud. In: transfer Forschung ↔ Schule Heft 9, Videovignetten – Unterricht professionell wahrnehmen. Bad Heilbrunn: Klinkhardt, 176–188.

According to Seidel, Blomberg, and Stürmer (2010) and Sherin and van Es (2009), teachers' professional vision (TPV) is the teachers' selective noticing of events in the classroom based on knowledge for their interpretation (knowledge-based reasoning). In recent years, it has become apparent that the use of classroom recordings (CR) can be beneficial for the development of TPV (e.g., Aulinger, Körber & Meyer, 2022; Blomberg, Renkl, Gamoran, Borko & Seidel, 2013 or Seidel & Stürmer, 2014). The goal of CR is to provide learning experiences that are as authentic as possible (Krammer & Reusser, 2005). However, it is seldom considered that authenticity only exists when a classroom teaching situation can be depicted in its unadulterated entirety (Jürgens, 2021). In certain situations (e.g., consultations or group work phases) the focus can and should be directed to specific events or interactions. But if the CR aims to provide an authentic and realistic view of entire classroom practices, restricted image sections are a disadvantage (Sacher, 2008). In conventional CR, the situational control is always in the hands of the videographer or the individuals responsible for coordinating the overall recording setting. Due to technical limitations, there has been no alternative to this workflow until now (Windscheid & Gold, 2022). 360-degree CR, however, remove these optical and technical boundaries. According to Roche, Kittel, Cunningham, and Rolland (2022), they thereby create opportunities for skill development of future teachers, e.g., "the ability to notice" (p. 2). For example, providing students with a variety of viewing options can help them better grasp the complexity of classroom situations (Roche et al., 2022). Additionally, students can be supported to better cope with the effects of practice shock when entering the workforce (Roche et al., 2022).

However, students can easily be overwhelmed by the amount of information presented to them in CR, especially at the beginning of their training (Syring, Bohl, Kleinknecht, Kuntze, Rehm & Schneider, 2015). Notwithstanding the advantages mentioned above, this is especially the case for spherical 360-degree CR. Not only the novel viewing mode via head-mounted display[2] (HMD) (Kunz & Zinn, 2022), which requires an increased level of technological acceptance, but also the so-called extraneous load[3] (EL) (Albus & Seufert, 2022; Sweller, 2005), that can be

[2] A Head-Mounted Display (HMD) is an audiovisual device worn on the head which generates pictures right in front of the viewers' eyes. Auditory information is usually given via speakers built into the device.

[3] Extraneous load refers to unnecessary pressure related to cognitive processes that have a negative effect on learning. They are caused, for example, by unfavorably designed teaching/learning

experienced by students when viewing spherical images, are risks that need to be mitigated. While the challenges of viewing 360-degree CR via HMD can be reduced with repeated training, similar to the Fixed Frame[4] CR, a more elaborate approach has to be taken with regard to a potential information overload. As Roche et al. (2022) state in their SWOT analysis, interactive elements must be integrated into spherical 360-degree CR. This way, observation aids as well as work assignments (e.g., regarding noticing) can be provided for the viewers.

In the design-based research (Schiefner-Rohs, 2021) oriented discussion of planning and creating 360-degree real videos, the authors were able to determine tendencies that the use of such prepared content - apart from a high degree of authenticity or realism - is for example suitable for the development of “Exploratory Seeing”[5] (Draghina, Vettermann, Geier, Fahrner, Strehl & Bihler, 2022; Reinmann, Vohle, Brase, Groß & Jänsch, 2020). Despite the advantages in the field of observation and identification of e.g., interactions (Gold & Windscheid, 2022; Meinert & Tuma, 2022), impulses have to be given with regard to the training and further education of TPV. With the help of these impulses, student teachers can learn to interpret what they observe in a well-founded manner and to link it to teaching components that are effective for learning (Moser, 2017). The author team proposes a guiding support in the form of didactically motivated prompts (referred to as hotspots from now on), implemented within the 360-degree CR. This paper focuses on a theory-derived placement of didactic optical aids within 360-degree real video recordings of school lessons. This is done with the help of expert tests (cf. 4): a combination of eye-tracking and retrospective thinking aloud[6] (Olsen, Smolentzov & Strandvall, 2010). The aim is to make the advantages of these extremely realistic impressions of

environments (Sweller, 2005). These loads have also been observed in connection with the viewing of spherically prepared 360-degree content (Albus & Seufert, 2022).

[4] Fixed frame refers to the fixed image section available to viewers when viewing conventionally recorded video material. This fixed section allows only a limited and (by the producers) highly influenced insight into a videographed situation.

[5] This is a new concept in the scientific context by Reinmann et al. (2020), which addresses an extension of research-based learning enriched by videos (Draghina et al., 2022, p.4). The use of 360-degree videos which are considered to have an increased exploration and immersion potential, can favor and promote Forschendes Sehen. However, in order to generate a corresponding added value, this requires certain guiding elements or "focusing aids" (Gold & Windscheid, 2022, p. 175) that are embedded in the video.

[6] This method is often used in connection with eye-tracking data. This combined approach has proven to be a way to obtain richer data from subjects. It allows subjects to reflect on their gaze data in a way that they would otherwise not be able to (Olsen et al., 2010).

teaching practices of 360-degree real-life recordings available for the practice-oriented teacher training (Gold & Windscheid, 2022, p. 167).

2. Teachers' professional vision and videos

The fact that TPV can be fostered with the support of video material has been known since the work of Sherin, Russ, and Colestock (2008) or Gold, Pfirrmann, and Holodynski (2021). The core of TPV consists of two components: First the noticing of classroom situations and second the knowledge-based reasoning (Seidel et al., 2010; Sherin, 2007; Sherin & van Es, 2009).
Due to the repeatability and the variable areas of use, video material can serve as a supporting framework for the development of a practice-relevant professionalization of student teachers (Steffensky & Kleinknecht, 2016). The work with video material provides a valuable link between theory and practice (e.g., Barnhart & van Es, 2015). Despite these advantages, critical voices have pointed out limiting factors in the last few years: On a technical level for example, conventional CR are only able to show a limited view of reality which can additionally be edited by the videographer (Sacher, 2008). Also addressed are the following limiting aspects: On the one hand, a lack of complexity can cause that the situation represented in the video does not address the skills needed to handle the situation in real-life (Seifried & Wuttke, 2017, S. 308). On the other hand, deficits regarding clarity can lead to a loss of important information (Jürgens, 2021, S. 50). In the hope of being able to compensate for the addressed deficits, especially regarding the promotion of noticing skills as an important part of TPV (Seidel et al., 2010; Sherin, 2007), the authors' attention turned toward the novel recording format 360-degree CR. Despite its short existence, this format already has a high number of related publications (e.g., Ferdig & Kosko, 2020; Gold & Windscheid, 2022; Huang, Richter, Kleickmann & Richter, 2022; Kosko, Ferdig & Zolfaghari, 2020; Theelen, van den Beemt & den Brock, 2019; Vettehen, Wiltink, Huiskamp, Schaap & Ketelaar, 2019; Walshe & Driver, 2019), which are especially positive in terms of TPV development (specifically, noticing).

3. Theoretical assumptions about 360-degree videos

With reference to the aforementioned work on so-called circumferential recordings, 360-degree CR are associated with advantages, in particular immersion[7] and the feeling of (spatial) presence[8]. Wirth and Hofer (2008) state that these two concepts are codependent and influence each other. Another potential advantage of 360-degree real video is the increased degree of exploration freedom (Hebbel-Seeger, 2018): students are free to decide which interaction they want to focus on. Based on this, the authors question the existence and strength of the effect that circumferential recordings can have, for example, on the promotion of selective attentional control or the perception of events in the classroom (Sherin & van Es, 2009; Seidel et al., 2010).

The aforementioned literature shows that the viewing of 360-degree real videos can very quickly be overwhelming for viewers, especially for novices. In addition to the above mentioned EL, viewers can also experience a fear of missing out on important details or situations within the recording (Breves & Heber, 2020). Before we can ask the overarching question about an effect (e.g., regarding noticing) of 360-degree CR, we must first eliminate potential factors causing overload.

For this purpose, the authors focus on findings from the field of multimedia learning environments. Alpizar, Adesope and Wong (2020, S. 2097-2098) note that the use of attention-grabbing elements in such environments can be of triple benefit to learners:

1. Directing attention can be especially beneficial for learners who have difficulty identifying important information on their own. The use of guiding elements helps them focus their attention on relevant content, increasing the likelihood of processing essential aspects.

[7] Immersion refers to the sensation of an enhanced feeling of presence by the viewers. The extent always depends on how much the technology used is able to keep the physical world out of the mediated one (cf. Bech, De Moor, Durnez, Egger-Lampl, Naderi, Raake, Agrawal & Schmidt 2020, pp. 1-2).

[8] Concept of media reception that is subjectively experienced as so overwhelming that awareness of its mediation recedes into the background (Wirth & Hofer, 2008, p. 160).

2. With the help of guiding elements new information can be linked and/or related to preexisting knowledge more efficiently.
3. By using guiding elements, the cognitive load of learners can be reduced.

In addition, Mäkelä, Keskinen, Mäkelä, Kallioniemi, Karhu, Ronkainen, Burova, Hakulinen, and Turunen (2019) found that the use of attention guiding elements must be carefully considered in terms of their frequency of presentation and degree of guidance.
Following these findings and based on first experiences with the creation of 360-degree real images as well as the attempt to make their assumed advantages usable for the practical teacher education at the University of Augsburg (Draghina et al., 2022), the authors focus on the elaboration of a guiding instruction with the help of didactically motivated hotspots. These are elements (e.g., colored markings) within the 360-degree CR through which, on the one hand, a certain amount of attention directing can be achieved. On the other hand, hotspots can be used to provide the viewers with additional (audio-)visual material and information (Draghina et al., 2022). In the case of CR, work assignments or similar instruction can also be linked to the hotspots.

4. Applied research by means of explorative laboratory analysis

Based on the aforementioned considerations, the authors asked themselves on which assumptions or expertise the number, arrangement and presentation of integrated supporting hotspots must be based in order to generate the highest possible learning success for the training and further consolidation of TPV-related skills. In order to answer this question, the authors developed a 360-degree video prototype of a CR. In a first step, the goal of the study was less the direct support of competency development in the area of TPV but focused more on a mixed group of participants consisting of novices and experts in the field of teacher education. The aim was to capture the participants' observations with the help of eye-tracking data. In a second step, this data was combined with the retrospective thinking-aloud data, in order to use the overall results to create didactically useful and goal-oriented instructions in the form of hotspots. This way, the authors were hoping for an

optimization in the area of didactically motivated optical aids for the viewing of immersive 360-degree videos.
The expert group of participants consisted in equal parts of employees of the local chair for elementary school pedagogy and didactics (n=4) and local elementary school teachers (n=4). The novice group consisted of students obtaining their teaching degree for elementary schools at the University of Augsburg (n=4). Their statements were used to gain insight into students' opinions regarding potential advantages and disadvantages of using 360-degree CR in teacher education.

4.1 Planning the setting and creating a prototype

The video prototype was created in an elementary school class consisting of 13 students and shows an open learning period. The technical equipment consisted of a 360-degree camera (Fig. 1: A) with integrated microphone as well as several wireless microphones spread throughout the classroom (Fig. 1: B1-4). Another wireless microphone (Fig. 1: C) was given to the teacher.

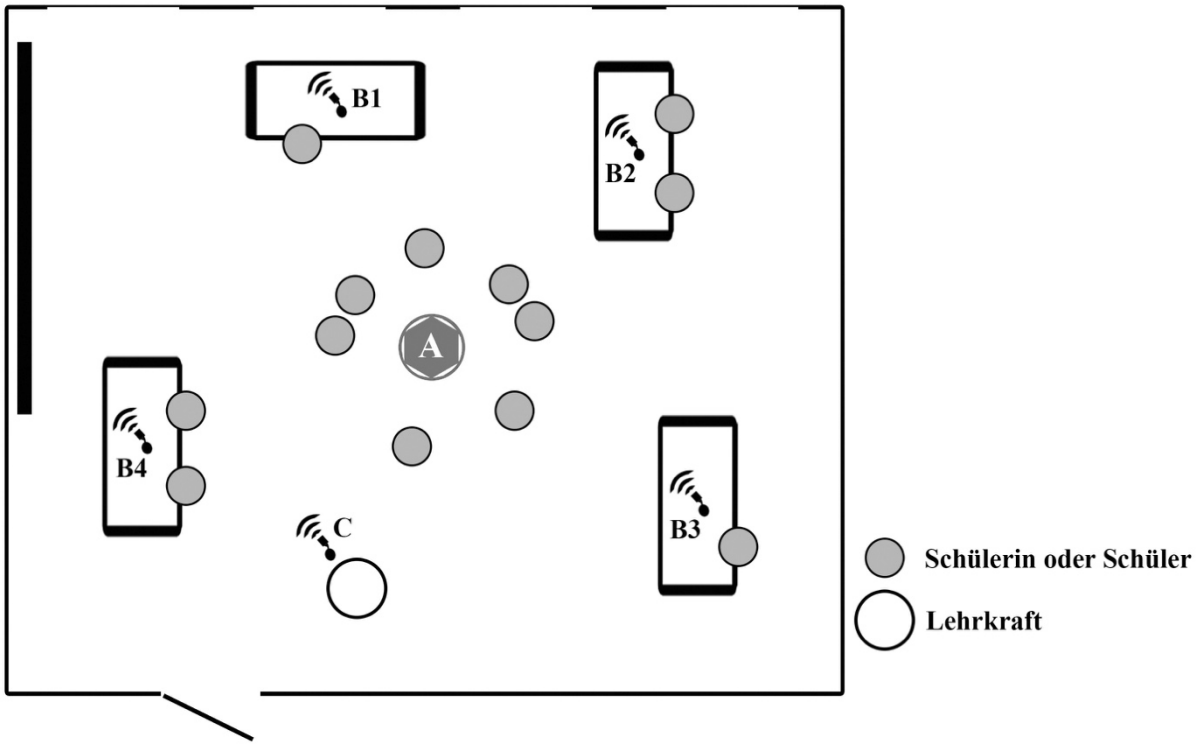

Fig. 1 The setting

A 15-minute block was extracted from the CR, which served as the basis for the study. Since none of the participants had more in-depth experience with viewing spherical CR, the authors deliberately decided on this time reduction.

4.2 Conducting the study

At first, all participants watched the above-mentioned 15-minute video via HMD. While they watched the video their head movements were recorded with the help of screen recording and their eye movements (gaze points) were captured with an eye-tracking software. In a next step, the participants were shown the video material containing a combination of their head and eye movement (Fig. 2: A). While watching they were asked to reflect on their viewing behavior with the help of a thinking aloud procedure in the form of a narrative interview related to TPV. If necessary, the authors asked additional questions[9]. For an easier analysis of the interviews, they were recorded with a camera (Fig, 2: B) and afterwards transcribed. Additionally, the expert group received a questionnaire with 13 open questions. This questionnaire served to determine the participants' previous experience with 360-degree content and video material in teaching/learning contexts. Furthermore, it was used to gather evidence on immersion and presence as well as their possible advantages over conventional fixed frame recordings.

[9] e.g., "Why did your gaze turn away from the situation, although it was still going on?" or "Why did you direct your gaze to this subject/object, although it has nothing directly to do with the current event?" or "Would you have wished for more concrete/further information about this situation/interaction?"

Fig. 2 Conducting the study A/B

4.3 Analysis

The gaze points were qualitatively analyzed with the help of Tobii Pro Lab. The questionnaires were analyzed following the content analysis by Mayring (2022). The data from the thinking aloud procedure was analyzed based on an approach proposed by Barton and Lazarsfeld (1984). This approach allows the exploration of contexts that so far have been marginally theoretically explored (Kelle, 2007, p. 51) and thus enabled the authors to identify goal-oriented clues for a didactically meaningful presentation of optical aids within spherical CR. In addition to a theory-derived deductive (Mayring, 2022) formation of categories (immersion/presence, free choice of image section, EL), an initially quasi-statistical[10] procedure was chosen for the further categorization (with the aim of generating possible hotspots), following Barton and Lazarsfeld. This approach was chosen to address the challenges arising from the thinking aloud data which could otherwise not have been adequately analyzed (Lamnek & Krell, 2016, p. 104). Resulting categories (in this case hotspots) will be qualitatively tested in future explorations of the topic (see conclusion and outlook).

[10] Quasi-statistics refers to an approach that follows quantitative research and statistical analysis, but which is simply an intuitive summary and generalization/abstraction based on qualitative or other data that cannot be analyzed statistically (Barton & Lazarsfeld, 1984).

5. Results and discussion

Overall, the participants had little to no experience with 360-degree material. Nevertheless, they were able to imagine themselves in the classroom and therefore obtained a realistic view of the teaching situation: e.g., "You can always turn and look, you are not limited to one image section ..., you are more flexible, you just have more leeway ... and it also seems a bit more natural ..." (participant 3, personal communication, December 15th, 2022). Free exploration of the classroom was particularly often emphasized: e.g., "...because I could experience quite a lot simultaneously." (participant 7, personal communication, January 26th, 2023). Except for one person from the expert group (teacher), all participants experienced immersion as well as an increased feeling of presence which has already been confirmed in connection with 360-degree CR in other studies (including Ferdig & Kosko, 2020; Gold & Windscheid, 2022; Kosko et al., 2020). This became evident because of statements like the following: “I thought he [the student] can see me now” (participant 6, personal communication, December 21st, 2022). Evidence of spatial presence and immersion was also found in the novice group: e.g., "I was there in the classroom ..." (participant 9, personal communication, January 31st, 2023). Referring to our previously mentioned statement of a non-influenceable image selection in conventional fixed-frame CR, the possibility to freely chose image sections and details within the spherical video was positively emphasized by all participants: e.g., “And because she [the teacher] only said here and here, I didn’t know what she was doing behind my back, so I turned around and looked there as well” (participant 1, personal communication, December 15th, 2022). The participants justified this primarily with the optional setting of their own observation focal points as well as the possibility of being able to focus not only on the main events, but also on peripheral activities. In particular, the observation of classroom dynamics, lesson structures and processes of classroom management were mentioned: e.g., “Who works with whom and with which material and how concentrated…” (participant 8, personal communication, January 26th, 2023). According to participants’ statements, the free choice of the image section additionally led to an increased exploration

within spherical CR: e.g., "... that's also quite good that you can look around the whole room" (participant 2, personal communication, December 15th, 2022).
The experts all agreed that videos play an important role in teacher education. In this context, they saw advantages of 360-degree CR especially in the promotion of TPV as well as in overcoming the theory-practice gap and mitigating the so-called practice shock when entering the profession. Particularly regarding TPV, they mentioned the promotion of selective noticing of key moments occurring in complex situations.
A similar complexity is also associated with the viewing of 360-degree videos (see EL and/or FOMO). Both the quasi-statistically oriented analysis of the gaze points as well as the evaluation of the thinking aloud date showed that not only the attention of the experts but also that of the novices was strongly guided by the teacher. The teacher served as a kind of anchor that helped the viewers navigate the spherical video: e.g., "I was strongly guided by what I heard from her." (participant 10, personal communication, January 31st, 2023). It is reasonable to assume that this reduced both EL and FOMO. This assumption was supported by the analysis of the gaze points (especially those of the novices): As soon as the teacher left the classroom, the gaze of the participants wandered around more uncontrolled and hectic: "When the teacher is not there, then it is somehow difficult to follow what is going on ... you're guided very strongly by her..." (participant 11, personal communication, February 1st, 2023). Statements like this one suggested that additional canalized information is needed. This was underlined by various expert statements such as the following: "Otherwise, it is just a huge amount [of information] with which less experienced students can do less, because they do not know, what is the point?" (participant 3, personal communication, December 15th, 2022).
Overall, the data analysis showed that the expert group expressed a clear desire for more information regarding work materials and work assignments: e.g., "I think it would have been nice, if we were shown an assignment that the kids had, regarding the learning goal and purpose…" (participant 2, personal communication, December 15th, 2022), or "…that you can sort of click on it and then it [the information] pops up and it's like that with all the materials…" (participant 4, personal communication, December 20th, 2022).
Furthermore, the participants wished for additional viewing angles in order to for example be able to take a closer look at details of working methods or student

interactions: “…closer to the student, next to the student, behind the student…” (participant 8, personal communication, January 26th, 2023). Additionally, the experts mentioned that while viewing they were missing a work assignment that could regulate the amount of information: e.g., “…you would have to tell the students to look at this or that assignment” (participant 5, personal communication, December 20th, 2022).

6. Conclusion and outlook

Based on the analysis of the thinking aloud data, the authors suggest three categories of hotspots for enriching 360-degree CR:

Declarative hotspots: This is additional background information such as the students’ work assignments or work material. According to the analysis, these hotspots should be presented as a combination of visual and textual information and should be adaptable to the prior knowledge of the viewers (Fig 3).
Positional hotspots: This refers to additional, in the 360-degree CR embedded, fixed frame videos which offer different viewing angles (e.g., close-ups). The participants expressed the wish to have the option to view details of students’ working methods or interactions more closely.
Instructional hotspots: These are work assignments for the viewers for example instructions for observing classroom dynamics or classroom management.

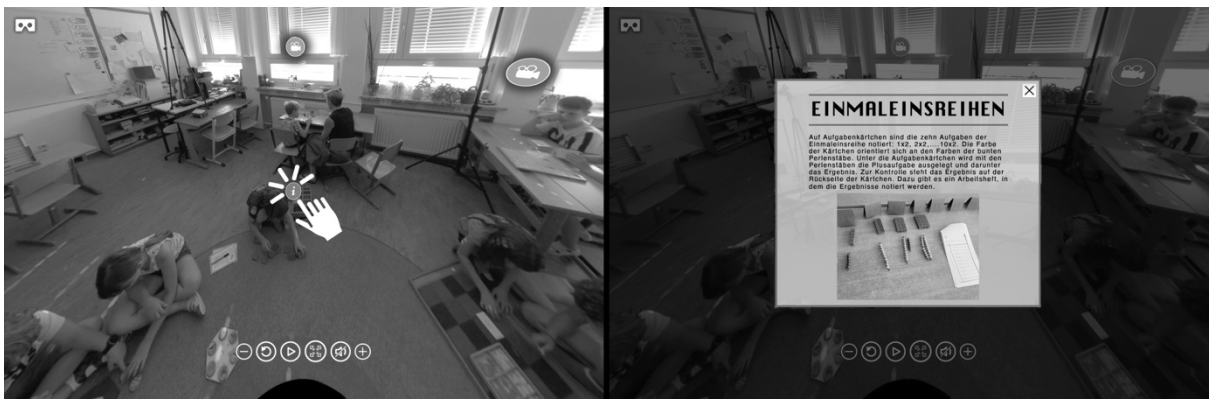

Fig. 3: Possible presentation of hotspots

If possible, these three categories should always be presented in combination. It should be noted that the declarative hotspots should be adjusted to the instructional ones in terms of quantity and quality. According to the expert group, e.g., observing classroom dynamics requires less additional information whereas observing students' interactions with the work material requires more.

As a next step, the practical use of this technology is planned. This is to be realized as a course within the teacher training program at the University of Augsburg. In this context, the production of new 360-degree CR is planned, which will be enriched with the hotspot categories described above. The videos will be made available to the students on a teaching/learning platform, where they can be viewed browser-based either via HMD or as manipulable equirectangular[11] clips.

Furthermore, it is planned to accompany this course with research and to let the obtained results flow into the further elaboration of 360-degree videos specifically made for teacher education with the overall goal to discuss the advantages of 360-degree CR regarding their positive effects on the training of competencies in the field of TPV (especially noticing)[12].

[11] This is an equal angle image. This technique is widely used, for example, in the field of map displays of the Earth. It offers the possibility to display spherical objects or images/videos as a flat fixed frame [2D] image/video (Amoruso, 2016).

[12] A possible approach in this context would be, for example, to optimize the auditory level: Not only the appearance of the teacher served as an anchor for the participants, but also her voice (e.g., "I was strongly guided by what I heard from her."). Here it would be for example possible to use a 360-degree ambisonic microphone to enable better spatial orientation and thus offer not only visual but also auditory anchor points.

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