

XR applications in the teaching of history – An overview

“Extended Reality” (XR) is a container term for technologies that combine real and digitally constructed settings in interactive applications. These include fully computer-generated spaces (virtual reality – VR), digital overlays on physical environments (augmented reality – AR), and hybrid formats that integrate the two levels (mixed reality – MR). XR technologies engage multiple senses simultaneously and create experiences adapted to situational frameworks. They differ sharply from the use of linear media. Precisely herein lies their potential for the teaching of history, including in the context of remembrance culture.¹ This essay systematizes major forms of virtual presentations involving eyewitnesses, develops a heuristic typology of dialogue-based and reconstructive formats, and provides examples of applications in these formats. It also considers empirical studies about XR effectiveness and challenges. As such, it provides a contextualizing framework for this volume’s study of the *For real?* application.

1 Steffen Jost maintains a list that users can contribute to, which includes XR applications; see “Digitalkrams in Gedenkstätten, Museen, Online etc.,” <https://docs.google.com/spreadsheets/d/1Y6G06VwNlLoGczOBitDGbjLv7KqebWz5jSpT7j6bvDY>. Good albeit now somewhat dated overviews of applications are found in Habbo Knoch, “Das KZ als virtuelle Wirklichkeit,” *Geschichte und Gesellschaft* (2021), 47:90-121 and in Steffi de Jong, *The Witness as Object: Video Testimony in Memorial Museums (Museums and Collections, vol. 10)* (New York and Oxford: berghahn, 2018). The developmental lines of 3D testimonies are well presented in Anja Ballis, Michele Barricelli, Markus Gloe, “Interaktive digitale 3-D-Zeugnisse und Holocaust Education – Entwicklung, Präsentation und Erforschung,” in Anja Ballis and Markus Gloe, eds., *Holocaust Education Revisited* (Wiesbaden: Springer Fachmedien, 2019), 403–436.

Eyewitness formats with abstract settings

Interactive dialogue-based XR applications place eyewitnesses into deliberately abstract and visually reduced spaces. Formats such as *Lernen mit digitalen Zeugnissen* (LediZ)² (with Abba Naor and Eva Umlauf) and *New Dimensions in Testimony* (USC Shoah Foundation) combine a neutral setting with a dialogue-centered structure and an extensive body of responses from videographed interviews.³ The *For real?* application, whose interactive core consists of volumetrically recorded conversational situations, is an example of this type of presentation.⁴ Its starkly reduced setting encourages users to focus on the three-dimensional presence of the speakers. It deliberately omits visual/spatial settings and directs attention to the speakers' bodily presence.

Eyewitness formats with reconstructed settings

These applications embed places and persons in a combined as opposed to parallel narrative structure. The AR app for the exhibition *Involuntary Community: The Labor Commandos of Prisoners in Hohenschönhausen* at the Berlin Hohenschönhausen memorial site lets visitors move through former forced labor spaces and barracks, which are overlaid with volumetrically recorded visuals of former inmates talking about these places.⁵ The VR app *The Last Goodbye* guides users through the former concentration camp of Majdanek together with Holocaust survivor Pinchas Gutter. The app *The Lost Time* also combines visual, audio and narrative elements into a layered infor-

2 LediZ, <https://www.en.lediz.uni-muenchen.de/projekt-lediz/index.html> (accessed 20 June 2025). In the *LediZ* project, the digital testimony is understood as a distinct medium that enables a specific form of encounter. The speakers situate their statements with an initial specification of the recording's time and place ("I'm in a studio in 2018"), thus providing a media-ethical framework. See Anja Ballis, "Digitales Gedenken an den Holocaust: Ein Interview über das Projekt 'Lernen mit digitalen Zeugnissen' (LediZ)," *Zeitgeschichte-online*, 27 January 2023, <https://zeitgeschichte-online.de/interview/digitales-gedenken-den-holocaust>.

3 A pronounced interactive format is taken by *Erzähl mir, Inge...*, which simulates a conversation with Inge Auerbacher in a WebXR setting. Users can ask questions via their microphones or by clicking on objects, which prompts the virtual space to respond with animated remembrance images. The visuals are symbolic in design and the dialogue structure is limited to predefined answer sequences.

4 Volumetric recordings are compilations of simultaneous footage of a person from multiple perspectives. Subsequent processing produces a dynamic 3D model that can be placed in VR spaces.

5 The app *WDR AR 1933-45* (2019) also uses eyewitness videos with a 3D appearance, but which are "enriched" by animated images and audio material.

mational ensemble. Some of its scenes show Margot Friedländer at a schoolroom blackboard, for example, while other sequences use her voice as the sole narrative element. The setting remains stylized, with the narrative carried by the acoustic framework.⁶ Recurring topoi such as the camp entrance with the inscription “Arbeit macht frei” (*The Last Goodbye, Ernst Grube – The Legacy*), train tracks or freight cars (*The Last Goodbye, The Lost Time*) make visual reference to Shoah contexts. They activate cognitive and emotional registers of remembrance culture that help authenticate the narrative. Authenticity functions here not as an objective property but rather as a media-facilitated “mode of staging the past in the present” (*Vergegenwärtigungsmodus*)⁷ – an interplay of design-evoked impression and subjective perception, which can allow a sense of historical immediacy to arise in immersive XR applications without requiring factual validity.⁸

6 Abelina Junge and Christian Günther, “‘Die wenige Zeit’ – Immersionsstrategien und emotionale Involvierung,” in *Virtual Reality: Zukunft der historischen Bildung?*, eds. Christian Kuchler and Kristopher Muckel (Göttingen: Wallstein Verlag, 2025).

7 Habbo Knoch, “Erleben oder verstehen? Virtual Reality als geschichtswissenschaftliche Herausforderung,” in *Virtual Reality: Zukunft der historischen Bildung?*, eds. Christian Kuchler and Kristopher Muckel (Göttingen: Wallstein Verlag, 2025), 13–39, here 26–28.

8 For an extensive treatment of theory and conceptualization, see Christian Günther, *Virtual Reality und Authentizität: Gedenkstätten im Wandel immersiver Vermittlung* (Bielefeld: transcript Verlag, 2025), <https://www.transcript-verlag.de/978-3-8376-7738-6/virtual-reality-und-authentizitaet>.

State of research and empirical inroads

Numerous researchers have studied the impact of medialized and live eyewitness formats.⁹ Gaps remain in the empirical findings, however.¹⁰ This is also the case for XR technologies.¹¹ The question of how XR formats influence specific perceptual, reflective and learning processes has thus far been largely unanswered.

In one of the few differentiated studies in this area, Bertram compared four educational formats (live, video, text, control group) under standardized conditions. She confirms the general effectiveness of both medialized and live eyewitness testimonies, but shows marked differences. The media formats had a primarily motivational effect and favored analytical distancing. By contrast, the personal encounter in live formats was beneficial for comprehending terms but made it more dif-

- 9 See Martin Sabrow and Norbert Frei, eds., *Die Geburt des Zeitzeugen nach 1945* (Beiträge zur Geschichte des 20. Jahrhunderts, vol. 14), (Göttingen: Wallstein Verlag, 2012); e.g. Axel Doßmann, "Visualisierte Zeitzeugenschaft, made in Germany: Beobachtungen und Rückfragen," in *Ende der Zeitzeugenschaft? Über den Umgang mit Zeugnissen von Überlebenden der NS-Verfolgung*, eds. Anika Reichwald, Julius Scharnetzky, Johannes Lauer et al. (Göttingen: Wallstein Verlag, 2024), 182–204; Nicola Przybylka, "'Zeitzeuginnen des Zweiten Weltkriegs per App treffen?' Eine medienwissenschaftliche Perspektivierung auf die Augmented Reality App WDR AR 1933-45"; Michele Barricelli and Markus Gloe, "Neue Dimensionen der Zeitzeugenschaft: Digitale 2D/3D-Zeugnisse von Holocaust-Überlebenden aus fachdidaktischer Sicht," in *Jahrbuch für Politik und Geschichte*, eds. Claudia Fröhlich and Harald Schmid, vol. 7 (2016-2019) *Virtuelle Erinnerungskulturen* (Stuttgart: Franz Steiner Verlag, 2020), 45-65; Elke Gryglewski, "Zur künftigen Arbeit mit Zeitzeuginnen und Zeitzeugen in Gedenkstätten zur Erinnerung an die nationalsozialistischen Verbrechen," *Totalitarianism and Democracy* 15 (2018), 165–175.
- 10 Christiane Bertram, "Live oder medial vermittelt: Was lernen Schülerinnen und Schüler mit Zeitzeuginnen und Zeitzeugen?" in *Entgrenzte Erinnerung: Erinnerungskultur der Postmemory-Generation im medialen Wandel*, eds. Anne-Berénike Rothstein and Stefanie Pilzweiger-Steiner (Berlin, Boston: De Gruyter Oldenbourg, 2020), 247–266, here 255, <https://doi.org/10.1515/9783110668971-010>. Bertram refers to Christina Brüning and Sanna Stegmaier's study accompanying a project using the USC Shoah Foundation's Dimensions in Testimony (see Christina I. Brüning and Sanna Stegmaier, "'Jetzt würde ich sie voll gerne in echt treffen': Das Projekt 'Dimensions in Testimony' der USC Shoah Foundation in der historischen Bildung. Analyse und Auswertung der Begleitstudie zum ersten interaktiven Zeugnis in deutscher Sprache," in *Historisches Erzählen in Digitalien: Theoretische Reflexionen und Empirische Beobachtungen*, (Bielefeld: transcript Verlag, 2024).
- 11 Stephan Schwan, "Virtuelle Realitäten," in *Handbuch Historische Authentizität*, eds. Achim Saupe and Martin Sabrow, (Göttingen: Wallstein Verlag, 2022), 536–544. See also X-Mem, "Virtual Reality Beyond the 'Time Machine' – A Manifesto," *Public History Weekly* (2023); Elena Lewers and Lea Frentzel-Beyme, "Und was kommt nach der Zeitreise?" *MedienPädagogik: Zeitschrift für Theorie und Praxis der Medienbildung* (2023), 51:402–429, here 408.

difficult to apply them critically – an effect Bertram ascribes to an immediate “aura of authenticity” attributed to the eyewitnesses.^{12,13} Brüning’s empirical study of classroom instruction, which examines the use of digitalized survivor interviews in heterogeneous school settings, points to a similar tendency.¹⁴ Whether – and in what way – these results are transferrable to XR applications remains open. However, they suggest key dimensions of reception that could also be of relevance for XR.

Two recent studies by Kolb et al. and Browning et al. compare the reception and impact of interactive 3D eyewitness formats to those of classical presentations.^{15,16} Kolb et al. compare three variants of interactive digital testimonies from the *LediZ* project in a laboratory setting: audio only, 2D video, and 3D stereoscopic. Browning et al. study visitor reactions to Dimensions in Testimony (DiT) exhibits from the USC Shoah Foundation at two Holocaust museums in the USA. Both studies show that audiovisual content – including 2D – is experienced (*erleben*)¹⁷ as considerably more impactful than purely audio formats. For the 3D DiT formats, Browning et al. show greater perceived levels of positive emotion (joy, fascination, surprise) and higher self-reported levels of learning, satisfaction and the intention to act as “upstanders” for other people’s rights. Neither study found any significant difference among the formats regarding empathetic connection with the survivors.

- 12 Christiane Bertram references and uses Sabrow’s term here: Martin Sabrow, “Der Zeitzeuge als Wanderer zwischen zwei Welten,” in *Die Geburt des Zeitzeugen nach 1945*, eds. Martin Sabrow and Norbert Frei (Göttingen: Wallstein Verlag, 2012), 13–33, here 27.
- 13 Christiane Bertram, *Zeitzeugen im Geschichtsunterricht. Chance oder Risiko für historisches Lernen? Eine randomisierte Interventionsstudie. Dissertation* (Frankfurt am Main: Wochenschau Verlag, 2016), 123.
- 14 Christina Isabel Brüning, “Holocaust Education in Multicultural Classrooms: Some Insights into an Empirical Study on the Use of Digital Survivor Testimonies,” in *Holocaust Education Revisited*, eds. Anja Ballis and Markus Gloe (Wiesbaden: Springer VS, 2019), 391–402. DOI: https://doi.org/10.1007/978-3-658-24205-3_21.
- 15 Daniel Kolb, Simona Maiolo, Patricia Maier, Fabio Genz, Simone Müller, Dieter A. Kranzlmüller, “Effects of Visual Modality on Conversations with Interactive Digital Testimonies,” in *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*, eds. Naomi Yamashita, Vanessa Evers, Koji Yatani et al. (New York: ACM, 2025), 1–25.
- 16 Matthew H. E. M. Browning, Katie M. Thurson, Allison Maynard, Olivia McAnirlin, Mahtab Kiani, Robert B. Powell, “Beyond the screen: comparing Holocaust museum visitor outcomes from interactive dimensions in testimony exhibits with 2D film exhibits,” *Holocaust Studies* (2025), 1–28.
- 17 On distinguishing the concepts of *erfahren* and *erleben* (both translated as “experience” in English) see Christine Gundermann, Juliane Brauer, Filippo Carlà-Uhink, eds. *Schlüsselbegriffe der Public History* (Stuttgart: UTB GmbH; Vandenhoeck & Ruprecht, 2021), 99–120.

Challenges

Virtual eyewitness testimony formats are new forms of representation on the one hand, yet they are also remembrance cultural practices that perpetuate visual repertoires and narrative patterns. One major problem concerns the reproduction of established memorial topoi. Referring to the 360° film *Inside Auschwitz* (2017) which reactivates well-known concentration camp iconography, Knoch criticizes “historically inaccurate *pars pro toto* effects” that do not coherently link these images with the narration.¹⁸ The constructed element that always accompanies representations of history remains largely unremarked upon.¹⁹ In this context, Lewers and Frentzel-Beyme caution against the illusion that history can in fact be experienced in this way.²⁰ In her analysis of *The Last Goodbye*, Rothstein also points to signals such as clattering train tracks or barking dogs that imply transport and arrival but do not show concrete visuals.²¹ Applications such as *Ernst Grube – The Legacy* show how immersion is generated and shaped, but often with less attention paid to principles such as problem orientation, multiple perspectives and transparency. Episode 5 of this app, for instance, shows the gate of the Theresienstadt small fortress and its inscription “Arbeit macht frei” with the counterfactual addition of train tracks. This produces a collage of motifs, which (can) exert a strong emotional effect on users but do not stand in relation to the actual narrative.

A second complex of problems has to do with how the figure of the Holocaust survivor functions in a culture of remembrance. Since the 1980s, the “eyewitnesses” (*Zeitzeugen*) have functioned as bearers of personalized memory and moral authority – initially on television, and subsequently in exhibitions and digital applications.²² Their privileged

18 Knoch, “Das KZ als virtuelle Wirklichkeit”, *Geschichte und Gesellschaft* (2021), 47:90–121, here 113.

19 Christian Bunnenberg, “Mittendrin im historischen Geschehen? Immersive digitale Medien (Augmented Reality, Virtual Reality, 360°-Film) in der Geschichtskultur und Perspektiven für den Geschichtsunterricht,” *Geschichte in Wissenschaft und Unterricht* (GWU Zeitschrift des Verbandes der Geschichtslehrer Deutschlands), 47.

20 Elena Lewers and Lea Frentzel-Beyme, “Und was kommt nach der Zeitreise?,” *Medienpädagogik: Zeitschrift für Theorie und Praxis der Medienbildung* (2023), 51:402–429, here 407. Here too with reference to Christian Bunnenberg and Habbo Knoch.

21 Anne-Berénike Rothstein, “‘The Last Goodbye’, The First Encounter,” in *Entgrenzte Erinnerung*, eds. Anne-Berénike Rothstein and Stefanie Pilzwegger-Steiner (De Gruyter Oldenbourg, 2020) 193–222, here 202.

22 Martin Sabrow, “Der Zeitzeuge als Wanderer zwischen zwei Welten,” in *Die Geburt des Zeitzeugen nach 1945*, eds. Martin Sabrow and Norbert Frei (Göttingen: Wallstein Verlag, 2012), 13–33, here 24–25.

interpretative position continues after medialization, for example in films by means of the camera settings, editing and narrative framing. Virtualization is shifting the conditions once again: digital formats – and especially VR – heighten the promise of immediate encounter while glossing over the constructed nature of the medium.²³ Virtual eyewitnesses are visually present and can be addressed by means of voice – yet are removed from real interaction. The relationship between user and eyewitness is not based on real mutual reference. Schwan speaks of a *Wissensillusion* or “illusion of knowledge” here – an experience that suggests understanding without delivering the associated cognitive or analytical content.²⁴

A third problem lies in the difficulty of studying these formats empirically. XR applications have a multimodal structure whose effects cannot be reduced to technology or narration alone. Their interlinked visual, acoustic and interactive levels produce a receptional milieu framed by situational factors. Emotional responses such as closeness or consternation are context-dependent and users often do not reflect on them consciously. Standardized instruments, however, primarily measure articulated impressions. Processes that can measure subconscious reactions – via eye movements, for example – are hardly mainstream on account of their methodological or ethical considerations. The hybrid nature of many formats is also an obstacle to clear typological categorization. Analysis of these formats therefore requires integrated methodological approaches that can evaluate design features, incorporate receptional qualities and address media-theoretical issues.

Conclusion

The analysis here elucidates not only the specific historical-cultural logic of XR formats, but also the epistemological and methodological challenges empirical approaches will need to face. The *For real?* application, whose empirical investigation follows, is a prime example of a dialogue-based interactive format. The deliberately abstract design of its setting could well simplify analyses of the reception of its eyewitnesses.

23 Cf. Christina Brüning’s essay in this volume, which refers to the ethical problems in unsupervised use of interactive formats or in preferring recorded formats over live meetings with the same individual.

24 Stephan Schwan, “Erleben und Verstehen? Virtuelle und Augmentierte Realitäten als innovative Formen historischen Lernens,” in *Virtual Reality: Zukunft der historischen Bildung?*, eds. Christian Kuchler and Kristopher Muckel (Göttingen: Wallstein Verlag, 2025), 40–53, here 53.

At the same time, *For real?* represents a new approach. It combines an innovative medium with educational responsibility. It takes an abstract design that avoids narrative frameworks and enables recipients to position themselves within the dialogue. Embedded in accompanying educational and outreach formats, *For real?* stands for a practice of digital remembrance with ethical reflection, like that in the *End of Testimony?* project and in institutional perspectives developed further by Jannelli, Reichwald and Vollhardt (in this volume). As such, the investigative essays that follow do not consider themselves analyses of effect, but rather contributions to the question of what digital testimonies can achieve.

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