

## How to Record 360-degree Videos of Field Trips for Education in Civil Engineering

### Recommendations and Experiences

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**Abstract:** As part of Virtual Reality, 360-degree videos have potential to enhance tertiary education. One application area is the documentation of field trips in the discipline of civil engineering. Field trips are usually organized infrequently, with shifting motives and are limited to small groups of students. 360-degree videos share the experiences of field trips with a wider student-audience. However, recording 360-degree videos requires careful preparations. Therefore, the paper addresses the issue how 360-videos should be recorded for usage as supportive medium in educational contexts. Based on a literature research the authors compile a set of recommendations and verify it through two case studies in Bangladesh. The aim of the paper is to enable educational stakeholders to record elaborated 360-degree videos to enrich tertiary education in civil engineering by a promising medium of learning.

**Keywords:** Virtual Reality, 360-degree video, Education, Recording, Guideline, Civil Engineering, Bangladesh

## 1 Introduction

Civil engineering is a discipline that deals with the planning, construction, calculation and operation of structures, such as buildings, roads, bridges and waterways. Technical environmental protection, such as noise protection, water and soil protection, also belongs to the discipline's responsibilities. In addition to teaching the technical basics, practical experience by means of field trips to educationally relevant sites is an essential part of the curriculum. The aim is to enable students to experience problems first handed and gain a deeper experience of the overall context. Field trips, however, are expensive and sometimes even unfeasible due to cost and organizational effort as far as structures in distant countries are concerned. Although the educational benefits of field trips are confirmed [BF14], field trips are usually organized infrequently. As a result, only a limited amount of students can participate in irregularly conducted field trips with even shifting motives.

This is where Virtual Reality (VR), including 360-degree videos can contribute to education: VR allows to “Experience a situation in an inaccessible or distant [...] location“ [VVP19]. Therefore, we believe 360-degree videos to be one option to strengthen the

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amount of almost practical experience in the study of civil engineering. According to our experiences, 360-degree videos have been barely integrated into civil engineering education. So far, the majority of education is still lecture based.

360-degree videos can be considered as a genre of VR [VVP19],[Ei19]. It combines authentic recordings from reality with virtually enhanced scenarios. Unlike conventional video that limits the viewer to the director's point-of-view, 360-degree videos are interactive and allows viewers immersing into the virtual environment and to watch to the given scene with the freedom to look omnidirectional instead of limiting viewers to a fixed point of view. 360-degree videos can also be referred to as 360°, immersive, omnidirectional, panoramic, spherical, or surround videos. In essence, 360-degree videos can be described as moving images that have been captured so that viewers can look around in any given angle as if viewers are turning the camera [B112].

So far, 360-degree videos have been used in diverse educational fields, as the following examples indicate. Pham et al. understand 360-degree videos as an medium to foster safety education prior to entering construction sides [Ph18]. Ardisara and Fung use 360-degree technology to record different laboratory techniques in an undergraduate organic chemistry course [AF18], while Izard et al. focus on the visualization of an operating and an anatomical dissection room as part of medical training [Iz17]. In the same discipline, Yoganathan et al. present the positive results of a study in which 360-degree videos were used to significantly improve the knot-tying skills of surgeons compared to traditional 2D instructional videos [Yo18]. 360-degree videos as educational medium for training in emergency situations in hospitals are investigated by Herault et al. [He18]. Further, Berns et al. analyze the applicability of 360-degree videos in the field of foreign language learning [Be18]. Walshe and Driver consider 360-degree videos as a potential “more active and student-centered approach to initial teacher education” [WD19], while Feurstein integrates 360-degree videos in higher education [Fe18]. For the field of Cultural Heritage, Argyriou et al. work on the immersion-enhancing effect of 360-degree videos using game elements [AEB17].

From the general perspective of VR-based learning, Zender et al. outline various currently confirmed and discussed advantages of VR-based learning environments [Ze18]. These advantages include the promotion of learning as a situated process by providing authentic, realistic learning settings. A further advantage is the integration of context-sensitive and individualized learning clues as well as the integration of learning analytics. On the other hand, there are various hypotheses currently being debated that have not yet been substantiated. The assumption that perceived presence in VR learning environments particularly promotes retention processes has not yet been clearly proven. However, the response to the needs of different types of learners has at least partially been confirmed. Although novelty effects on motivation can still be observed at present, it cannot be counted among the advantages of VR technology due to its foreseeable weakening. Focusing on 360-degree videos in particular, Callies describes opportunities of 360-degree video in educational contexts ([Ca17] cited in [VVP19]). For example, 360-degree videos

allow experiencing a situation from another person's view, experiencing dangerous, inaccessible or distant locations; experiencing alternative approaches to situations: Eisenlauer adds the advantage of 360-degree videos allowing for learning experiences impossible in real life [Ei19]. Other positive findings range from the fact, that compared to conventional non 360-degree video cameras, 360-degree videos capture a wide panoramic view, therefore "one typically does not need to worry if a part of demonstration is out of the scope of view" [AF18], to the user-friendliness since different processes in a situation, such as a laboratory room, can be recorded simultaneously without another filming operator [AF18]. In comparison to model-based VR applications [IJP17], 360-degree videos are an approach to create educational VR content with low entry barriers. VR technology and its affordability has evolved at a fast pace. Equipment such as cardboards and head-mounted displays (HMDs) are now available for the average consumer at reasonable prices potentiating the use of VR contents, such as 360-degree videos. Special attention in research receives also the subject of immersion [EEW18].

Didactically, videos became one of the most common and accepted forms of educational material [Sm12], [BV16]. Thus, we suggest 360-degree video as part of the learning video genre, being understood as a method of blended learning [Fr12]. As an educational approach, the term initially could mean "almost any combination of technologies, pedagogies and even job tasks" [Fr12], while it generally describes the combination of virtual and physical learning environments today [SG08]. Launer considers it as a mix of "technology supported self or distance study settings and face-to-face settings" [La10]. Reportedly, blended learning is more effective than purely face-to-face or entirely online classes [TB07], making 360-degree videos an promising educational medium.

## 2 Scope and Methodology

To delineate the methodology, first, the scope of work is delimited in the following. Processes creating 360-degree videos are divided into different phases. For 360-degree video creation in general, Wohl distinguishes the phases *Preparing to Shoot*, *Production*, *Post Production* and *Finishing* [Wo19]. For educational 360-degree videos, Eisenlauer describes the phases *Draft*, *Production* and *Post Production / Delivery* [Ei19]. The *Draft* phase includes the selection of learning objectives and filming locations. The actual shooting takes place in the *Production* phase. The *Post Production* phase includes software-based optimizations, such as stitching, but also the augmentation of the videos for the learning objective, such as adding sound effects, inserting signaling and annotations, and embedding the videos in appropriate learning scenarios. The recommendations considered here refer primarily to the *Production* phase. Research goal is working out recommendations to be observed when recording the videos, e.g. recommendations guiding filming locations, selection of objects to be filmed and selection of learning objectives. The study does not focus on content extensions of the video material in the *Post Production* phase. The basis for the development recommendations is

a literature search. Thereafter, the recommendations derived are compared with the characteristics of two case studies to perform a validation.

With the solely focus on the production phase, the article is structured in five sections. Following the introduction and the current section, in the next section recommendations found in the literature are presented and compiled into a set of recommendations. In section four the case studies are presented and aligned to the recommendations compiled. Finally, the results are discussed and conclusions are drawn.

### 3 Recommendations

The recording of 360-degree videos faces different challenges. Based on a case study of creating 360-degree videos Kavanagh et al. point out the issue of directing the viewer's attention [Ka16]. While in conventional videos it is assumed, that the viewer is statically seated in front of the screen, watching 360-degree videos might require to sit in a swivel chair or even stand [Li18]. In this context Kavanagh et al. noticed in their study, that a "major issue presenting educational VR lectures was that users could easily become distracted by the surroundings. Furthermore, simple lecturing actions like gesturing towards an object become less reliable as there is no guarantee the user will even be looking in your direction." [Ka16]. Also an unintentionally loss of focus or disorientation were noticed [Ka16], [AF18]. Moving the camera while recording can produce motion sickness trough "[...] a conflict between sources of sensory information specifying self-motion and orientation." [He02]. Further issues are the positing of the camera in order "to find the correct point of view for capturing the content, and whether to capture using a hand-held (selfie-stick) or fixed (tripod) camera support" [Li18], clear visibility or an insufficient blinding out of stands such as tripods, quality of video recording, relatively low quality displays for VR purposes limiting the presentable educational content (e.g. posters appear blurry) and the general high price of the equipment [Ka16]. Additionally, the creation of 360-degree videos requires technical skills in terms of producing and editing the video. Hiring external contractors demands sufficient financial resources.

Recommendations to support recording 360-degree videos for educational settings can be found in different studies. Based on the nature of the recommendations, they can be categorized in five different groups: the *Didactical approach*, which might be considered also as part of the *Draft* phase, comprises recommendations about specific educational settings, for which the 360-degree video is used, *Preparation of the presenter* refers to the interaction of the presenter with the camera, *Technical requirements* describe aspects of technical preparation, *Location and positioning* addresses questions of where to place the camera and the category *Recording process* involved issues that might appear during the capturing of a 360-degree video.

Categories	Recommendations
<b>Didactical approach</b>	<ul style="list-style-type: none"> <li>- Define the subject matter and learning objectives before recording 360-degree video [Ei19]</li> <li>- Decide, for which elements/aspects a full 360-degree video is required [AF18]</li> <li>- Appoint objects, scenes or processes that can be photographed or in sound recorded</li> <li>- Develop ideas, how the learner could be guided through the video</li> </ul>
<b>Preparation of the presenter</b>	<ul style="list-style-type: none"> <li>- Give a genuine introduction of how to interact with 360-degree videos to presenters</li> <li>- Focus on a natural interaction of the presenter with the camera as it was a real person. This includes not only talking directly to the camera, but also communicating gestures such as point or showing objects to the camera [Li18]</li> <li>- Present objects in the videos like you would do to a real person. Hold objects not too far or too close to the camera [Li18]</li> <li>- Attempt to record static, rather than moving/hand-held videos [AF18]</li> <li>- Note, that if the camera is moved by a walking presenter, e.g. through a selfie stick, it is should be moved with the same pace [Li18]</li> <li>- Hold the camera in the same direction as the presenter walks, instead of constantly rotating it around [Li18]</li> </ul>
<b>Technical requirements</b>	<ul style="list-style-type: none"> <li>- Use a monopod to decrease the appearance of a tripod and to provide a natural view [Ka16]</li> <li>- Select a high-resolution camera for recordings of small items. Otherwise a low-resolution camera could fit, although the lower quality video could dissatisfy viewers [AF18]</li> <li>- If text is used for explanations as annotations, the font should be in colour, put on maximum contrast (in the picture) and in some cases underlined with a so called billboard (a colour bar) for fast and good readability (Post production) [Fi13]</li> </ul>
<b>Location and positioning</b>	<ul style="list-style-type: none"> <li>- Select the location and position of the camera that most of the needed aspects/points of interests are recorded [Ka16], [Ei19]</li> <li>- For the optimal height the camera should be kept at eye level [Li18]</li> </ul>
<b>Recording process</b>	<ul style="list-style-type: none"> <li>- Record the sound atmosphere/off component separately to produce 3D sounds that help to orientate inside the video [RC13]</li> <li>- In cases of poor audio recording capability, minimize scripted speech in the video [AF18]</li> <li>- Check with the mobile app that is monitoring the recording to preview that the camera is positioned properly [AF18]</li> </ul>

Tab. 1: Recommendations for recording 360-degree videos

#### 4 Case Studies – 360-degree Videos of Padma Bridge and Khulna Toilet

A potential task of civil engineers specialized in the field of urban water economy and water resource management is to improve the infrastructure of developing countries. So, it is relevant for students to experience such projects in their implementation and construction. Therefore, during a two-week field trip to Bangladesh in February 2019 with a group of civil engineering students 360-degree videos for educational settings have been recorded aiming to apply the videos later in educational contexts.

Technically, an INSTA360 ONE X 360-degree video camera was used. The camera records with an angle of 200 degrees. The 5.7K (5760 px x 2880 px) image resolution currently is state of the art. Advertised as a surfer and skater camera, it is equipped with a lot of features like remote control via smartphone, image stabilizing and automated stitching of the two images. The decision to use this camera was based on various criteria, in order to set low entry levels for creating 360-degree videos: affordability, portability and user-friendliness. The recorded videos were edited, processed and loaded onto the video platform Vimeo. For viewing the videos, a head-mounted display (HMD) of the type Oculus Go has been used. Additionally, it is possible to view the videos online in VR-mode by the smartphone app that comes with the camera.

In Bangladesh, videos on various sites were recorded. In particular, the focus of the 360-degree videos lied on two different scenes. As the field trip offered to opportunity to visit the construction site of the largest infrastructure project in Bangladesh so far - the first scene was the Padma Bridge (length 4:05 minutes) [We19]. The approximately 6.15-kilometer-long construction site was passed by boat on the Padma River (Fig. 1 and Fig. 2). For the recording, the camera was attached on a selfie stick and hold above the head of the other participants. Recordings were made on two different spots on the boat.



Fig. 1: Film still of the Padma Bridge construction site (view backwards) [We19]



Fig. 2: Film still of the Padma Bridge construction site (view to the front) [We19]

The other captured scene is part of the existing waste water system. During the trip various toilets and sanitation systems of the lower income people in Bangladesh were surveyed to evaluate the options of improving the hygienic situation in urban slums. In one particular case a highly frequented toilet in an apartment building in a slum area of Khulna City was recorded (Fig.3). The camera was positioned in front of the toilet and set on self-timer in order to decrease distraction from the actual object. The video was recorded at eye level to create the impression of standing in front of the toilet.



Fig. 3: Film still of a slum toilet in Khulna

In the case studies, the following implementations and findings have been generated in alignment with the recommendations described in Table 1:

**Didactic approach:** The aim of the recordings was an atmospheric description of physical locations: viewers should get an impression of the filmed location, to be able to grasp the formative characteristics, which is a comparatively generic learning objective. Much more

detailed learning objectives have to be accommodated in future videos, which then also require guidance for the learner.

**Preparation of the presenter:** No presenter has been used for the presented case studies due to the format of the atmospheric description of physical locations. However, further current case studies seem to confirm the recommendations given.

**Technical requirements:** The selected camera has proven to be sufficient to deliver decent 360-degree videos. The first case study utilized a selfie-stick, while in the second case study a monopod confirmed the recommendations.

**Location and positioning:** In the first case study, an elevated camera position was chosen to ensure a clear view of the entire bridge construction site, even over the boat superstructure. In the second case study, a central position was also chosen, but at eye level. For the choice of a suitable position the experience of a photographer or cameraman is advantageous.

**Recording process:** No separate sound recording was required for the format of the atmospheric description of physical locations. Since the camera is operated via a smartphone app, the recorded images can be continuously monitored.

Further, a qualitative user study with 10 participants gave the following insights:

**Immersion.** Every user had the impression that he was actually standing on the boat in Bangladesh and moving next to the construction site. However, the state of immersion has been broken in a few cases users after a while. One user got bored after a while and turned his attention to the shortcomings of the technology, such as the edges of the HMD display or its relatively low resolution, breaking the state of immersion. Two other users lost immersion when they wanted to cross the boat after about two minutes, which is not possible in a static video.

**Specific capabilities of the medium 360-degree video.** The crossing of the boat under the bridge was reported as an interesting moment by most users. The user has the possibility to look up and see the construction in detail. At this point, the user fully recognizes the possibilities and functionality of 360° video by moving his head in all directions.

**Further Information.** Due to the missing post production phase, no further information was integrated into the videos. Users missed additional information about the video content and felt overburdened trying to categorize the sequence.

## 5 Conclusion and Outlook

360-degree videos are a comparatively easy-to-create and easy-to use genre of Virtual Reality (VR). 360-degree videos are commonly implemented in learning contexts as



educational medium and have been proven to enhance the quality of education. In civil engineering, 360-degree videos are applied, among other purposes, as an educational medium to provide more students with experiences of distant sites that otherwise can only be gained in costly field trips. A recent field trip to Bangladesh gave this study the idea to collect recommendations for the creation of 360-degree videos via a literature review enabling the provision 360-degree videos for later use in teaching. The main results of the study are the recommendations for the recording of 360-degree videos and first evaluations of the resulting 360-degree videos of the field trip to Bangladesh. A user study proved – among some weaknesses – that the videos recorded offer valuable insights into the local situation in Bangladesh.

From the perspective of instructional design and learning psychology, however, there is further potential for optimization, which is also a subject of current research. For example, appropriate learning scenarios must be developed, in which the videos can be used effectively, e.g. by motivating students to actually watch the videos. Developing the learning scenarios also includes the definition of learning objectives with a higher level of detail than presented in this study. The 360-degree videos can be more strongly aligned to the learning objectives by the subsequent insertion (post production) of optical and acoustic indicators (signaling, annotations). Brown et al. explore different types of subtitles in 360-degree videos [Br17]. Further, Mäkela et al. investigate so-called *social indicators* to guide the focus of attention of users of 360-degree videos [Mä19]. A more holistic approach to visual guidance is being explored in [Sp19]. Specifically, the aspect of interactivity of 360-degree videos, e.g. via hot spots, should also be included in the further design [Sa17]. Additional research is required to consider the psychological notions of learning purposefully. For example, Parong and Mayer, have observed lower learning success but higher interest and motivation when using immersive VR compared to a desktop application [PM18]. Makransky et al. have reported in a comparable study of immersive VR and desktop applications also on increased motivation but lower learning success [MTM19]. Ramahlho and Chambel explore techniques to increase the emotional perspective of the learner using 360-degree videos [RC13]. In addition, the applicability of frameworks for immersive content creation (e.g. [Ro18]) has to be reviewed.

Nevertheless, a step-by-step improvement of the production process can be expected. For the learning context of civil engineering presented here, a methodology is available which facilitates a documentation of the field trips carried out from now on and makes them available to the next generation of students in a library of 360-degree videos.

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