A Model for Collaborative Immersive Classroom Management Development Using Multi-User Virtual Reality

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Abstract: Classroom management has been identified as a key challenge in becoming a teacher, as newly qualified teachers are overwhelmed by the complexity of professional teaching practice. This paper explores the transformative potential of immersive technologies in fostering a collaborative reflection and problem-solving space for the continued development of newly qualified teachers' classroom management competencies – allowing newly qualified teachers to become better prepared for facing the unexpected, local, and situated challenges of becoming a teaching professional. Through iterative cycles of design-based research, we have developed a model of immersive collaborative classroom management training using multi-user Virtual Reality. The model consists of four phases: (1) 360-degree video recording, creating an immersive version of the classroom and the complex interactions that occur within it. (2) clip selection, giving teachers the ability to select clips that are relevant for them and their practice. (3) Multi-user Virtual Reality training, allowing teachers to get feedback on their selected clips and construct actionable knowledge together with local teaching supervisors (4) Debriefing, for ensuring the joint understanding and transfer of knowledge to practice. Through analysing teacher's and supervisors' meaning making processes of 18 selected video clips across five multi-user Virtual Reality training sessions, we uncover three main phases: Analysis, Abstraction, and Actionability. By being able to collaboratively watch, re-watch, and discuss selected video clips and moving between these three main phases, teachers and supervisors co-create actionable knowledge, creating an improved understanding of current practices, and supporting the ability to transform future practices. These findings contribute both theoretical insights and practical implications for educators and learning designers, emphasising the importance of creating social immersive reflective spaces in which real situations may be revisited in order to examine the intricacies of classroom practices, allowing newly qualified teachers to better engage with their profession.

Keywords: Collaborative learning, Immersive virtual reality, 360 Video, Classroom management, Teacher training, Feedback

1. Introduction

Newly qualified teachers often experience overwhelming feelings of stress and emotional exhaustion in their first job (Voss and Kunter, 2020). A common reason is the surprising amount of invisible work, which newly qualified teachers find they are untrained for, such as classroom management (Böwadt and Vaaben, 2021). To support the movement between reflecting on what happened (past actions) in the newly qualified teachers classroom practice and coming up with future classroom management strategies (future actions), we turn to video – a resource with a long history of supporting e.g., classroom management development in the teaching profession (Gaudin and Chaliès, 2015). Recently, studies have shown that the use of 360-degree video in teacher training can provide a more realistic and authentic experience, especially when using 360-degree video of teachers own teaching, which has shown to increase reflection compared to videos of others' teaching (Atal, Admiraal and Saab, 2023). In this paper, we present a novel digital learning space using 360-degree video recordings and Immersive Virtual Reality (IVR) – commonly addressed as 360VR or RealVR (Pirker and Dengel, 2021). 360VR uses 360-degree video recordings as the primary content of the virtually mediated space, paving the way for more accessible VR-learning. According to Atal, Admiraal and Saab (2023), 360-degree videos in VR further increases the likelihood of teachers ability to notice, identify, and transfer skills from VR to the classroom. The immersive affordance of 360-degree video blurs the line between reflection-in and on-action (Schön, 1983), so while the teachers are not able to make changes in practice, they are able to re-live practice, getting a feeling of being in-action, while reflecting on-action, setting the scene for this kind of training.

The digital learning space in this study is designed as a collaborative IVR environment, a space which may be conceptualised as "a shared experience in an immersive, virtually mediated space, where there is a shared goal/problem which learners must attend to collaboratively." (Paulsen et al., 2024, p. 10). In this paper, we explore: *How does multi-user Virtual Reality support the development of classroom management competencies, and how can the knowledge acquired in VR be translated into practical teaching strategies?*

2. Related Work

Most current VR solutions are aimed at pre-service teachers' training decision making in programmed environments, in order to improve their procedural knowledge (Wang & Li, 2024). When entering service, teachers find that problems are complex and locally situated (Böwadt and Vaaben, 2021). Systems aimed at

preparing for practice by training standardised procedural knowledge are then at risk of being unable to effectively support the conceptualisation and transfer of the local problems that the newly qualified are experiencing when engaging with complex, real practices. Here, we find it relevant to highlight another observation - the distinction between 360VR systems and programmed VR systems. Programmed VR systems are, as also identified by Wang and Li (2024), mostly aimed at training procedural classroom management skills. A couple of examples include: Building on generalised cases to create VR scenarios, allowing pre-service teachers to work with conflict scenarios (Kugurakova *et al.*, 2023); Using a commercial VR training solution for analysing the effect on pre-service teacher's classroom management ability (Chen, 2022); Comparing use of the same commercial VR training solution for pre-service teachers' training classroom management with 2d video on a flat screen (Seufert *et al.*, 2022). While these examples each in their own way address the complexity of classroom management, Wang and Li (2024) noted that programmed VR applications for teacher training mostly focus on recreating traditional classroom scenarios, rather than exploring the difficult situations found in the actual classroom practices that teachers engage with. A reason for this might be that the tools are mainly aimed at pre-service teachers, meaning that the student teachers are not connected to a specific practice, apart from when engaging with practice placements. 360VR allows for engaging with these specific scenarios in an accessible manner, as it allows for recording authentic practices. A recent study on 360VR for pre-service teachers also concluded "360 videos should be personalized according to PST career and professional goals." (Gandolfi, Ferdig and Kosko, 2024, p. 2), emphasising the need to connect VR-based classroom management training to actual practices that teachers can connect to.

Use-cases of 360VR in teacher training seems to be aimed at broader goals such as pre-service teachers professional noticing (Kosko, Ferdig and Zolfaghari, 2021) or reducing pre-service teachers' anxiety (Theelen, van den Beemt and Brok, 2020). We argue that this might be because using 360VR allows VR training to go beyond training procedural and operational knowledge, and move towards a more practice-oriented view of learning, a notion which is also common with 2D-video analysis (Sormani, 2016). 360VR should then allow teachers to go beyond looking at just classroom management procedures and attend to how classroom management is intertwined with the rest of teacher's local and situated classroom practices. Finally, both programmed-VR and 360VR are currently used exclusively as single-user systems. While individual work with 360VR recording of own teaching has shown to support reflective processes, improving teacher self-efficacy (Walshe and Driver, 2019), we hypothesize that shared reflection could support this process, paving the way for multiple perspectives when working with situations.

3. Designing a Digital Learning Space for Participation and Shared Reflection

The work presented in this paper is building on the parallel development of a software tool for collaboration in immersive virtual reality – CAVA360VR (Collaboratively annotate, visualise and analyse 360-degree video in Virtual Reality) - a software tool built on Unity and PhotonEngine, which allows up to 20 multiple users to remotely collaborate around 360-degree video – creating a shared space for training, problem-solving, and reflection (Davidsen and McIlvenny, 2022; Davidsen *et al.*, 2022).

Throughout October 2023 to January 2024, a design-based research project (Barab and Squire, 2004) has been run together with a Danish primary- and lower secondary school, exploring how CAVA360VR may support the supervision of newly qualified teachers. The project is part of a PhD-project, exploring how facilitated reflection using digital tools may support newly qualified teachers in navigating the complexity of entering practice. Together with practitioners from the participating school, a four-step model has been devised for implementing CAVA360VR sessions (Figure 1).

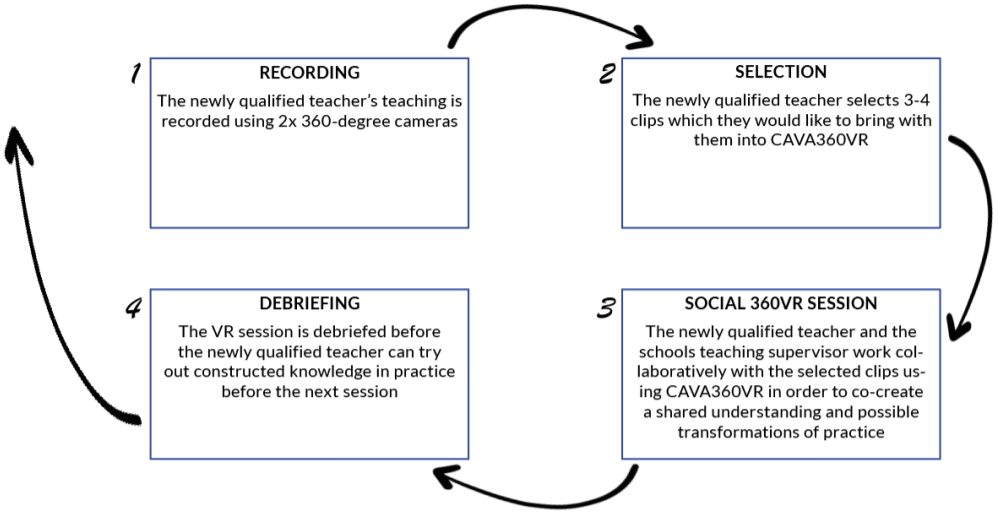

Figure 1: Four steps of using CAVA360VR for collaborative immersive classroom management development

First, the newly qualified teacher's teaching is recorded with two 360-degree cameras following students' and parents' informed consent. For each CAVA360VR session, shorter clips are selected from the recorded double-lessons (1½ hours in length). The newly qualified teacher then reviews the footage together with one of the researchers on a laptop screen, highlighting their initial noticing. Typically, 4 clips were selected, with a combined length of around 10 minutes. The clips were selected for teachers to highlight their own experiences, showcasing both good and problematic experiences.

Following the selection, clips are assigned a thematic title by the teacher, before being imported into CAVA360VR (Figure 2). The CAVA360VR session are structured by a short introduction for technical familiarity, before the newly qualified teacher and the teaching supervisor begin working with the clips in VR using two HTC Vive Cosmos HMDs. In this step, the researchers are purely observing, the VR session is entirely directed by the participants, using built-in resources in CAVA360VR: 360-degree video feeds, coloured laser pointers, an overview of the lesson, and media controls. Following the VR training, the session is debriefed, establishing an understanding of what occurred within VR, supporting the transfer of knowledge by reifying it using images from the clips, and discussing further iteration. CAVA360VR sessions and debriefings are all video recorded using screen recordings from the laptops and external cameras.

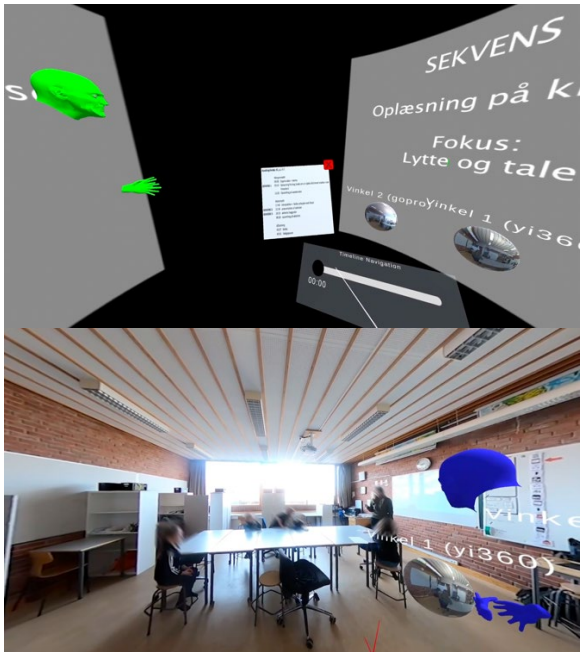

Figure 2: Title screen and resources (left), Being jointly (re)immersed into classroom practice (right).

After the session, a couple of weeks go by, where the newly qualified teachers have time to individually reflect on and try out the constructed knowledge and strategies. After this, the cycle is repeated. 2 and 3 full cycles were completed with two newly qualified teachers. The 5 cycles resulted in the teachers and supervisor co-constructing shared understandings of 18 different clips from the newly qualified teachers' teaching (Table 1).

Table 1: Overview of VR training sessions.

Session	**Number of selected clips**	**CAVA360VR Session length**	**Debriefing length**
Teacher 1, session 1	4	59 minutes	31 minutes
Teacher 2, session 1	4	44 minutes	23 minutes
Teacher 1, session 2	3	56 minutes	19 minutes
Teacher 2, session 2	4	62 minutes	20 minutes
Teacher 2, session 3	4	30 minutes	32 minutes
Average length		*~ 50 minutes*	*~ 25 minutes*

4. Results

Video recordings of all VR sessions have been inductively coded and categorised using DOTEbase (McIlvenny, Davidsen and Stein, 2024). In coding the sessions, we take a situated and interactional approach to knowledge (Jordan and Henderson, 1995), identifying different phases and sub-phases based on the visible talk and actions performed by participants in the physical and virtual space as they engage with the 18 selected clips across the 5 sessions. The VR sessions were coded through making media clips and inductively assigning tags based on the activity performed by participants, e.g. examining the hand movements of the teacher in a certain clip would be tagged as "analysing actions" (Figure 3).

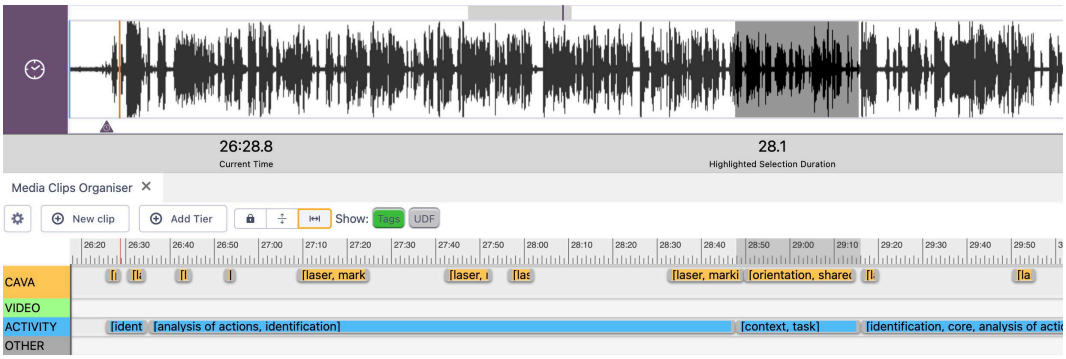

Figure 3: Excerpt of coding and tagging clips in DOTEbase

In order to move towards an empirical, data-driven model for Collaborative Immersive Classroom Management Development the tagged clips were grouped together in larger categories based on the activities performed by the newly qualified teacher and teaching supervisor. The initial grouping of the activity codes shows that working with 360-degree video clips of newly qualified teacher's own teaching is centred around moving between the three A's – Analysis, Abstraction, Actionability, and their sub-phases (Table 2).

Table 2: Coding of main- and subphases.

Main phase	**Subphase**	**Number of codes**
Analysis	(re)-identification	66
	Context	88

	Analysing actions	78
Abstraction	Other scenarios / clips	49
	Theory / general statements	38
	Team	11
	Personal experiences	9
Actionability	Alternative past actions	24
	Possible future actions	39

It is important to note that coded sub-phases are not mutually exclusive. This means that a clip can entail abstraction that is e.g., both aimed at other clips and theory, thus being coded in both sub-phases. The movement present during VR sessions consists of an overall linear motion from presenting the clip to summing up the constructed knowledge, with a non-linear movement between the three A's taking place during this overall movement (Figure 4).

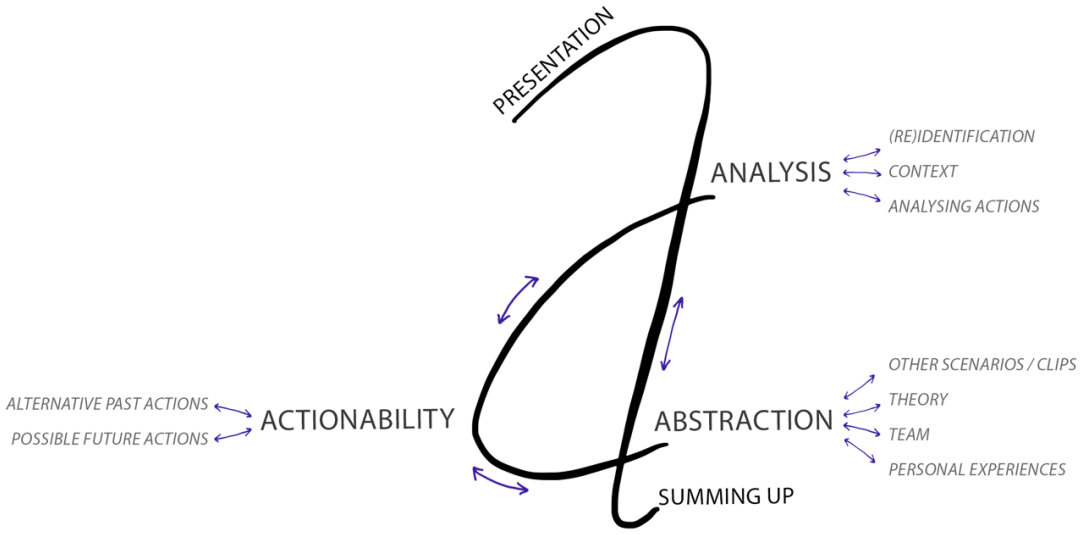

Figure 4: The three A's of Collaborative Immersive Classroom Management Development Using Multi-user Virtual Reality

The situated and interactional view of learning imposed upon the coding of the VR sessions means that while this model is a generalisation of the overall notion of classroom management competency development in social 360VR, deviations from the model exist in the empirical data, as the complex nature of situated and experiential learning processes is difficult to model. In order to show how the model unfolds, we wish to unfold the phases and expand on how the digital learning spaces supports participants in identifying and discussing classroom management strategies.

4.1 Initial Phases - Being Immersed into Recorded Classroom Practice

In the initial phases, participants present the clip and perform an initial watching of the clip. The first subphase, *presentation*, entails the newly qualified teacher presenting the clips that participants are about to watch in order to establish an initial understanding and focus. Here, the overall notion of social interaction is afforded by participants being able to communicate through the CAVA360VR software, providing a communication channel between participants' avatars. Title screens, which are embedded into the 360-degree video before each clip (Figure 2), are also a key part of this phase, providing a thematic title that helps newly qualified teachers recall the clip. As 360-degree videos are very data rich, an initial focus is needed. Initial sessions without titles revealed that clips had to be paused during initial watching in order to negotiate a shared orientation.

After the clips have been presented, they can be *watched* and *re-watched*. Here, the CAVA360VR built-in media controls such as play/pause and a timeline for scrubbing assist participants in performing such actions, with the HMD allowing participants to freely orient themselves in the 360-degree video sphere. After these two initial

subphases, a non-linear movement between Analysis / Abstraction / Actionability begins – typically starting at analysis and ending with abstraction or actionability.

4.2 Analysis - Establishing a Joint Focus and Understanding

In the analysis phase, participants identify the central theme of the clip and analyse interactions in the recorded material while providing the needed contextual knowledge in order to produce such analysis.

Identification and *re-identification* entails defining and re-defining a shared premise for watching and working with the clip. While the presentation establishes the newly qualified teacher's initial perspective on the situation, the initial watching allows the teaching supervisor to establish their own perspective. Previous studies on teacher noticing has shown that teachers with different experience levels notice different things when observing classroom situations (Wolff *et al.*, 2015). Here, the digital learning space allows the teaching supervisor to perform their own observation and noticing of the situation, leading to a re-identification of what the newly qualified teacher has initially noticed. This allows the teaching supervisor to perform their supervision with roots in the actual situation, and not just the teacher's interpretation of the situation, as would typically had been the case without the immersive video.

While the re-identification is ongoing, participants typically move into a *context* subphase, with the teaching supervisor requesting additional contextual knowledge about the clip. This both entails context about the task that students are performing but is mostly aimed at relational knowledge – "tell me about this student, what are they usually like, what do I need to know about them". This emphasises the digital learning space's ability to re-immerse participants into actual situations, and not generalised cases. It shows that professional development of teachers' classroom management competencies cannot be developed in isolation from the situational context.

Analysis of actions is aimed at micro-level analyses of the complex interactions occurring in the clip in order to co-construct an understanding of the situation. The primary affordance of this phase is being able to manipulate the 360-degree video using media controls, allowing participants to pause playback in order to freeze the classroom interaction, allowing them to perform micro-level analysis of the practice. In order to support this micro-level analysis, participants make use of their colour-coded laser trails (Figure 5), acting as a virtual marker for establishing joint-attention when pointing and marking objects/areas as relevant.

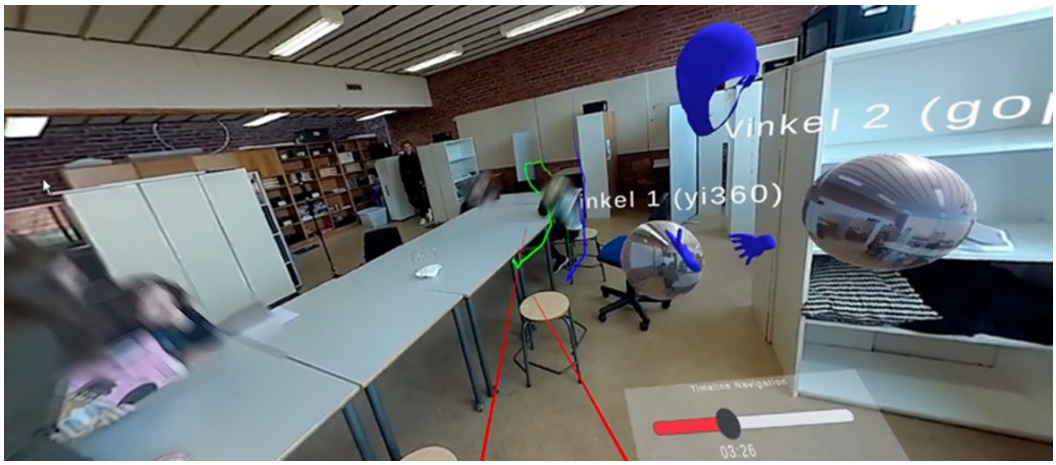

Figure 5: Pointing with colour-coded lasers (blue/green).

Identification and analysis of actions is a key part in building new understandings and reflecting upon classroom management strategies. Studies of programmed VR found that teachers struggled interacting with the virtual avatars representing the students in these spaces due to their lack of facial expressions and bodily conduct (Chen, 2022; Kugurakova *et al.*, 2023; Wang and Li, 2024). In CAVA360VR, the interactivity of being able to implement strategies on virtual students is traded for the ability to better notice what is going on in the classroom due to the immersive nature of 360-degree video, giving participants access to the students and their complex interaction in the classroom. Giving access to this complexity is then also what necessitates the use of collaborative learning strategies, with different experiences levels providing different perspectives, allowing the newly qualified teacher to further their noticing and reflection competencies. The core of the digital learning space is then the ability to jointly notice, identify and conceptualise classroom management strategies in order to discuss past and future strategies.

4.3 Abstraction – Furthering the Understanding

As participants begin co-constructing a shared understanding of the clips, they begin moving into the abstraction phase, putting their analysis into perspective by building categories. Across the sessions, 5 overall categories have been identified, to which participants compare their co-constructed understanding of the clips in order to develop and/or challenge it: (1) other scenarios / clips from their teaching or other VR sessions (2) theory, typically classroom management theory and principles (3) the team of teachers surrounding the classroom practice, e.g. "have you talked with [teacher X] about it, how do they experience [student Y]" (4) personal experiences that may impact their understanding of how to perform classroom management (5) the teaching profession as a more general notion for establishing the teacher's role when doing classroom management.

The primary actions taken during this phase is the movement between phases. The movement allows participants to go back to analysis and identify certain actions, and then move back into abstraction in order to develop and/or challenge the shared understanding of the classroom practice beyond the micro-level. Wang and Li (2024) urged researchers to develop theory driven training designs for VR training. Creating a digital learning space which affords a clear abstraction phase by allowing participants to jointly pause the classroom interaction, creating a shared reflective space within the noticing-space allows for theory to play a core role in identifying and analysing classroom management strategies, as this space is not bound by a need for action, but can be prolonged for as long as participants wish and need. Creating this 'space within a space' by pausing, effectively freezing the classroom practice around the participants, stands in contrast to current approaches, where e.g., Seufert et al. (2022) make use of pre-service teachers conducting individual VR training and then following up in groups outside of VR. Here, the use of shared reflection during the activity allows for participants to repeatedly move between noticing / reflecting / discussing, instead of the shared reflection being a follow up activity, allowing participants to actively keep engaging in establishing shared understandings of the complex scenarios.

4.4 Actionability – Transforming Practice

While abstraction is one way for participants to develop and/or challenge their co-constructed understanding, participants are also able to move into the actionability phase, transforming understandings into actionable knowledge for transforming future practices. In this phase, the colour coded laser trail takes on another role. While in the analysis phase it was used for identifying and marking actions in the recorded classroom practices, it here becomes a tool for jointly imagining actions that are not present in the video. These actions either take shape as *alternative past actions* or *possible future actions*.

Alternative past actions entail imagining alternative actions that could have been taken in the situation that participants are currently watching. This is made visible through e.g. "if I had stood over there when moving my hand up instead, then…", while using the laser trail to visualise an imaginary trail of movement from the initial position in the recorded classroom to the suggested alternative position. Future actions are aimed at imagining and discussing actions that could be taken in future situations, e.g. "next time, if I encounter such a situation I could…". Here the laser is used more loosely for imagining actions, and not necessarily tied to the actions in the recorded clip. When discussing future actions, participants also move into an *implementation* sub-phase, negotiating how to best implement the actions. Here, the laser is again used as a shared tool for establishing joint-attention and imagining actions. This sub-phase is important for adjusting the implementation of e.g., more direct body language with what the supervisor deems as best practice in a more general sense, and what the newly qualified deems as the best practice in their own classroom practice.

In programmed VR environments, real time feedback can aid training by showing a direct output of selecting e.g., a certain classroom management strategy (Chen, 2022). In CAVA360VR, direct manipulation of the classroom is not possible due to the format being tied to a video recording. Here, the real time feedback is then provided by another teaching professional, who due to their own noticing can provide both an alternative perspective on the clip, but due to the experience of the supervisor, also provide feedback on the possible future implementation of actions, drawing on both theoretical knowledge and practical experience. As shown in the context subphase, this feedback will always be tied to the specific teaching context, and therefore possibly also more actionable, as strategies are tied to specific classroom practices of the newly qualified teacher.

4.5 Summing up – Moving Back into the Classroom

Summing up the constructed knowledge into more condensed understandings is a process that occurs both inside VR at the end of each clip, as well as something that is facilitated in the debriefing sessions, where the participants are presented with a storyboard on a printed sheet, showing a screenshot from each clip and a text

box. Participants are then asked to jointly note down the central theme of each clip, allowing them to summarise and re-establish their joint understanding of the situation. The newly qualified teacher then keeps the sheet after the session, with the goal of supporting transfer and transformation of knowledge from VR to the debriefing, and from debriefing to future classroom practice through reification of the co-constructed actionable knowledge.

5. Participants' Experience of Shared Reflection in Multi-User 360VR

At the end of the debriefing participants were asked to reflect on their experience with multi-user VR. Participants highlighted the realistic and immersive nature of the format, and how the shared experience allows for identifying and applying multiple perspectives on specific situations, which may exemplify larger themes. Participants expressed that CAVA360VR allows them to dynamically shift between looking at the specific actions and their broader implications in order to qualify future actions, which aligns with the three phases of analysis, abstracting, and actionability. During the second and third debriefing, the iterative process was also highlighted, with participants detailing the transformation of their teaching practices.

In one example, during the first selection phase, one of the teachers chose a sequence from their teaching that exemplified their wish to become more direct in their use of body language when communicating with students. In the VR session, the teacher and the teaching supervisor analysed the existing use of body language, abstracted it to other scenarios, and negotiated a strategy for implementing the knowledge in practice. In the following recording and selection, the teacher noted that they had tried being more direct. In the accompanying VR session, the analysis was centred around the new actions, comparing it to the clips from the previous sessions, and negotiating minor adjustments in the use of body language. This example shows the iterative nature of facilitated reflection in CAVA360VR and how trying out conceptualisations and actions in practice can lead to further reflection and improved strategies.

6. Conclusion

In this paper, we explored how 360-video and multi-user Virtual Reality can support the development of classroom management strategies. The findings demonstrate the transformative potential of immersive technologies, especially in collaborative learning settings using multi-user 360VR, to address classroom management challenges for newly qualified teachers.

Through design-based research, a model comprising four phases (360-degree video recording, clip selection, collaborative VR training, and debriefing) set the foundation for creating a digital learning space that affords participation and shared reflection in identifying and discussing past and future classroom management strategies. Through coding the actions taken by newly qualified teachers and their teaching supervisors in 360VR sessions, we revealed three phases: Analysis, Abstraction, and Actionability, showing an iterative movement between (1) creating shared understandings of classroom management strategies, (2) developing and/or challenging the understanding of strategies by generalising through theory and/or comparing to other situations, and (3) making future strategies actionable.

This study highlights the importance of shared immersive reflective spaces in teacher development, offering both theoretical insights and practical implications. By collaboratively engaging with classroom practices through social immersive technologies, newly qualified teachers may become better prepared for engaging with the complexities of classroom practice.

With our proposed models, we have begun unfolding the potential of 360-video and multi-user Virtual Reality in teacher training. We envision that this format, and the accompanying three A's of analysis, abstraction and actionability may also be explored in other professions in order to help professionals in engaging with complex real-world practises in their transition from education to practice.

Acknowledgements

The work presented in this paper is part of a Ph.D.-project titled "A better start: Reflective communities of practice for newly qualified teachers through social Virtual Reality" funded by The Danish PhD Council for Educational Research.

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