Training Classroom Management Skills with VR: A Learning Analytics Approach

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Abstract

Effective classroom management is a fundamental skill for teachers, yet it remains challenging to train and evaluate, especially for teacher trainees. Virtual reality (VR) provides a promising solution by offering immersive, controlled environments where trainees can practice handling classroom disturbances without real-world consequences. This paper presents steps towards a set of visualisations which use collected learner data to enhance the reflection process in a VR learning application. The application immerses the teacher trainees in a virtual classroom where the student behaviours is created in a combination of human and automatic control, simulating realistic scenarios to test and improve classroom management skills. The learning analytics-based solution that tracks and analyzes trainee performance during VR sessions could support learners' reflections after the VR experience by presenting objective data. Eye-tracking and interaction data are combined with behavioural events logged by the coach to create detailed evaluations of trainee responses to disturbances. These evaluations are presented through innovative visualizations within the VR environment, providing actionable insights into trainee performance. A user study assessed the tool's usability and effectiveness, revealing that it enhances awareness of classroom dynamics but highlights the need for improved visualization clarity. The findings demonstrate the potential of combining VR and learning analytics to create robust, data-driven training tools that support teacher development through objective feedback and immersive practice.

Keywords

Multimodal Learning Analytics, Virtual Reality, Classroom Management, Feedback, Teach-R

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1. Introduction

Classroom management is a critical skill for teachers; it is important for curriculum development, it has significant impacts on the learning outcomes of students, and it is a crucial part of creating a good learning environment [1]. Classroom management can be explained as the actions and directions that teachers use to create a successful learning environment. However, training this skill effectively can be challenging, particularly for teacher trainees who lack real-world classroom experience. Virtual reality (VR) offers an innovative solution, providing safe and controlled environments for teacher training.

Despite the potential of VR for teacher training, existing systems often lack objective tools to evaluate classroom management performance. The topic is usually addressed using subjective feedback, which may vary based on individual coach perceptions. Learning analytics can support this feedback and help get deeper insights into classroom management skills training.

The work presented here addresses this challenge by developing a tool that evaluates teacher responses using data such as eye-tracking and interaction logs. Starting point is the VR application *Teach-R*, which enables trainees to practice classroom management, focusing on behaviour management by simulating realistic classroom disturbances controlled by a coach. By integrating Learning Analytics insights into Teach-R, it's not only possible to quantify classroom management skills but also provide visual feedback

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to enhance the trainees' self-reflection and learning process. This approach exemplifies how technology can transform teacher education, making training more effective and objective.

2. Related work

Three topics are presented in this related work section, which form the basis for the work produced: classroom management, VR in education and learning analytics in virtual reality.

2.1. Classroom Management

As already introduced in the first part, Classroom management is a critical component of effective teaching and includes all strategies used by teachers to establish and maintain an environment that supports learning. While no universally accepted definition exists, classroom management generally refers to the teacher's ability to structure the classroom and manage interactions to minimize disruptions and maximize instructional time.

Research identifies multiple dimensions of classroom management, showing different approaches to investigating and training the mentioned aspects. Early foundations are laid in [2], in which the focus is on the strategies to structure lessons and to guide students through learning without a strong focus on misbehaviour. Doyle (2005) discusses that effective classroom management strategies are not limited to addressing individual behaviour but should try to maintain order at the group level, promote cooperation and support positive student behaviour [3]. Other researchers focus more strongly on misbehaviour, which poses a significant challenge in classroom management. It can disrupt the learning process and affect overall classroom dynamics. Kounin (1970), a researcher who shaped the research field of classroom management, introduced typical strategies to deal with misbehaviour and a group-oriented view to the social system "classroom" [4, 5]. Newer approaches like Spoden & Fricke (2018) categorize management strategies as reactive, proactive, or preventive, emphasizing the importance of addressing disruptions, but also establishing clear rules, and anticipating potential issues before they arise [6].

Classroom management is recognized as an essential skill for teachers, yet opportunities to develop it in realistic settings are limited during teacher training. Consequently, new teachers may feel unprepared to handle classroom disruptions [7]. Traditional training methods, such as acting or videos come with downsides: limited repeatability, enormous personnel costs, a high degree of abstraction, limited access due to personal data or limited through personal data or limited interaction possibilities [8], The use of virtual reality (VR) offers a potential solution by providing controlled, immersive environments where teacher trainees can practice classroom management skills and receive targeted feedback in a simulated setting.

2.2. VR in Education

VR's ability to engage learners and shift them from passive to active participants has been widely noted, with applications ranging from exploring historical settings to simulating complex systems and scenarios [9, 10]. Its strengths include enabling repeated practice, providing intuitive access to three-dimensional content, and offering safe environments for experimentation. These qualities make VR effective for teaching both practical skills and abstract knowledge [11, 12].

Despite these advantages, VR faces challenges, including issues like cybersickness, high development costs, and technical barriers. Furthermore, questions remain about its scalability and the types of content best suited to VR, as well as the lack of theoretical frameworks to guide its application in education [13, 14]. Despite these challenges, VR has great potential to drive innovation in teacher training because it enables teacher trainees to experience realistic scenarios, practice teaching in a safe space, and refine classroom management strategies without the consequences of real-world mistakes [15, 16].

VR offers the opportunity to simulate classroom environments in teacher training, allowing trainees to practice in a controlled and immersive setting where learners can experiment and repeat specific scenarios. Systems with this purpose are designed to replicate real-world classroom settings, scenarios and dynamics. The virtual students are either preprogrammed, and/or semi-automated, and/or controlled by a human.

Research demonstrates the effectiveness of VR-based teacher training. For instance, studies have shown that VR can enhance classroom management competencies by allowing trainees to repeatedly practice handling disruptions and adjust their strategies over time [17, 18].

However, implementing VR in teacher training is not without challenges. High costs (software, hardware and development of both), technical requirements, and the need for scalable, modular solutions remain barriers. At the same time, the added value of digitization is still hardly being used. VR enables the integration of objective data collection and evaluations. Addressing these challenges requires further research into developing cost-effective systems, integrating robust assessment methods, and aligning VR training with broader educational goals.

2.3. Learning Analytics (in VR)

Learning analytics is a growing field in education that focuses on collecting, analyzing, and interpreting data about learners and their contexts to enhance teaching and learning processes, e.g. [19]. The collected data it is possible to optimize learning environments based on learning data and to gain insights in complex educational phenomena, like group work or the professionalization of teachers. Another use case for learning analytics is to personalize the learning experiences.

In the context of teacher training, learning analytics offers interesting possibilities to support and evaluate classroom management skills. In virtual reality (VR) environments like Teach-R, learning analytics can track metrics such as eye movements, the teachers' position, interactions with students, and responses to simulated disturbances. For example, the teacher's gaze is an important factor for classroom management [20]. The multimodal data points can be used to provide trainees with feedback on their performance, support reflective practices on the experience, and highlight areas for improvement. Visual feedback plays a central role in reflective learning processes by transforming raw data into accessible and actionable insights. Effective visualizations allow learners to perceive patterns, identify strengths and weaknesses, and make data-informed adjustments to their strategies. In the context of teacher training, visual feedback mechanisms provide an opportunity to translate complex classroom dynamics into intuitive representations, enabling trainees to understand the impact of their decisions and actions.

One approach is to use the possibilities of VR and Learning Analytics is to provide recordings from the experience in the VR classroom through the spectator's view [21]. The spectator-view videos were shown to be a good support for the learners and the coaches in reflecting on challenges and enhancing learning.

Another attempt to develop a dashboard for teacher training in VR, which focuses on eye tracking data, discussed feedback with visualization using heatmaps [15]. This type of visualization is easy to understand, but the presented approach only depicts one modality, other data sources and other aspects of classroom management via eye contact with students are not covered. Hlosta et al. emphasize the opportunities of the multimodal data, which is possible to collect using VR devices in the context of teacher training [22]. The proposed pipeline, in connection with a co-designed dashboard, serves to create assistance in reflective processes after training experiences in VR. They highlight the importance of the reflection phase.

3. Methodology

3.1. Application Overview

Teach-R is a virtual reality (VR) application designed to support teacher training, one focus of the application is on developing classroom management skills. It provides an immersive, interactive platform where teacher trainees can practice managing classroom dynamics in a controlled environment.

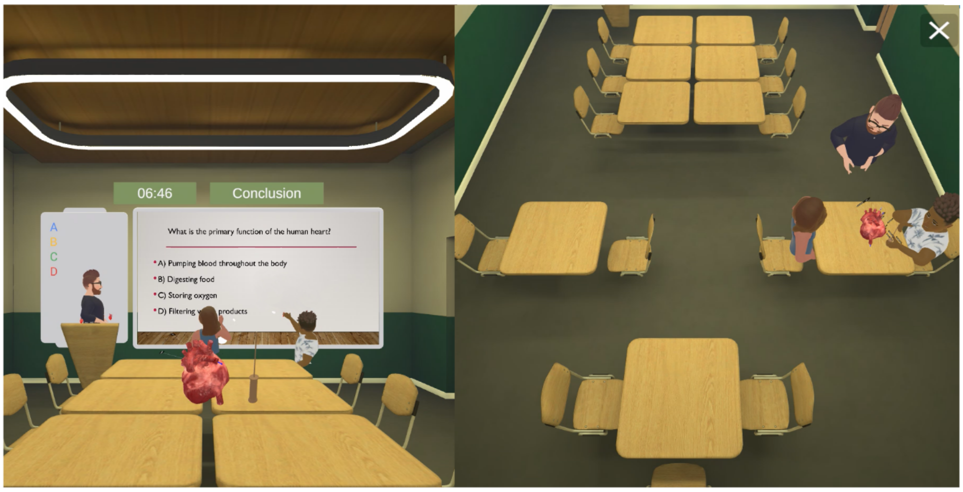

Figure 1: Screenshot of the spectator's view in a VR classroom [23].

The core functionality of Teach-R revolves around a simulated classroom environment, where learners engage with virtual students whose behaviours are either preprogrammed or controlled by a coach. Moreover, a few automations are implemented to support the coach. One example of this is that the virtual students (automatically) might stop disturbing the closer the teacher gets. The behaviours of students range from active participation to varying levels of misbehaviour, allowing trainees to experience and respond to disruptions. Scenarios include a variety of classroom setups, such as group seating arrangements, media rooms, and laboratories.

Teach-R is implemented using the Unity game engine and is compatible with various VR headsets, e.g. the HTC Vive (pro eye) VR hardware. This setup provides a fully immersive experience for the learners while the coach monitors and influences the virtual classroom via the desktop interface. The system supports features such as real-time interaction, behaviour scripting, and feedback mechanisms.

3.2. LA Integration

The system leverages the xAPI (Experience API) specification[1] to collect structured data on user interactions, movements, eye-tracking events, and coach instructions during training sessions. These data points are captured as statements, consisting of an actor, verb, and object (activity), with extensions for additional context such as activity details or environmental information.

Teach-R's technical integration of learning analytics is facilitated through the OmiLAXR framework[2], which simplifies the incorporation of tracking mechanisms into Unity-based applications. The framework provides a semi-automated approach for data collection, ensuring consistent and reliable tracking of user activities in the VR environment [24]. Eye-tracking data, for instance, is used to identify which virtual students the learner focuses on. Together with the tracking of the coach's commands (the timing and behaviour of the students), these data streams form the foundation for evaluating classroom management performance. This opens the possibility to track and give feedback to things, which are otherwise challenging to obtain through traditional human observation. Moreover, the integration of learning analytics enhances the system's capacity to identify patterns and trends in teaching behaviour.

3.3. Algorithms and Visualizations

To enable feedback concerning classroom management (and here especially the misbehaviour and the teacher's reactions), the systems need to quantify classroom disturbances and the learner's ability to manage them. For this, each virtual student is assigned two scores: a disturbance score and a teacher

[1] www.xAPI.com, accessed 03.12.2024; Archive at Wayback Machine (https://web.archive.org/) from 28.11.2024 checked
[2] https://omilaxr.dev/, accessed 03.12.2024; archived at Wayback Machine (https://web.archive.org/) > 03.12.2024.

control score. The disturbance score increases when misbehaviour occurs, with higher increments for severe disruptions such as loud talking or throwing objects, and continues to rise as the misbehaviour persists. Conversely, the teacher control score increases when the learner successfully addresses a disturbance by prompting the student to return to an appropriate behaviour.

Figure 2: Screenshot of the bar chart visualization. The red bar shows the disturbance score, while the light grey bar displays the teacher control score.

Eye-tracking data is used to determine whether the learner notices a disturbance, while coach instructions indicate the type and duration of the misbehaviour. When a disturbance is resolved, the respectives scores are updated.

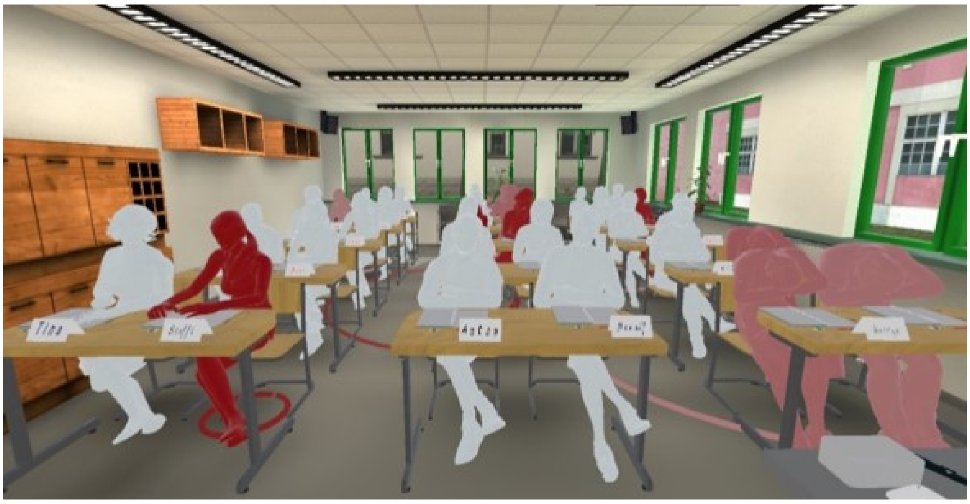

Figure 3: Screenshot of the radius and colour visualisation.

The scores are used to give feedback about the behaviour and to facilitate reflection processes. To do this, three visualizations were implemented.

1. Bar Chart Visualization: Each virtual student has a bar chart above the head, displaying their disturbance and teacher control scores side by side. This visualization is intended to provide a clear, real-time overview of individual student behaviours and the learner's responses; see Fig. 2
2. Radius and Color Visualization: This visualization maps the classroom dynamics spatially, using colour gradients to represent the difference between disturbance and teacher control scores for each student. A circle around the origin of a disturbance indicates its spatial impact. Using this

visualisation, disturbance developments can be traced, and the time and space of disturbances can be aligned; see Fig. 3.

3. Surface Map Visualization: This visualization projects a three-dimensional surface map onto the classroom floor, where the height and colour intensity correspond to the severity of disturbances and the effectiveness of teacher control. This feedback should help to highlight areas which might require attention quickly and easily; see Fig. 4.

Figure 4: Screenshot of the surface map visualisation.

These visualizations are accessible in the VR environment through a portable user interface, allowing trainees to toggle between different modes.

4. Evaluation

The first evaluation of the new visualisations was designed to review their usability. The study was designed with five tasks, which will be detailed after the participants' descriptions.

4.1. Population

The study sample consisted of 11 participants (N = 11), who were recruited voluntarily. Participation was non-compensated and spanned eight days, with each participant taking part in one session within the eight days. The participants ranged in age from 23 to 38 years, with a mean age of 29.7 years. Of the 11 participants, three identified as female and eight as male.

In terms of educational background, nine participants held degrees from universities or universities of applied sciences, while two had completed doctorate degrees. To provide a comparison with the target audience of pre-service teachers and coaches, participants were asked about their teaching experience. Nine reported prior teaching experience, which varied from coaching in sports and leading vacation camps for pupils to delivering lectures and seminars at universities or participating in school internships. Among these, three had direct experience teaching pupils in schools, and eight had experience teaching in higher education settings.

Regarding familiarity with VR, only one participant had no prior experience with the technology. Two participants had some knowledge of the application before, having seen screenshots of earlier versions of the visualizations, which may have introduced a slight bias in their responses.

4.2. Experimental Setup

Firstly, a brief introduction to the topics of classroom management was done. The application and hardware (HTC Vive controllers and the head-mounted device - HTC Vive Pro Eye) were explained.

The next part was to think about a topic for a short lecture, around two or three minutes. If the participants struggled to come up with a topic, the topic of a "planned city trip with the class to a city" was suggested.

The third task was to get active in VR and to use the application for a short lecture about the chosen topic in front of the virtual class. The participants had to deal with certain disturbances while lecturing. The behaviour of the virtual students was manipulated using human control via the website.

After finishing their micro-teaching experience, the participants were asked to work on the following tasks while performing a think-aloud-protocol,

- Open the visualization menu to start the learning analytics reflection
- Find the classroom management visualizations (Fig. 5)
- Start the radius and colour visualization and explore the visualization with the classroom management UI
- Start the surface map visualization and explore the visualization with the classroom management UI
- Start the bar chart visualization and explore the visualization with the classroom management UI

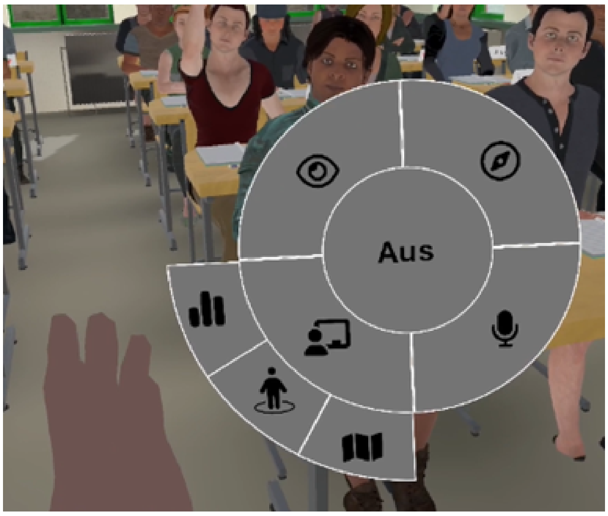

Figure 5: Menu with the selection of classroom management visualizations. In the centre, "Aus" translates to "off"; it's used to close the menu.

Lastly, after giving the participant the possibility to stay in VR for further exploration, an online questionnaire was conducted. The questionnaire consisted of demographic data, the User Experience Questionnaire (UEQ) [25] and some additional open questions. The open question addressed the feelings towards the visualizations if they helped to evaluate their classroom management skill, and how they could be improved.

4.3. Results

The User Experience Questionnaire (UEQ) was employed to evaluate the usability and overall experience of Teach-R, providing insights into six key factors: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. The UEQ uses a 7-point scale for 26 adjective pairs, where scores range from -3 (very bad) to +3 (very good). The results are grouped into three broader categories: Pragmatic Quality, Hedonic Quality, and Attractiveness; for more information, see Laugwitz et al. (2008) [25].

The stimulation scale received the highest average score (mean 2.0), indicating that participants found the tool enjoyable to use. It also showed the lowest variance, suggesting agreement among participants on this aspect. On the other hand, perspicuity had the lowest average score (mean 1.14) and the highest variance, reflecting mixed feedback on the tool's intuitiveness and ease of learning. Participants noted challenges in understanding certain visualizations, particularly the bar chart, without additional guidance.

Other dimensions, such as efficiency, dependability, and novelty, scored positively (averages ranging from 1.36 to 1.5, see Table 1), with moderate variances, indicating generally favourable perceptions. When grouped, hedonic quality (1.7) was rated higher than pragmatic quality (1.33).

Scale	Item	Mean	Std. Dev.
Attractiveness	annoying/enjoyable	1.6	0.9
	bad/good	1.9	0.9
	unlikeable/pleasing	1.1	0.8
	unpleasant/pleasant	1.3	0.9
	unattractive/attractive	1.5	1.1
	unfriendly/friendly	1.7	1.0
Perspicuity	not understandable/understandable	1.0	1.7
	difficult/easy to learn	1.6	1.1
	complicated/easy	0.8	1.7
	confusing/clear	1.1	2.1
Efficiency	slow/fast	1.9	1.4
	inefficient/efficient	1.5	1.2
	impractical/practical	1.4	0.9
	cluttered/organized	1.5	1.6
Dependability	unpredictable/predictable	1.3	1.4
	obstructive/supportive	1.5	1.6
	not secure/secure	1.2	1.2
	does not/meets expectations	1.5	0.7
Stimulation	inferior/valuable	2.1	0.8
	boring/exciting	1.8	1.3
	not interesting/interesting	2.4	0.7
	demotivating/motivating	1.7	0.9
Novelty	dull/creative	1.4	0.7
	conventional/inventive	1.4	0.9
	usual/leading edge	1.5	1.5
	conservative/innovative	1.4	1.4

Table 1
UEQ Results: Scale, Mean, and Standard Deviation for Each Item

4.4. Discussion

When grouped, hedonic quality (1.7) was rated higher than pragmatic quality (1.33), suggesting that participants valued the enjoyable and innovative aspects of the tool over its functional utility.

These findings highlight the strengths of Teach-R in engaging users while pointing to areas for improvement, particularly in making the interface and visualizations more intuitive and accessible.

Teach-R provides, on a theoretical basis, a good environment to practice classroom management, specifically behaviour management. It also enables multimodal learning analytics and visual feedback.

The developed visualizations highlight classroom dynamics and help learners to reflect on their performance. The visualizations can be combined with other visualizations created in Teach-R in earlier projects [8, 15, 26].

The radius and colour visualization was particularly noted for its intuitive design. The tool helps to raise awareness for disturbances and supports self-reflection, encouraging learners to analyze their responses to classroom challenges.

The bar chart visualization should be reworked to be easily accessible. A short-term solution to use this visualization more efficiently is to explain it and its value to the coaches so they can help learners with comprehension. After providing more explanation, a real-time view of the bar chart visualization during or in a video analysis after the session might also provide helpful insight into classroom behaviour.

In this study, we allowed the participants to use the visualizations very freely; in most real-life contexts, there is at least the coach, but often also various peers who are involved in the reflection process. It's future work to analyse the visualizations in such a context. Another factor, which should be investigated is the time factor, the explanaition as well as the discussion of the visualizations in reflective processes needs time, choaches need to develop best practices. Do we need all visualizations all the time? How long does it take? Does it depend on the subject-specific didactic background?

5. Conclusion

In contrast to conventional classroom management evaluation strategies, such as questionnaires, visualizing the collected data provides further insight. Exhausting the possibilities that VR provides is crucial for a helpful user experience. By combining objective scoring with interactive visual feedback, Teach-R promotes a deeper understanding of classroom dynamics and supports the development of effective classroom management strategies.

5.1. Insights and Challenges

The combination of subjective feedback in its current form and the newly implemented additional objective feedback aids in understanding classroom behaviour. Apart from aiding the coach by lowering the cognitive load of managing the session and noting feedback details, it provides an objective foundation for a data-based discussion. Because the teaching styles of different coaches and teacher trainees may vary widely, visualising the classroom events objectively influences the way such a feedback discussion is structured, providing a guideline.

VR provides many possibilities which can be used effectively in teacher training. Using learning analytics to display data without judging the trainee's behaviour during the session aids in the process of gaining further insight to evaluate their performance. Contrary to 2D data visualization, visualization in VR provides possibilities as well as challenges which have to be adressed developing such a tool, including immersion inside the visualization, interacting with the data and the possibility to take different viewpoints.

The presented tool addresses classroom management from a behavioural point of view. The manually performed student control addresses single students with instructions and enables the same instructions for each student. However, this neglects the social fact of the classroom and the roles of each participant within this social system. Additionally, the same session performed by the same learner with different coaches may lead to different visualization results based on the preferred teaching style and response speed of the coach. Sessions and classroom management visualizations have to be analyzed keeping in mind the objective, automated nature of the tool in a highly subjective field. Another challenge is to highlight that LA is only supportive of reflection with the risk of creating an oversimplified understanding of teaching.

5.2. Future research

The next steps in advancing this work involve several areas of development. First, the clarity and usability of the current visualizations need refinement, incorporating user feedback to ensure they effectively represent the complex data. Enhancing usability for both learners and coaches is also critical for the long-term perspective of a standardised integration at different institutes and in various curricula.

Exploring alternative visualization techniques and integrating more personalized elements could further enhance their impact on learners or the reflection process.

Additionally, expanding the range of data sources is needed. Integrating other aspects, especially connected to classroom management (like the proximity to students, gestures, or very advanced concetps like sentiment analysis) would provide a more holistic evaluation.

Another innovative possibility is AI integration. This includes developing AI-driven models to simulate diverse and realistic student behaviours autonomously and reducing reliance on manual control by coaches. Incorporating adaptive AI systems to analyze the learner's performance could expand personalized feedback.

Broader user testing across diverse populations and contexts will help evaluate the system's generalizability and effectiveness. At the same time, longitudinal studies could assess the long-term impact of VR training on real-world classroom management skills. Finally, evaluating the learning outcomes of trainees who use this system will provide evidence of its effectiveness compared to traditional methods.

References

[1] F. Soheili, H. Alizadeh, J. M. Murphy, H. S. Bajestani, E. D. Ferguson, Teachers as Leaders: The Impact of Adler-Dreikurs Classroom Management Techniques on Students' Perceptions of the Classroom Environment and on Academic Achievement, The Journal of Individual Psychology 71 (2015) 440–461. URL: https://muse.jhu.edu/pub/15/article/609027, publisher: University of Texas Press.

[2] W. Doyle, Classroom management techniques and student discipline, ERIC: Instutue of Education Sciences (1986).

[3] W. Doyle, Ecological Approaches to Classroom Management, in: Handbook of Classroom Management: Research, Practice, and Contemporary Issues., Lawrence Erlbaum Associates Publishers, 2006, pp. 97–125.

[4] J. Kounin, Discipline and Group Management in Classrooms, Holt, Rinehart & Winston, New York, NY, 1970.

[5] J. S. Kounin, Techniken Der Klassenführung, Waxmann Verlag, 2006.

[6] C. Spoden, K. Fricke, Measurement of teachers' reactive, preventive and proactive classroom management skills by student ratings – Results from a two-level confirmatory factor analysis, Psychological Test and Assessment Modeling 60 (2018) 223–240.

[7] R. M. Oliver, D. J. Reschly, Effective Classroom Management: Teacher Preparation and Professional Development. TQ Connection Issue Paper., National comprehensive center for teacher quality (2007).

[8] A. Wiepke, B. Heinemann, U. Lucke, U. Schroeder, Jenseits des eigenen Klassenzimmers: Perspektiven & Weiterentwicklungen des VR-Classrooms., in: A. Kienle, A. Harrer, J. M. Haake, A. Lingnau (Eds.), DELFI 2021, Gesellschaft für Informatik e.V., Bonn, 2021, pp. 331–336.

[9] V. S. Pantelidis, Reasons to Use Virtual Reality in Education and Training Courses and a Model to Determine When to Use Virtual Reality, Themes in Science and Technology Education 2 (2009) 59–70.

[10] J. Martín-Gutiérrez, C. E. Mora, B. Añorbe-Díaz, A. González-Marrero, Virtual Technologies Trends in Education, Eurasia Journal of Mathematics, Science and Technology Education 13 (2017) 469–486. URL: https://www.ejmste.com/article/virtual-technologies-trends-in-education-4674. doi:10.12973/eurasia.2017.00626a, publisher: Modestum Publishing LTD.

[11] D. Baberowski, T. Leonhardt, L. Lilienthal, N. Bergner, Beyond Realism: Rethinking Presence in Virtual Environments for Abstract Concept Learning, in: Proceedings of DELFI 2024, Gesellschaft für Informatik e.V., Bonn, Germany, 2024, p. 10.18420/delfi2024_09. URL: https://dl.gi.de/handle/20.500.12116/44547. doi:10.18420/delfi2024_09.

[12] M. M. Asad, A. Naz, P. Churi, M. M. Tahanzadeh, Virtual Reality as Pedagogical Tool to Enhance Experiential Learning: A Systematic Literature Review, Education Research International 2021 (2021) 1–17. URL: https://www.hindawi.com/journals/edri/2021/7061623/. doi:10.1155/2021/7061623.

[13] J. Radianti, T. A. Majchrzak, J. Fromm, I. Wohlgenannt, A systematic review of immersive virtual

reality applications for higher education: Design elements, lessons learned, and research agenda, Computers & Education 147 (2020) 103778. URL: http://www.sciencedirect.com/science/article/pii/S0360131519303276. doi:10.1016/j.compedu.2019.103778.

[14] B. Wu, X. Yu, X. Gu, Effectiveness of immersive virtual reality using head-mounted displays on learning performance: A meta-analysis, British Journal of Educational Technology 51 (2020) 1991–2005. URL: https://onlinelibrary.wiley.com/doi/10.1111/bjet.13023. doi:10.1111/bjet.13023.

[15] B. Heinemann, U. Schroeder, Learning Analytics and Classroom Management in Specialized Environments: Enhancing the VR Classroom for CS Teacher Education, in: M.-L. Bourguet, J. M. Krüger, D. Pedrosa, A. Dengel, A. Peña-Rios, J. Richter (Eds.), Immersive Learning Research Network, Springer Nature Switzerland, Cham, 2024, pp. 37–52. doi:10.1007/978-3-031-47328-9_3.

[16] E. Bradley (Ed.), Games and Simulations in Teacher Education, Advances in Game-Based Learning, Springer International Publishing, Cham, 2020. doi:10.1007/978-3-030-44526-3.

[17] J.-L. Lugrin, M. E. Latoschik, M. Habel, D. Roth, C. Seufert, S. Grafe, Breaking Bad Behaviors: A New Tool for Learning Classroom Management Using Virtual Reality, Frontiers in ICT 3 (2016). doi:10.3389/fict.2016.00026.

[18] K. Vince Garland, D. Garland, TeachLivE™ and Teach Well: Simulations in Teacher Education, in: E. Bradley (Ed.), Games and Simulations in Teacher Education, Advances in Game-Based Learning, Springer International Publishing, Cham, 2020, pp. 183–195. URL: https://doi.org/10.1007/978-3-030-44526-3_13. doi:10.1007/978-3-030-44526-3_13.

[19] G. Siemens, What are Learning Analytics?, 2010. URL: http://web.archive.org/web/20180803152224/http://www.elearnspace.org/blog/2010/08/25/what-are-learning-analytics/.

[20] C. E. Wolff, H. P. A. Boshuizen, H. M. Jarodzka, Open Universiteit (Heerlen ; 2010- ...), Revisiting 'withitness': differences in teachers' representations, perceptions, and interpretations of classroom management, Ph.D. thesis, Open University of the Netherlands, Heerlen, 2016. OCLC: 940552792.

[21] M. Penn, U. Ramnarain, C. Van der Westhuizen, A. Ogegbo, N. Mdlalose, K. Pila, M. Hlosta, I. Moser, P. Bergamin, Evaluating Pre-service Teachers' Science Teaching Practices in a Virtual Reality Classroom Using a Learning Analytics Spectator View, in: Companion Proceedings 14th International Conference on Learning Analytics & Knowledge (LAK24), SOLAR, 2024. URL: https://www.solaresearch.org/wp-content/uploads/2024/03/LAK24_CompanionProceedings.pdf.

[22] M. Hlosta, I. Moser, P. Bergamin, U. Ramnarain, C. Van der Westhuizen, M. Penn, N. Mdlalose, K. Pila, O. Ayodele, Designing a Dashboard to Enhance Reflection of Microteaching in Multi-user Virtual Reality application for Pre-Service Teacher, in: Companion Proceedings 14th International Conference on Learning Analytics & Knowledge (LAK24), SOLAR, 2024.

[23] I. Moser, M. Hlosta, P. Bergamin, U. Ramnarain, C. Van der Westhuizen, M. Penn, N. Mdlalose, K. Pila, A. Ogegbo, Approximating eye gaze with head pose in a virtual reality microteaching scenario for pre-service teachers, in: Joint Proceedings of LAK 2024 Workshops, Kyoto, Japan, 2024.

[24] S. Görzen, B. Heinemann, U. Schroeder, Towards the automatization of integrating Learning Analytics into Virtual Reality using xAPI, in: Joint Proceedings of LAK 2024 Workshops, Kyoto, Japan, 2024.

[25] B. Laugwitz, T. Held, M. Schrepp, Construction and Evaluation of a User Experience Questionnaire, in: A. Holzinger (Ed.), HCI and Usability for Education and Work, volume 5298, Springer Berlin Heidelberg, Berlin, Heidelberg, 2008, pp. 63–76. doi:10.1007/978-3-540-89350-9_6.

[26] B. Heinemann, U. Schroeder, Learning Analytics zur Unterstützung der Reflexionskompetenz in der Lehrkräftebildung, in: Lernen:Digital - Digitale Transformation für Schule und Lehrkräftebildung gestalten, Potsdam, Germany, 2024. URL: https://publications.rwth-aachen.de/record/996103/files/996103.pdf.