



# Exploring students' immersive VR experiences as resources for collaborative meaning making and learning

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## Abstract

By adopting a situated and interactional approach, we explore students' immersive VR experiences as resources for collaborative meaning making and learning. We draw on data from a project in which teachers and researchers co-developed a learning design for upper secondary students involving immersive VR technology. In this learning design, students viewed a cinematic VR film where they encountered different people telling personal stories about exclusion and discrimination, followed by reflective group dialogues with their teacher about their experiences in this environment. Through a detailed interaction analysis of these dialogues, we identify four dimensions that characterize students' meaning making: (1) the feeling of taking part in conversations, (2) attending to bodily expressions of others, (3) students' own bodily responses, (4) teacher guidance. We discuss how the findings from our analysis contribute to the field of CSCL, and which also have implications for instructional work that includes the use of immersive VR environments.

**Keywords** Virtual reality · CSCL · Situated learning · Interaction · Immersion · Learning design · Teacher-researcher partnership

## Introduction

Virtual reality (VR) technologies provide users with the opportunity to become immersed in environments that offer insights into how other people experience the world and themselves (Shin, 2018; Young et al., 2022). However, few qualitative studies have examined

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how teachers and students make meaning of experiences in fully immersed VR environments in K-12 education. VR-enhanced learning environments in education are often centered on individuals, and studies are often designed as experiments that measure learning- and behavioral outcomes. These studies do not take the socially and culturally situated nature of teaching and learning practices into account. Additionally, from a design perspective, collaborative activities around VR have been underexplored. Thus, further studies are required that explore and identify the opportunities for collaborative learning experiences in and around immersive technologies in authentic K-12 settings, especially how students and teachers, through dialogue, reflect on VR experiences (Enyedy & Yoon, 2021; Freeman et al., 2017). As a field, CSCL is well positioned to lead the investigation of such collaborative and dialogic approaches to the integration of immersive VR in the classroom.

We report on a project where teachers and researchers co-developed a learning design for upper secondary students in a Norwegian context. In this learning design, students viewed a cinematic VR film, using a head-mounted display (HMD), followed by teacher-mediated reflective group dialogues about their experiences in this environment. The learning design targeted the interdisciplinary topic of *Health and life skills* in the national curriculum, which emphasizes that students should learn, in and across the different disciplinary domains, about interpersonal relationships, respect and tolerance for other people, and managing thoughts, emotions, and relations with others. In the VR film, students encounter people who share personal stories about exclusion and discrimination, which touch on relevant themes regarding the interdisciplinary topic. This case study offers a unique opportunity to explore how VR technologies can be used in developing collaborative learning activities in K-12 settings. By adopting a situated and interactional approach to meaning making and learning (Danish & Gresalfi, 2018; Suthers, 2006), we aim to explore how students and teachers collaboratively make meaning of the VR experiences. It is important to emphasize that this situated approach allows us to consider the reflective dialogues as an authentic classroom activity that is mediated by the VR experience, even though the dialogues themselves take place in the physical environment. The following research question guides our analysis: *How do students' immersive experiences become resources for collaborative meaning making and learning?*

The article is structured as follows. First, we review relevant studies of VR technologies. Then, we outline our theoretical approach to meaning making and learning around VR environments. Third, we provide a description of the educational setting and learning design, as well as the data that were produced, and outline the analytical procedures. We then present our results based on a detailed analysis of the reflective dialogues. Finally, we discuss our findings in relation to existing research and indicate the implications for instructional design work.

## VR technologies, learning, and instruction

Digital and interactive visualizations have, for some time now, been used as tools for computer-supported collaborative learning; however, recent developments in VR technologies have expanded the potential for student learning in schools (Ferguson et al., 2020; Maas & Hughes, 2020; Pellás et al., 2021). These technologies provide students with innovative embodied ways of accessing and engaging with knowledge (Huang et al., 2023; Johnson-Glenberg, 2018), and the ability to engage with simulated environments may enhance student motivation and engagement (Bailenson et al., 2008; Maas & Hughes, 2020). They

also potentially offer students learning situations in which abstract ideas and concepts become more concrete (Salzman et al., 1999; Winn, 1993), making it possible to observe and engage with phenomena more directly at different levels of detail and from multiple perspectives (Dede, 2009; Fauville et al., 2021; Lindgren & Johnson-Glenberg, 2013; Sobocinski et al., 2023).

By using VR environments, students can gain access to experiences that are usually restricted in classrooms. For instance, by being immersed in environments simulating different aspects and dimensions of the real world. This allows students to, for example, learn about climate change by experiencing destruction of oceans due to pollution (Markowitz et al., 2018), engage in close-up examinations of planetary movements within the solar system or galaxy (Kersting et al., 2021), zoom in on particles and microscopic structures to learn about processes in the body (Lui et al., 2023), or explore and walk around buildings and artifacts in ancient civilizations (Taranilla et al., 2022).

This paper focuses on immersive virtual reality where individuals are wearing head-mounted displays (HMDs). Such displays can range from simple cardboard goggles that can contain a smartphone as the virtual screen (e.g., Google Cardboard) to expensive headsets with integrated sensors and processing elements, as well as headphones. This is in contrast to virtual worlds accessed through more traditional computer screens that offer fundamentally different types of experiences. The difference is that, in HMDs, the visual-perceptual experience is completely inside the constructed scene. Recent reviews have revealed that the majority of VR studies in K-12 have analyzed desktop and projector-based arrangements (Luo et al., 2021; Maas & Hughes, 2020). One of the exceptions is Markowitz et al. (2018), who studied upper secondary students learning about the possible consequences of climate change through a designed HMD VR environment where users were placed on an underwater reef. The researchers used a questionnaire to measure the extent to which the students had gained insights into climate change after the immersive VR experience, and the results were generated using quantitative statistical techniques. The students reported that they had obtained more knowledge about ocean acidification and were willing to learn more about this topic.

Furthermore, the learning environments described in the existing literature are often centered on individuals (Freeman et al., 2017; Scavarelli et al., 2021). Immersive VR is often viewed as an individually oriented resource, and most of the studies have focused on how individual users gain knowledge or change their attitudes as a consequence of being exposed to VR environments. Thus, there is a need for more work that explores how immersive VR resources can be used in learning designs that foster collaborative learning (Enyedy & Yoon, 2021; Lui et al., 2023). Interesting studies in this respect are Southgate et al. (2019) and Lui et al. (2023). Southgate et al. (2019) studied junior high-school students learning in STEM subjects with VR technologies. In this project, researchers and teachers collaborated to create a learning design for students in a classroom and developed a collaborative learning activity where students used HMDs to engage with Minecraft VR for learning about photosynthesis by creating plant models. The researchers collected data through observations and video-recordings of activities, interviews, and surveys. The findings showed that it was difficult to provide the students with enough time to explore the learning opportunities together in the VR environment, because of the time schedules that typically structure school days, but that some of the students engaged in deep learning and were willing to engage in collaborative activities in the networked Minecraft VR. Lui and colleagues (Lui et al., 2023) studied how undergraduate biology students engaged in an immersive VR environment to learn about a model of gene regulation known as the 'lac operon' in a specific bacterium. In this study, students used a HDM resource, allowing

them to build the gene regulation and gain insight into its functions through running simulations. Throughout the VR experience, the student received guidance from a co-present facilitator. The researchers collected audio and video data of the activity, as well as physiological sensing data (such as skin temperature and heart rate) of the student. The findings show that students and the facilitator jointly examined the functions of the model related to the bacteria. The students were enabled to engage with abstract concepts through tactile and hands-on experiences provided by the VR environment, allowing them to explore multiple functional outcomes of the model. The resources integrated in the VR environment enabled students to reason about the model as a system and developing conceptual understanding of the complex interactive systems within the human body.

Moreover, the importance of a facilitator who elicits reasoning and meaning making in students' engagement with immersive VR environments is now recognized (Huang et al., 2023; Luo et al., 2021; Maas & Hughes, 2020). Studies have indicated that to fully realize the potential of immersive VR environments, it is important to facilitate reflection during or after the VR experience. For example, in the study conducted by Lui and colleagues (Lui et al., 2023), the facilitator had a pivotal role in supporting students' conceptual understanding of the model's function. In this study, the teacher used specific strategies during the VR session, including directing student's attention to particular aspects and features of the 3D space, encouraging them to explore various aspects of the model, and using targeted prompts to elicit students' articulation, reasoning, and explanations regarding the model's function. Studies of this nature contribute significantly to enhancing our understanding of vital role facilitators play in designing immersive VR learning experiences. However, there remains a limited number of studies that explore the specifics of how teachers provide support within the context of immersive VR resources in K-12 education (Luo et al., 2021; Maas & Hughes, 2020).

Another strand of research outside the context of classroom learning has recently emphasized the immersive storytelling potential of the technology along with the opportunities for experiencing empathy, perspective-taking, and deeper understandings of social and historical situations (Shin, 2018; Ventura et al., 2020; Young et al., 2022). According to Shin (2018), "In a virtual environment, viewers who are close to characters, and sharing the same space, may feel their emotions or situations more strongly" (p. 65). In an empirical study of the cinematic VR story "Travelling While Black" (which is also the VR environment involved in the current study), Young et al. (2022) studied adults experiences in this environment where the viewer encounters personal stories about exclusion and discrimination. The participants were told to view the VR story at home and to answer a questionnaire before and after watching it, to measure possible changes in empathy and perspective-taking. The users reported that they experienced empathy and connectedness with the protagonist in the VR film and obtained an understanding that was different from that obtained from other mainstream media. Based on these insights, it is interesting to explore how such immersive storytelling, targeting deeper understanding of social and historical situations, can be used in classrooms as a tool for learning and teaching.

Thus, research has shown that there are benefits to using VR for learning in educational settings. However, more fine-grained qualitative research can offer insights into how immersive VR experiences are integrated into K-12 classroom contexts, how teachers make connections between VR experiences and existing curricula, and how students make meaning of the experiences gained through the VR environment. Furthermore, much of the existing research displays promising results regarding learning procedural tasks. However, we need more studies on the learning of other more complex issues (Billingsley et al., 2019; Maas & Hughes, 2020), such as how VR can be used for learning about socio-political

issues. In addition, we need more innovative methods for studying the complexities of learning designs using VR (Luo et al., 2021) and how it can be integrated into more collaborative learning practices in educational settings (Enyedy & Yoon, 2021; Freeman et al., 2017). In the current study, we explore how a VR environment addressing the topics of social exclusion and discrimination is experienced by students in an upper secondary classroom, where we approach the challenge of VR as being seen as an individual resource by placing it in a sequence of activities that emphasize dialogue and collaboration.

## Theoretical approach

This study takes a dialogic approach to Computer-Supported Collaborative Learning emphasizing the interrelationships between technological tools and representations, social interaction and sociomaterial settings (Arnseth & Ludvigsen, 2006). From this perspective, learning is viewed as a situated meaning making activity (Danish & Gresalfi, 2018; Suthers, 2006). Meaning making is fundamentally social and a matter of joint construction, and learning is enacted in negotiations between interlocutors in social practices (Hall & Stevens, 2016; Lemke, 2001). This implies that meaning making and learning are interactional achievements. Meaning and learning are facilitated through social interactions through which participants mutually coordinate action for specific purposes (Mercer, 2008; Valsiner, 2007).

An important assumption in situated theorizing about learning is the role of mediating cultural tools (Hatano & Wertsch, 2001; Säljö, 2010). When people make meaning of the world and the activities in which they are engaged, different semiotic and material tools mediate these processes (Danish, 2014; Vygotsky, 1978). Material tools such as computers and books, and semiotic tools such as language, metaphors, and stories, are resources for participants. Such tools more broadly enable people to deal with tasks and assignments (Mercer et al., 2019; Wertsch, 1998). However, they are not readymade resources and must be made meaningful collaboratively by the participants in relation to their local problems (Furberg & Silseth, 2022; Silseth & Arnseth, 2022). How learners together create meaning of and in activities by mobilizing various relevant cultural tools becomes a point of departure. Thus, tools that enable collaborative reflections are viewed as important when creating learning designs for students.

From a CSCL perspective, we emphasize the mediating potential of computers in particular as both material and semiotic resources through a triadic relationship between participant, computational artifact, and participant (Ludvigsen & Steier, 2019; Lui et al., 2023). This triadic relationship can be seen in different spatial and temporal constellations; computer mediation may be synchronous or asynchronous, for example, and collaborators might interact within a computational resource (e.g., a chat window) or around it (e.g., a digital model on a shared screen). In the case of the present study, the VR experience precedes the reflective dialogues yet serves as a mediating tool for collaboration when taking the activity sequence as the unit of analysis. We will present the activity design in more detail below, but we note that the students are learning about exclusion and discrimination through listening to and reflecting on stories and testimonies about these issues in VR. Importantly, the VR technology itself also becomes a topic for meaning making, entwined with notions of immersion, empathy, and discrimination as guided by the teacher.

Instructional work is a process of guiding students' meaning making processes in their trajectories of learning by facilitating reasoning and engagement by activating relevant

tools and resources (Collins, 2006; Sawyer, 2014). Facilitating educational dialogues targeting topics and issues of concern, where students are positioned as active contributors in the ongoing co-construction of knowledge, has been a primary interest (Berland et al., 2020; Clarke et al., 2016). Through carefully orchestrating dialogue, by acknowledging student contributions and enabling students to share and build on each other's ideas and perspectives, teachers can contribute to elevating engagement and participation (Engle & Conant, 2002; Furberg, 2016). The (computer-supported) educational dialogue as both activity and object of study has long been of interest within CSCL (Arnseth & Ludvigsen, 2006), and Baker et al. (2021) suggest that new mediational means may be considered "game changers" (p. 584) requiring careful consideration of our conceptions of dialogue and how we investigate them. This paper aims to explore how collaborative dialogues enable students to make meaning of experiences gained in and through the VR environment.

Furthermore, immersion and presence are important concepts for making sense of how students talk about their experiences in VR. We recognize that these terms have varying definitions across fields and disciplines, are sometimes used interchangeably, and often one is used to define the other (Dede et al., 2017; Nilsson et al., 2016). In VR contexts, immersion generally refers to the level of realness or fidelity in the experience, whereas presence relates to a sense of 'being there' in the alternate situation created (Johnson-Glenberg & Megowan-Romanowicz, 2017). A VR environment can immerse a user in an alternative experience that feels real or authentic. This realness, however, can manifest in diverse forms. For instance, narrative immersion in VR involves a sense of realness in the story, whereas sensory immersion is more about perceptual fidelity (e.g., visual and auditory). Presence and particularly co-presence (sometimes referred to as social immersion) in the realm of VR, involves the social experience of how one relates to others and feeling of being with others, whether real people, avatars, or characters (Markowitz et al., 2018; Steier, 2020). Achieving co-presence in VR poses intriguing challenges, given that the social experience is often mediated in some way through the technology. While striving for precision in using these terms, we also rely on concepts from others' work, which is dependent on a nested and entangled relationship between notions of immersion and presence.

A highly relevant concept in our context, developed in the CSCL field, is *emancipatory immersion* (Enyedy & Yoon, 2021). Enyedy and Yoon (2021) explain this concept as follows: "By immersing ourselves in the experiences of others and by seeing learning as becoming part of and immersing oneself in a community, we can develop a critical consciousness that promotes epistemological curiosity taking ownership of one's own constructed world" (pp. 391-392). Emancipatory immersion is about experiencing oneself as not only physically present in another situation, but also being present and becoming a (temporary) participant in a conversation or activity. This might over time extend the understanding of oneself in the world. In this study, we explore how a learning design can support students learning about exclusion and discrimination by offering them an opportunity to become immersed in an environment where they meet people telling stories about racialized exclusion and violence. It is crucial to note that we do not interpret the process of emancipatory immersion as *becoming* someone else, nor as fully identifying with or understanding the experiences of the people the students meet in the VR environment. Rather, it is about taking part in situations and settings and where others' experiences are taken seriously, and which invite students to reflect on their own lives and how issues of discrimination and exclusion penetrate their lifeworlds.

Finally, notions of embodiment and embodied interaction are crucial for making sense of how learners construct meaning in general (Steier et al., 2019; Danish et al., 2020;

Nathan, 2021) and of VR experiences in particular (Fortman & Quintana, 2023). Whether occupying the body of a virtual avatar (Slater, 2017) or merely occupying space in a virtual scene through a first-person perspective, the senses of being immersed and present rely on bodily understandings. These senses rely on motion, for example, or orientation to the visual surroundings. Notions of embodiment are also relevant for characterizing how participants describe the bodies of others, including aspects such as gaze, gesture, or bodily orientation, when making meaning of situations and activities (Huang et al., 2023; Streeck et al., 2011). In our analytical work, we focus on how bodily expressions and actions become resources for meaning making in collaborative dialogues.

Our analytical focus is on how students talk about their immersive experiences and how these experiences become resources for meaning making and learning. When analyzing how students make meaning of their VR experiences, we focus on how they use the language of immersion, what aspects of the VR environment become important for them, and how this is talked into being through collaborative achievements. In the next section, we describe the methods and learning design that we created to study how VR technologies can be enacted in collaborative activities in an educational setting.

## Methods

### Research design and participants

This paper reports on data from the research and development project DigiLiv, taking place in an upper secondary school in Norway. This project was designed as a collaboration between teachers and researchers with a common aim of developing innovative learning environments to support students' participation and engagement by means of immersive technologies (Goldman et al., 2022). By fostering collaboration, both researchers and teachers can identify the possibilities and constraints of learning environments in new ways that enable us to envision and enact learning designs that allow students to participate and evolve as learners. Three teachers with substantial teaching experience were part of the project team: one teacher from the language arts, another from social science, and a third teacher teaching sports science. The student class that was part of the project comprised 30 students (10 girls and 20 boys) in the second year of upper secondary school (17–18 years old). The teachers and researchers collaborated over a period of 15 months to create innovative learning designs in a naturalistic setting.

Immersive environments are interesting in themselves, but they need to be appropriated by teachers in ways that they feel are relevant and manageable in their everyday practices (Southgate et al., 2019). Conducting research in a classroom is very different from conducting research in controlled environments, such as laboratories and experiments, since the social dynamics and activities are more complex and unpredictable. The strategy of designing the project as a partnership between teachers and researchers enabled us to engage in the mutual development of ideas and practices that are sensitive to the local needs of the school, the national curriculum that teachers must orient to when planning and executing their teaching, and scientific knowledge about how students learn through immersive environments. The project team wanted to produce knowledge about how immersive technologies can support students' learning and how such technologies can be relevantly enacted by practitioners in everyday classrooms.

Regarding the curricular dimension, we aimed to create innovative learning experiences targeting the interdisciplinary curricular topic of *Health and life skills* (Folkehelse og livsmestring) in the national curriculum. In Norway, the national curriculum consists of descriptions of what competences students should develop in relation to the different subjects, but also different interdisciplinary topics that teachers must address in their everyday teaching. The interdisciplinary topic of Health and life skills is particularly interesting because it emphasizes that students should learn, in and across the different disciplinary domains, about interpersonal relationships, respect and tolerance for other people, and managing thoughts, emotions, and relations with others. The teachers in the project team had identified a need for developing new ways of supporting students learning about contemporary issues related to this topic and wanted to use immersive technologies and relevant software in these efforts.

## Learning design

During the development phase of the project, we conducted multiple workshops where researchers and teachers discussed possible software and pedagogical designs that could be further developed into learning designs for students. One idea that the team decided to further develop was to create a learning design that offered students a space to engage with and reflect on inequity and prejudice through immersive environments, which the team thought connected well with the topic of Health and life skills. When we first started planning the learning design, the teacher told us that he was already focusing on the civil rights movement in the US as a cross-disciplinary topic when teaching the subject English as a foreign language. This indicates that this was a topic already being treated as relevant. We, as researchers, did not decide on the particular content for this activity and did not have a say in whether it was relevant or not for Norwegian students to learn about the civil rights movement. It is clear that the teacher found this to be a relevant subject for his students.

We decided to develop a bodily experience that could potentially engage students in other people's situations and contexts, which included student–teacher dialogues and collaboration to support such engagement. It was important for us to work with off-the-shelf software, both to manage the project scope and to ensure that the resulting learning designs could be shareable with other practitioners. Our search for potential software and ongoing discussions about possible applications to use led us to “Travelling While Black” (hereafter referred to as TWB). When we came across this application, which connected to the teacher's teaching in English as a foreign language, the teacher realized that, firstly, he could create cross-disciplinary connections between social science and English as a foreign language. Secondly, he saw that the topic could be expanded to address social exclusion and discrimination more generally as problems in societies across the world.

TWB was developed through a partnership between Roger Ross Williams and Felix & Paul Studios Film. It is described by its makers as a cinematic VR experience that is “Confronting the way we understand and talk about race in America, Traveling While Black highlights the urgent need to not only remember the past but to learn from it, and facilitate a dialogue about the challenges minority travelers still face today” (Felix & Paul Studios, 2019). TWB narrates how African Americans experienced racism in different ways and the importance of the Green Book, which was developed by Victor Hugo Green as a guide for African American travelers to avoid dangers and inconveniences on their way. In this 19-min VR experience, the user encounters different people in the famous diner Ben's Chili Bowl, which was an important safe space in Washington DC for African Americans, who

tell stories about their personal experiences of racism in the United States. The reason for using TWB was that the VR environment offers students a space where they could encounter personal stories about exclusion and discrimination. The educational aim was not learning about racialized violence and the history of the civil rights movement in America *per se*, but to share these stories and accounts for learning about exclusion and discrimination.

In the broader educational context, the Norwegian national curriculum does not limit itself to strictly national or Eurocentric topics and concerns. Global issues related to the emergence of colonialism and its ongoing effects worldwide hold significant importance in several subjects throughout Norwegian classrooms. It is against this backdrop that the American civil rights movement stands out as particularly important. The history of slavery, colonialism and persistent racism carries global significance. In this context, Rosa Parks serves as a model for protesting against oppression, with educational relevance that extends far beyond the United States.

Since the project team aimed to develop a learning design for everyday classrooms, we decided that the VR experience should be combined with other activities in which students can collaboratively make sense of their experiences from TWB. From the beginning of the design work, one of our interests concerned how to create meaningful social interactions with and around immersive technology. We know from the literature and from everyday experiences with the technology that VR tools are individually oriented tools. A person engaged in a VR environment is typically wearing a headset, and possibly headphones, which makes collaboration difficult. Seeking to identify opportunities for collaboration and social interaction, we decided to explore dialogic activities as part of the learning design. Thus, our developed learning design involved the following three, temporally organized activities: (1) an introductory lecture by one of the teachers, (2) VR experiences, and (3) reflective group dialogues.

The first activity in the learning design was organized as a whole-class event in a regular classroom, where all students participated, and the teacher provided a lecture about the Green Book and the civil rights movement during the last century in the United States. This activity lasted approximately 30 minutes. Following this activity, the students watched TWB using Oculus HMD and two handsticks in the school's library. We had five VR headsets available, and thus, at a time, five students could watch the movie together while sitting in their chairs (Fig. 1). Prior to their participation in this learning design, the students attempted different VR applications, such as Rec Room, Tilt Brush, and TWB, to familiarize themselves with the technology, something that has been recommended to avoid the awe factor of using immersive technologies for the first time (Hew & Cheung, 2010; Southgate et al., 2019).

The reflective dialogues immediately followed the VR activity in another area of the library, facilitated by one of the teachers/researchers. The class was organized into eight groups, each comprising 2–5 students. We believed that these facilitated dialogues would allow the students and teacher/researcher, in small groups, to collaboratively articulate and explore their VR experience. Each reflective dialogue lasted 20–30 min, where the students were asked to describe their virtual experiences and collaboratively reflect on issues raised in TWB and the introductory lecture. From a situated and interactional perspective, such activities are where meaning making and learning become visible and analyzable.

We recognize that watching a VR film may appear to be a purely individual experience. In fact, in observing that portion of the activity, the groups of students generally sat quietly at a table, wearing the headsets while sometimes turning their heads in different directions. This arrangement is not the typical CSCL constellation. And yet, we view this study as being highly relevant for the CSCL field in several respects and



**Fig. 1** Illustration of the VR activity. Both images show students watching TWB

as making important contributions about the kinds of computer-supported collaborations that can occur in regular K-12 classrooms. First, to investigate the learning processes, we take a unit of analysis that focuses on the activity sequence. This includes the teachers introductory lecture, the VR experience organized in small groups, and the reflective dialogues. This approach is important as the activity depended on making links across different aspects of the sequence. Importantly, the teacher also viewed the learning as unfolding over this sequence. Thus, the computational artifact, though only physically available during the seemingly individual portion of the activity, remains a relevant resource into the reflective dialogues and mediating the unfolding meaning making. Second, an ongoing debate in the field involves the extent to which definitions of CSCL should expand to include learning designs involving digital tools not intentionally created within an explicit CSCL framework, such as computer games and virtual reality environments (Wise & Schwarz, 2017 – see provocation 7). There is a long tradition of researcher designed tool-interventions being the focal point for research in this field. A powerful argument for a more expansive approach to notions of CSCL is that to become relevant for regular classrooms, we also need to apply CSCL lenses to off-the-shelf technologies and to support teachers in working in collaborative epistemologies. In the recent special issue on extended realities in *ijCSCL* (Fortman & Quintana, 2023), we see that the studies investigating the use of VR were performed in higher education contexts, perhaps where some of the challenges of working with VR could be managed in ways that are more challenging in a regular K-12 classrooms, which are managed by the teacher. In the present study, the choice to involve the VR film (a seemingly individually-oriented medium) was made by the teacher, and CSCL perspectives guided the activity design and subsequent analysis. We feel that this kind of expansive view of CSCL is important for the field to develop.

## Data and analytical procedures

Video data of activities enabled us to explore in detail how the students and teachers collaboratively made meaning of their experiences (Derry et al., 2010; Erickson, 2011). When generating the data corpus, we filmed the introductory lecture and the reflective dialogues of all eight groups. It is important to emphasize that these reflective dialogues are considered to be part of the learning design; student reflections that emerge in dialogue are treated as such and not as 'self reports'. We did not film the VR viewing by students but conducted observations of the students sitting relatively silent wearing the HMDs. These primary data were also supplemented by extensive documentation of the design process, including notes and recordings from design meetings with our teacher–researcher team and pilot testing of the activities conducted with students. From our primary corpus, all talk during the reflective dialogues was transcribed verbatim. This resulted in transcripts of 164 minutes of video interactions.

The applied analytical method is that of detailed moment-by-moment analysis of social interaction (Hall & Stevens, 2016; Jordan & Henderson, 1995). A review of the transcribed data of the reflective dialogues indicated that much of the talk also covered topics other than TWB, such as the affordances of VR in general. Thus, for the analysis to focus on the research questions, we selected sequences containing references to specific situations and features of TWB. Once all relevant sequences were identified, following interaction analysis procedures, we reviewed the transcripts to identify general themes and patterns across the groups. We noticed that the students and teacher/researcher referred to the VR experience in various ways using the language of immersion and embodiment, as well as relating these experiences to external references from their everyday lives. We then selected seven longer interaction sequences that were particularly dense with the patterns identified across the corpus. These longer sequences were reduced to Sequences 1–4 presented for analysis in this study to efficiently capture the breadth of our observations. These sequences were iteratively analyzed in detail by focusing on how meaning and learning were built moment-by-moment, turn-by-turn. In the analytical work, we looked at how the interlocutors oriented to each other in sequences of utterances, and how they built on each other's contributions and collaboratively made meaning of the experiences gained through participating in TWB. The transcripts of the sequences were translated from Norwegian to English. The applied transcription conventions can be found in the [Appendix](#). The data and preliminary analysis were also shared and discussed in a larger research group environment. Having these episodes analyzed by different researchers in multiple group settings is consistent with a general strategy of accounting for validity in interaction analytic work.

## Results

When reviewing all identified sequences where the students referred to situations and features of TWB, by looking for how they talked about their immersive experiences, we were struck by how often they described the experience of being there together with the people they encountered. Our premise had been to use the reflective dialogues to compensate for the more individually oriented VR film viewing. However, we discovered that the students experienced the VR film as highly social. This is despite the fact that, visually, when one observes that part of the task, one just sees a small group of headset-wearing students sitting silently around a table. The students characterized these experiences in terms of the

social and bodily relationships with the people in TWB. In the reflective dialogues, they talked about being spoken to and being seated among other people in the film. They also made aspects of social and bodily expressions relevant, such as eye contact, body language, and politeness.

In addition, the students often referred to one specific scene in TWB that made a great impression on them, which often became a resource for discussing their experiences. In this particular scene, the viewer sits together with a mother in Ben's Chili Bowl diner sharing a story about her son being killed by police officers. This is the final episode in TWB, and while the mother is telling her story, there are multiple bystanders present in the diner who are listening to her. This scene and the mother telling her story became a powerful and emotional moment for the students.

We also found variations in how the teacher guided the reflective dialogues. Many of the students were quite talkative, eager to share their experiences, and built on each other's contributions without specific cued questions by the teacher. Sometimes, students needed help in articulating what they experienced in TWB, and the teacher now and then encouraged them to elaborate on what the experiences put forward in the dialogue meant to the students and groups. In all cases, the teacher allowed the students to share their thoughts such that they often took the lead in the conversations. A common interactional pattern across the groups involved multiple overlapping utterances made by the students and the teacher (shown in the detailed analysis below), something that bears witness to an informal and safe environment that the teacher created.

Looking for patterns across all eight groups, we identified four prominent dimensions that occurred across all groups in the way students talked about their experiences and characterized their meaning making: (1) the feeling of taking part in conversations, (2) attending to bodily expressions of others, (3) students' own bodily responses, (4) teacher guidance. Below, we analyze in detail four interaction sequences from the reflective dialogues that display these dimensions.

### Sequence 1: The feeling of taking part in conversations

A common pattern observed across the groups was the emphasis by the students on feeling part of the conversations in TWB. The first sequence is from a group of three students and a teacher and demonstrates how this aspect emerges. The students share their experiences with TWB, and we zoom in on the dialogue when Student 1 mentions that he felt part of the conversations and what this meant to him (Fig. 2).

Student 1 starts talking about how he not only experienced that people in TWB were talking about issues that meant something to them but also that he was becoming part of the conversation in the VR environment. When this contribution is acknowledged by the teacher (line 2), Student 1 elaborates by adding that he felt that people were not only talking to each other or an imagined audience but also to him ("to: me") (line 3), suggesting that this aspect of the VR experience contributed to this feeling. The teacher once again acknowledges the contribution (line 4), whereupon Student 1 focuses on what this feeling can lead to: a situation in which he is attentive to the information provided by the environment (line 6). The teacher repeats Student 1's contribution, which can also be interpreted as a token of acknowledgment, and continues by focusing on the specificities of VR (lines 8–9). When Student 1 again articulates the perspective about the feeling of being addressed directly by the people in VR (line 10), which is different from watching a movie (line 13), Student 2 joins the conversation. Here, Student 2 revoices Student 1's account and explains

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1 Student 1: I felt that I was part of the conversation.  
 2 Teacher: yes,  
 3 Student 1: and that they were talking to: me,  
 4 Teacher: yes.  
 5 Student 1: so that it was easier to (0.2) take in the information.  
 6 Teacher: it was easier to take in the information,  
 7 Student 1: mm.  
 8 Teacher: yes (1.6) and like the other say this was because it was  
 9 in VR,  
 10 Student 1: yes it is because you feel that they talk directly to you,  
 11 Teacher: yes.  
 12 Student 1: uhm:: (0.7) instead of only watching it in a video,  
 13 Teacher: [if you  
 14 Student 2: [it's easier to like take in when you (0.4) yes when you  
 15 ((gestures VR goggles with his hands)) feel that you  
 16 are part of the conversation.  
 17 Teacher: right.  
 18 Student 2: than when you like ju::st when you just see it.  
 19 Teacher: yes.  
 20 Student 2: or hear it.  
 21 Teacher: yes.  
 22 Student 2: then it's perhaps not that interesting but when you  
 23 like (0.3) feel that you are part of the conversation and  
 24 they talk to you and with you and you're you get  
 25 the feeling of being there,  
 26 Teacher: yes.  
 27 Student 2: that makes you may (0.2) take more in.  
 28 Teacher: that you take it in more in yes (0.4) [so you:: yes,  
 29 Student 3: [feel (0.4) you almost  
 30 feel like you're rude  
 31 if you do not pay  
 32 attention,  
 33 Teacher: yes (0.3) so it appeals to like,  
 34 Student 2: mm.  
 35 Teacher: social instincts,

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**Fig. 2** The feeling of taking part in conversations

that the feeling of being part of the conversation makes it easier to process and relate to what is being told (lines 14–16). Here, Student 2 compares *viewing* an episode (line 18) or *listening* to it (line 20) with what they experienced in TWB. He extends Student 1's reflection by focusing on the feeling of being not only talked *to* but also *with* (line 24), something that he believes created a situation in which he felt like “being there” (line 25). These contributions engage Student 3, who builds on the insights and perspectives of Students 1 and 2 and extends them by contributing another dimension of the intersubjective aspects of the conversations that the students become part of in the VR environment. The feeling of being “rude” (line 30) if you do not pay attention to people you meet in the VR environment is an interesting aspect of the relationships that are created between the students and other people in the film, and the teacher brings in the concept of “social instincts” (line 35) to explain what this feature of the VR environment might be about.

The analysis of Sequence 1 shows how students, together with their teacher, talk about their experiences in TWB through the lens of co-presence and dialogue with the people in the film. The students are using the language of immersion (Kersting et al., 2021; Southgate et al., 2019) to characterize their experiences, referring to being spoken to and with, and being participants in the conversation. In addition, the sequence demonstrates a process of collaboration and joint construction of meaning (Danish & Gresalfi, 2018; Suthers,

2006) with Student 1's articulation of being a part of the conversation, leading to Student 2 expanding his thoughts about the feeling of physically being there. Student 3 takes this reasoning a step further by bringing the notion of rudeness into how he, as a viewer, should respond to the person in the film. Thus, the students emphasize that the situations and conversations they are part of make them morally accountable to the people they meet in TWB. The situations and conversations from the film become mediating cultural tools and resources (Danish & Gresalfi, 2018; Hatano & Wertsch, 2001) for engaging with the topics of exclusion and discrimination. It is important to point out here that the VR film is experienced as a kind of dialogue by the students despite the fact that they are not speaking. However, it is in the context of collaborative reflection (an 'actual' dialogue!) that this kind of conversational immersion is expressed. The analysis suggests how the participants are experiencing emancipatory immersion (Enyedy & Yoon, 2021) as they reflect upon how TWB invites the students to be immersed and situated in conversations and relationships with others that tell powerful stories about exclusion and discrimination.

## Sequence 2: Attending to bodily expressions of others

In many of the reflective dialogues, the students gave rather detailed descriptions of the people they encountered. They often referred to bodily expressions of the people they met and it became evident that such expressions were important when interpreting their emotional state. In Sequence 2, another group, also comprising three students and the same teacher, activates the scene with the mother, and the analysis demonstrates how the students experience the encounter with her and how bodily expressions become a resource for engaging with her story (Fig. 3).

In the opening of the sequence, Student 4 refers to the specific scene with the mother that has lost her child while at the same time asking the teacher if he has seen TWB (lines 1–2). The student wants to know that they have a shared resource to engage with in the dialogue. When the teacher confirms that he has also seen TWB, Student 4 continues to recount the scene with the mother (line 4). In this particular scene, the viewer is sitting at a table together with the mother and her interviewer, and a crowd of people have gathered around the table. Student 4 explains that the people present are paying attention to what the mother is saying (lines 6–7) and, more importantly, that this leads to a feeling of being integrated and part of the event with the mother (line 10). Student 5 interjects by emphasizing that “everyone” is paying attention (line 11). Student 5 then extends this account by not only emphasizing that all people present in the situation are paying attention to what the mother is saying but also looking at “us” (line 13), which is acknowledged by Student 4 (line 14). Then, Student 5 contributes more details about the situation and the mother's bodily expressions. By gesturing with his fingers, Student 5 activates a specific moment in TWB when the mother fiddles with her fingers while talking about her son (lines 16–17). This is acknowledged by the teacher (line 19), whereupon Student 5 comments on how the bodily expressions might signify her feeling of distress when talking about this tragic event in her life. Utterances such as “this is not good” (line 24) and “it's painful” (line 28) signify the student's emotional responses to the mother's story, which are expressed in this dialogue. Student 4 builds on this and comments on how he experienced that the bystanders also grasped the emotional distress of the mother (lines 25–27), and Student 5 then replies by contrasting the experience to seeing someone without being there (“a person on a screen”); it was like “a real person who sat in front of you and talked” (line 35). When this contribution is acknowledged by the teacher, Student 5 concludes the meaning making

1 Student 4: when you sat in that (0.5) have you seen the  
 2 video actually,  
 3 Teacher: yeah yeah,  
 4 Student 4: yeah when you sat in the final.  
 5 Teacher: m[m.  
 6 Student 4: [where she talks about the death of her son [then you see  
 7 like (0.2) everyone is paying attention and,  
 8 Teacher: [mm mm.  
 9 Teacher: mm.  
 10 Student 4: you [feel like you're more part of it,  
 11 Student 5: [everyone,  
 12 Teacher: yes.  
 13 Student 5: everyone is sitting and looking at like (0.2) us,  
 14 Student 4: mm,  
 15 Teacher: mm [yes,  
 16 Student 5: [you see that she sits and constantly [fiddles with  
 17 something aeh [like. ((gesticulates with his hands))  
 18 Student 4: [mm,  
 19 Teacher: [yes with her fingers [her nails yes mm,  
 20 Student 5: [you see that she is  
 21 like (0.2) this is  
 22 not.  
 23 Student 4: you you.  
 24 Student 5: this is not good,  
 25 Student 4: no [and you yes (0.3) and you like get that (1.3) people  
 26 there (0.2) they understand it [0.5) they pay  
 27 attention, [  
 28 Student 5: [it's painful.  
 29 Teacher: [mm. [mm.  
 30 Student 5: it [wasn't a person.  
 31 Student 4: [listening to her story,  
 32 Teacher: mm.  
 33 Student 5: it wasn't a person on a screen,  
 34 Student 4: no.  
 35 Student 5: it was a real [person who [sat in front of you and talked.  
 36 Student 4: [yeah yeah.  
 37 Teacher: [ye:s (0.4) right.  
 38 Student 5: it's like if we would have been sitting here and talked  
 39 together at least that was what it did for me anyway.

**Fig. 3** Attending to bodily expressions of others

event by comparing the experience of being with other people in TWB with that of being in a real-life conversation in the school's library, where this reflective dialogue is situated (lines 38–39).

The analysis of Sequence 2 shows how the scene with the mother is a powerful and emotional moment for the students. Bodily expressions and embodied interactions are important when making sense of human actions and interactions (Danish et al., 2020; Streeck et al., 2011), including collaborative interactions with and around technology (Davidsen & Ryberg, 2017). The students in Sequence 2 mutually interpreted the social situation (where people gathered around the mother) as contributing to their feelings of immersion/realness. In the previous excerpt, the students talked about being in a conversation and feeling spoken to by the people who tell the stories. Here, students' awareness of how the behavior of the audience in the film (the people in the VR scene who are not speaking) contributes to framing how the students should treat the story, placing them in a community of listeners. The students attend to bodily expressions as reflections of people's emotional states, and these reflections become a resource to engage with the story of the mother. This finding

resembles prior CSCL research in which the bodily resources of collaborators become joint resources for meaning making (Danish et al., 2020; Davidsen & Ryberg, 2017), yet here it is not collaborators bodies being attended to but people in the VR environment. Thus, the analysis demonstrates how bodily expressions of the people present in the VR environment and the students' noticing of these expressions contributes to the experience of emancipatory immersion; the students experience of taking part in situations where people belonging to other communities share stories about exclusion and discrimination that means something to the students.

### Sequence 3: Students' own bodily responses

In the next sequence, the same student group continues to elaborate on the scene with the mother. However, they now orient to *their own* bodily expressions, and that their immersive experiences contribute to providing more context for their encounters with stories about exclusion and discrimination prior to this learning activity. We zoom in when the boys start to talk about the importance of real people telling stories in TWB, as opposed to actors. As seen in line 1, the teacher orients to the realness of the experience (Fig. 4).

When the teacher acknowledges the students' orientation toward the importance of real people telling the stories, Student 5 brings in the expression "that knot in your stomach," which becomes a resource for describing his feelings when the mother tells her story (lines 2–5). This expression is followed by an orientation to the difficulties of recreating the feelings that the students have been exposed to for people who are actors. Thus, the fact that it is a person who has experienced a tragic event who tells the story, and not an actor, is something that the students view as an important aspect of TWB. This perspective is acknowledged by the teacher, but he also makes visible that he believes that the students recognize the scene with the mother as the most powerful in TWB (lines 18–19), something that is confirmed by the students (lines 20–23). The teacher's orientation to the importance of this scene makes Student 5 elaborate on this event's meaning (lines 25–27). In his contribution, Student 5 focuses on a video that appears on TWB when the mother tells about her son. Student 5 makes it clear that he encountered this video prior to his engagement with TWB, but that he now sees the video and what happened in it in a new light. The fact that the teacher acknowledges his contribution makes Student 5 further explain that his new understanding of the video, together with the feeling of sitting with the mother and having "talked to his mother" (line 30), leads to him being moved by this experience and that it "did something to" him (line 33). The meaning making that occurs between Students 4 and 5 triggers Student 6 to contribute with more explicit details about bodily expressions that made it into a powerful event. Here, Student 6 focuses on the mother's gaze and feels that he has eye contact with her at the diner (lines 36–38), which is acknowledged by the teacher and the other group members as a valid contribution.

The analysis of Sequence 3 shows how the students use bodily language to characterize emotional responses to what they experience in TWB. Noticing others' bodily expressions and embodied interactions is important when interpreting their actions (Streeck et al., 2011), which we started to explore in Sequence 2. In Sequence 3, we also see how gaze is an important feature of embodied interaction that humans bring into their meaning making processes. Here, we saw gaze being made relevant by the students, which made their encounter with the mother into a powerful experience for the students. Furthermore, in Sequence 3, the students also activate their own bodily expressions to reflect on their experiences in the VR environment. This is another example of the body's role in these feelings of immersion and the analysis display how the stories of the persons they encounter induce

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1 Teacher: no right that it is [real,  
2 Student 5: [that knot in your stomach when  
3 she[: sat and talked sat and talked  
4 about (0.3) her son being just murdered  
5 in the open [street (0.3) [no one can  
6 recreate that feeling.  
7 Teacher: [mm.  
8 Student 4: [mm. [mm.  
9 Teacher: [mm. [mm.  
10 Student 5: no no.  
11 Teacher: no no.  
12 Student 2: regardless of how good you are at [imitating.  
13 Student 4: [regardless of how good  
14 you are at (0.8) [acting  
15 I don't  
16 know,  
17 Teacher: [yes.  
18 Teacher: yes (0.8) so what is it that one (0.3) is that the one that  
19 you bring up that one (0.3) was [that the one that,  
20 Student 4: [I believe it's the one that  
21 made the biggest  
22 impression,  
23 Student 5: ye[:s.  
24 Teacher: [yes,  
25 Student 5: because I have seen it before that movie of the boy where  
26 the [police drive up and shoot I have seen that video before  
27 but now I got much more context,  
28 Teacher: [yes,  
29 Teacher: mm,  
30 Student 5: you like sat there and talked to his mother [it's li::ke.  
31 Teacher: [mm.  
32 Teacher: yes.  
33 Student 5: i:t did something to me.  
34 Teacher: yes.  
35 Student 5: it [was crazy.  
36 Student 6: [yes (0.3) I believe it meant the most that she actually  
37 looked it looked like she looked you  
38 in the ey[es and stuff,  
39 Teacher: [yes [yes yes,  
40 Student 4: [yes yes.  
41 Student 5: yes,

---

**Fig. 4** Students' own bodily responses

bodily emotional responses. In addition, the students encounter fragments of the stories that are told in TWB in their everyday life, which also become mediating cultural tools and resources (Danish & Gresalfi, 2018; Hatano & Wertsch, 2001) for making sense of their VR experiences, and the experiences from TWB become contextualizing resources for making meaning of prior experiences of witnessing discrimination. The video that the student had seen prior to this moment is given new life through the mother's telling, and it becomes a contextualizing resource that makes the video more meaningful for the student. Thus, the analysis shows how the students' own bodily expressions are something that contributes to the experience of emancipatory immersion, and that these expressions are activated in the reflections and become resources to engage with the mother's story. We also see that her story becomes a resource for providing students with deeper and richer knowledge about the community that she represents in a way that expands students' previous knowledge.

## Sequence 4: Teacher guidance

When analyzing the reflective dialogues, we see that the teachers adopt different levels of guidance for the students in their collaborative efforts to make sense of their experiences. How the teachers use different strategies in guiding the student talk during the dialogues is an important aspect of the students' meaning making. In the final sequence, we focus on a third group talking about feelings and emotions, where the teacher more actively guides the group by encouraging them in specific ways to elaborate on their accounts (Fig. 5). One student focuses on how sitting with the mother in the final scene contributes to a feeling of compassion for what she has experienced. This is picked up by the teacher, who wants the student to elaborate on this point for the group (line 1).

As a response to the teacher's request, Student 7 elaborates on how the VR environment enabled him to relate to the mother's feelings and emotions (lines 2–3). When the teacher acknowledges his contribution, Student 7 expands the idea by providing an account of how this was possible and realized. Here, Student 7 explains that he was enabled to imagine

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1 Teacher: can you say something about how you felt it,  
 2 Student 7 um::h (1.2) I was able to put myself in her situation and  
 3 felt how she felt and like.  
 4 Teacher: yes.  
 5 Student 7: because I imagined it (0.4) what had happened so:: (0.8) I  
 6 felt ( ) I saw that she was influenced by what had  
 7 happened.  
 8 Teacher: yes right mm (0.4) how did you see it,  
 9 Student 7 um::h she was almost in tears.  
 10 Teacher: mm.  
 11 Student 7: so yes she was sad.  
 12 Teacher: mm (1.2) umh (1.6) is the body language (2.3) noticeably  
 13 different in a VR experience compared to (0.5) if you only  
 14 watch it on film?  
 15 Student 8: you saw pretty clearly that she fiddled with that tea bag.  
 16 Student 9: yes.  
 17 Student 10: mm.  
 18 Student 8: means that it is a little bit difficult to talk about (2.6)  
 19 so that you see much clearer.  
 20 Teacher: right (0.4) because if you had seen it more like this  
 21 ((holds his hand flat in front of him gesturing that he  
 22 watches something on a screen)) versus that you maybe you  
 23 looked down and then. ((puts down his hand, moves his body  
 24 forward and looks down and up))  
 25 Student 10: mm.  
 26 Teacher: yes mm (1.2) so that supports wha::t Student 7 says (0.2)  
 27 that the body language is a part of it that we communicate  
 28 with feelings with body language,  
 29 Student 10: mm.  
 30 Teacher: yes.  
 31 Student 8: I don't know I noticed like the whole setting li::ke  
 32 was sitting and talking and then like (1.7) then I just  
 33 noticed that cars were passing in the background,  
 34 Teacher: mm.  
 35 Student 8: and then in a way (1.5) it felt even more real like this is  
 36 the world she walks out in she goes out that door I'm  
 37 going out that door [(0.2) and in those streets it like  
 38 happens, [  
 39 Teacher: [mm. [mm.

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Fig. 5 Teacher guidance

“what had happened” (line 5) and orients to his reckoning that the mother was affected by the incident she tells about (lines 6–7). The teacher acknowledges the contribution and encourages the student to elaborate on this issue (line 8). This triggers Student 7 to provide an even more detailed account orienting to the bodily expressions of the mother and her emotional state (lines 9 and 11). The teacher then wants to know if the students view VR and the traditional film as different experiences regarding their affordances to display bodily expressions (lines 12–14). This is not explicitly addressed by the students, but the conversational pattern and the teacher’s question triggers Student 8 to contribute by orienting to details regarding the mother’s bodily expressions (line 15), such as fiddling with her fingers, which is acknowledged by Students 9 and 10. This acknowledgment makes Student 8 continue to elaborate on the reason for the mother’s fiddling, “it is difficult to talk about” (line 18), and the VR experience enables the students to experience this in a clear way (line 19). The teacher replies by again orienting to the differences between VR and the film (lines 20–24). When this is acknowledged by Student 8, the teacher refers to what Student 7 addressed earlier about bodily expressions (lines 26–28). Student 8 then contributes by orienting to the setting in which he encountered the mother and mentions that the background details (“cars were passing”) made him feel part of something bigger than just this event (lines 31–33 and lines 35–38).

The analysis of Sequence 4 shows that the teacher more explicitly guided the students’ reasoning compared to the prior sequences. Studies of classroom interactions in CSCL contexts have shown that a teacher plays a crucial role in supporting and driving students’ meaning making and engagement, and by using specific strategies such as elicitation and revoicing, teachers can enable students to reach deeper understandings (Furberg, 2016; Rasmussen et al., 2020; Silseth, 2012). In this study, the teacher encourages the students to elaborate on their accounts, pushing them directly and eliciting their reasoning and perspectives. The strategy of referring to and revoicing students’ utterances contributes to the collaborative flow of making sense of the students’ experiences with TWB, but also enabling the students to reflect more deeply about the meaning of their experiences from the VR environment. The analysis also shows how students invoke the relationship between the details in the conversation that they become part of in TWB and the broader context in which the conversation is situated, through the teacher’s support. Making such connections can also be an important issue regarding the experience of emancipatory immersion, which can be seen in the way the students together with their teacher move outside of the framing of the VR film itself and toward addressing the realities of the people from the community that the mother represents.

## Discussion and implications for instruction

In this study, we have explored how students’ immersive VR experiences became resources for collaborative meaning making and learning. Through analyzing social and embodied interactions emerging in the reflective dialogues, we identified four dimensions that characterize students’ meaning making and engagement in the learning design: the feeling of taking part in conversations, attending to bodily expressions of other persons, students’ own bodily responses and teacher guidance of students’ meaning making. The analysis showed emergent meanings developed through mutual elaboration in the reflective dialogues. We saw similar patterns across the groups in terms of characterization of the experiences, but within the groups, the students clearly built on

each other's ideas. Few qualitative studies have shown how HDMs can be used in collaborative activities in K-12 classrooms to learn about and engage with complex societal issues (Billingsley et al., 2019; Luo et al., 2021; Maas & Hughes, 2020), such as social exclusion and discrimination. In our study, we saw that through VR storytelling and engaging in the reflective dialogues, the students could experience and learn about such issues. The expression of grief and suffering and being the victim of racialized violence is available as a powerful story that elicits emotion and sympathy in students, and through the blending of emotional engagement and description of exclusion and discrimination through the story of the Green Book, the students learned about these issues as historical facts and lived experiences. In the following section, we highlight and discuss some of the findings in relation to theory and existing research on VR and (collaborative) learning. We aim to highlight four particularly interesting findings from our analysis that contributes to the field of CSCL, which also have implications for instructional work that includes the use of immersive VR environments.

First, the VR experience provides the feeling of participating in social interactions. Scholars have emphasized that we need more knowledge regarding the complexities of integrating VR environments into more social and collaborative learning activities (Enyedy & Yoon, 2021; Lui et al., 2023; Freeman et al., 2017). Co-presence and social presence in VR are often described as based on interactive features of the mediating activity (Oh et al., 2018); in other words, there is another human (or at least avatar) that the participant is interacting with through a VR environment. Even though the people in the TWB film do not respond to the students' actions, the students characterized their experiences as highly social. The students talked to each other about feeling co-present with the people in the film; they talked about feelings of being spoken to and of being part of the conversation in the virtual space. They were also highly attuned to bodily expressions, movements, and orientations. These features are important in physically co-present interactions (Nathan, 2021; Streeck et al., 2011) and were activated and attuned to in the way the students talked about their VR experiences. This suggests that we should reconsider what counts as *social* in such immersive environments. This suggests that some central ideas within CSCL such as notions of dialogue and embodiment with collaborators *around* mediating technologies are also relevant for making sense of seemingly individually oriented immersive experiences. This is not to suggest that students were truly collaborating with people in the virtual film, but that theories of collaborative learning are useful lenses here.

Second, VR experiences provide a certain sense of place that enables students to attune to other peoples' stories and perspectives. This finding relates to notions of perspective-taking that are associated with VR in the literature. Opportunities for developing perspective-taking and empathy are exciting affordances of VR (Herrera et al., 2018; Shin, 2017, 2018; Young et al., 2022). Studies investigating this typically ask participants to adopt the perspective of others, often literally, so that the VR experience involves adopting the first-person perspective of those one wishes to identify with. For instance, in the study of TWB outside the classroom, Young et al. (2022) found that adult users reported at they experienced empathy and connectedness with the persons that they met in the VR film. The results of our analysis indicate that the students and teacher articulated powerful shared understandings or at least emotional engagement with the stories about exclusion and discrimination. However, in TWB, students are immersed in the room where the stories are told, and they are placed in dialogue with others, but we believe that the experience does not invite them to become someone else. This aspect perhaps makes the experience so powerful; students remain themselves but experience that they are (feeling) with others. Thus,

the sense of being there potentially impacts their experiences, which has implications for instructional work around these environments. Students talk about a sense of being there, of being addressed, and taking part in a conversation. This is very different from reading a text or watching a movie. The students articulated that this particular feature of the immersive experience had a strong emotional impact on them. Our findings imply that teachers can use these types of technologies, which provide such senses of places, to provide students insights into other peoples' worlds and struggles.

Third, the analysis indicates some important considerations regarding the idea of emancipatory immersion. According to Enyedy and Yoon (2021), this concept is about "immersing ourselves in the experiences of others," "learning as becoming part of and immersing oneself in a community," and "epistemological curiosity" (pp. 391-392). Our analysis showed how students talked about becoming immersed in the experiences of the people they encountered in TWB and were willing to and curious about engaging with the stories that were told and learn from the universe that TWB created. However, emancipatory immersion is also something that was collaboratively established by the participants in the joint enterprise of making meaning of the students' experiences. The learning design made spaces for collaborative reflection available to the students, and through the reflective dialogues, the students co-created and re-invented the spaces in which they were engaged through TWB. In our case, the students could share their thoughts and feelings about their experiences and bring them in as shared resources to think and feel within the dialogues, often triggered by contributions from their peers. This contrasts with prior studies of VR environments for learning, most of which are centered on individual learners (Freeman et al., 2017; Scavarelli et al., 2021). Regarding instruction, our study shows the importance of providing students with spaces for reflection about their VR experiences that enable them to think and feel together.

Finally, the analysis demonstrates the importance of teacher support in such learning environments. According to the literature, through guiding dialogues and interactions, teachers can support students' engagement in CSCL classrooms (Furberg, 2016; Silseth, 2012; Baker et al., 2021). This body of research has emphasized, among other things, that using specific strategies to elicit elaborated accounts from students can prove important for supporting more advanced reasoning. We consider the teacher-facilitated dialogue, in this case, as part of a sequence of computer-supported collaboration as it is a form of joint meaning making which is mediated by a (shared) digital experience. At the activity level beginning with the lecture, through the VR experience and into the dialogue, the teacher is inviting connections between different themes linking stories of racism to the affordances of VR in communicating those stories. The screen (literal VR lenses) may not be co-present during the reflection, but it very much serves as a mediating resource, shared reference point, and integrated part of the CSCL activity sequence.

Furthermore, even though the VR field literature has emphasized the importance of facilitating reflection during or after the VR experience, few qualitative studies have explored in detail how teacher facilitation might look like in K-12 classroom contexts (Luo et al., 2021; Maas & Hughes, 2020). In the context of higher education, Lui et al. (2023) found that a facilitator guidance had an important role in supporting one undergraduate students at a time in reasoning about a model in a biology course. By attuning the students to different features of the model, encouraging students to examine these features, and using prompts to facilitate articulation and explanations, the facilitator supported a student's reasoning about the science content. Our study shows similar findings but expands the CSCL field by studying a K-12 educational setting where multiple participants collaborate during activities of making meaning of and learn about societal

issues of social exclusion and discrimination. In our study, we saw how the teacher contributed to meaning making among a groups of students in the context of upper secondary education, where they discussed topics related to the national curriculum. Even though many of the students were quite talkative and eager to share their experiences, the teacher's acknowledgement of students' contributions and his curiosity when listening to these contributions were important driving factors for the co-construction of meanings and feelings in the reflective dialogues. Moreover, the teacher sometimes did more than just acknowledging student contributions. Sometimes, he asked clarifying questions, making sure that the students and he himself understood the meaning of utterances and what situations in TWB had made the most impression on the students. Sometimes, the teacher also, as illustrated in Sequence 4, encouraged the students to go deeper into their experiences. Thus, such elicitation strategies are also important to be considered when planning and executing instructional designs that include VR environments. Furthermore, the teacher sometimes referred to contributions from specific students, building on their thoughts and feelings, when driving the groups' meaning making forward. Such guided participation seems valuable when students make sense of their experiences in post-VR activities and learn about the world of others made available in immersive environments.

## Future research

In this study, we have explored how students' immersive VR experiences became resources for collaborative meaning making and learning in a K-12 setting. We examined how such experiences became valuable resources in collaborative activities after students had individually engaged in a VR environment targeting socio-political issues. This pedagogical design was based in part on the teacher's perception of the challenges of integrating VR in a classroom. These include the cost and availability of the headsets, the requirements of managing the physical classroom, and the care required to manage discussions of sensitive topics like discrimination and violence. With the current sequence of VR film followed by reflective dialogue, the teacher was able to take advantage of a limited number of headsets, manage the organization of the whole class (with other teachers) and also facilitate these small group dialogues. One direction for future research on VR technologies in K-12 settings is to investigate different activity sequences and arrangements including over longer time scales, and explore how teachers and researchers can collaborate in creating learning designs that include collaborative activities during all phases of a learning trajectory centered around VR resources. Since very few studies have scrutinized how VR resources can be used to engage students in socio-political issues, examining how students, together with teachers, make meaning of social situations in a VR environment, and how the participants make meaning of such activities in subsequent collaborative activities might contribute to enhancing the CSCL field even further. In particular, researching how a teacher might implement specific prompts during interactional activities inside and outside the VR environment will be highly valuable. Investigating the relationship between meaning making and teacher support within and across such settings might enhance our understanding of how to best design productive and supportive VR-mediated collaborative learning environments for future classrooms.

## Appendix: Transcription Conventions

<i>Sign</i>	<i>Explanation</i>
(2.5)	Time (in seconds) between end of a word and beginning of next
>word<	Right/left carats indicate increased speaking rate (speeding up)
<word>	Left/right carats indicate decreased speaking rate (slowing down)
<u>word</u>	Underlining indicates emphasis on words and expressions
[	Brackets indicate where overlapping talk begins
:::	Colons indicate a prolonged, stretched sound
. , ?	Punctuation markers indicate intonation. The period indicates falling intonation. The comma indicate slight rising intonation and question-mark sharp rising intonation
( )	Empty parentheses indicate difficulties in hearing what was said
°word°	Degree sign indicates words distinctly quieter than surrounding speech
((looks up))	Double parentheses contain analyst comments or descriptions
“word”	Indicate when participants cite a text (read aloud)

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