Laidlaw Undergraduate Research and Leadership Programme Research Report

Title: Pre-service and in-service teachers' vocal, psychophysiological and self-reported responses to different 360-degree virtual classroom environments

Student: Wong Ming Wai Sophia, BSc(SLP)
Supervisor: Prof. Estella P.M. Ma

Abstract:
The application of virtual reality (VR) in speech therapy has been widely discussed, particularly in public speaking anxiety and voice. In Hong Kong, voice disorders are prevalent among teachers. This study serves as a preliminary probe into the potential of using VR in behavioural voice therapy for teachers, especially as a middle ground for generalising effective voicing techniques learnt from clinical environments to real-life classrooms. Research objectives of this study included: 1. To investigate the effects of different 360-degree VR classrooms with increasing levels of contextual distractions (student attentiveness, parent presence and attentiveness) on teachers' vocal (F0, intensity, shimmer, jitter, noise-to-harmonics ratio) and psychophysiological (pulse rate, oxygen saturation and self-reported vocal effort and emotions) performance, and 2. To compare the responses of teachers with varying lengths of teaching experience. Cantonese-speaking pre-service and in-service teachers (n = 8, mean age = 42.73, SD of age = 16.13) participated in this study. Participants completed a background questionnaire on teaching experience and self-report digital literacy, and attended an individual data collection session. During the lab session, participants viewed six 360-degree VR classrooms (with varying contextual distractions) in a randomised order while carrying out a mock lecture and undergoing voice recording and monitoring using photoplethysmographic finger oximetry. After viewing each classroom, participants completed self-report questionnaires regarding their vocal efforts and perceived emotional levels. Results showed huge individual variance, with no significant differences across classrooms. Qualitative feedback from participants indicated a large subjective influence, as well as inadequate immersiveness for some, due to a lack of interpersonal interaction caused by the pre-recorded nature of the VR classrooms. Further research may include a larger sample size, plus the incorporation of AI to create a more realistic environment with real-time interactions.

1. Introduction

Virtual reality (VR) technology has been widely discussed and considered as a new tool for therapy. This is because VR systems may provide interactive, 3-dimensional and reusable environments specific to the treatment, immensely helpful for therapy stimuli hard to recreate and control in real life (Šalkevicius et al., 2019). Currently, the application of VR in speech therapy has been investigated, with intervention for public speaking anxiety in particular (Atal & Kizilişikoğlu, 2022; Fehlmann et al., 2023; Reeves et al., 2021), with some employing voice analysis and circulatory system measurements as psychophysiological indicators (Aljabri et al, 2020; Barreda-Ángeles et al., 2019).

In Hong Kong, voice problems were one of the three major occupational health problems of teachers, which had been under long-term study (Chong & Chan, 2010). The first-line approach for treating voice problems in Hong Kong teachers is behavioural voice therapy, in which patients learn effective voicing techniques from speech-language pathologists. Since 360-degree VR in education could enhance various aspects such as learning, engagement, and emotions by providing immersive experiences (Pirker & Dengel, 2021), there is potential for VR to be used in behavioural voice therapy to help teachers generalise voicing techniques learnt in clinical environments, through simulations in virtual classrooms under the supervision and guidance of speech therapists, to application in real-life classrooms.

As a preliminary probe for using VR environments for voice assessment, training and skills generalisation for teachers, this study aimed to address the following research questions:
1. What are the effects of different 360-degree VR classrooms with increasing levels of contextual distractions on teachers' vocal and psychophysiological performance?
2. Are there any differences among the responses of teachers with varying lengths of teaching experience?

2. Hypotheses

In this study, there were three within-subject independent variables: 1. Virtual students' level of attentiveness (low and high), 2. Virtual parent attendance (presence and absence of parents in the classroom), and 3. Virtual parents' level of attentiveness (low and high). There was also a between-subject variable of teaching experience.

Although the effects of knowledge in classroom management and discipline strategies on teachers' work stress were found to be trivial, for teaching experience caused no significant difference in teachers' perceived stress levels (Chan et al, 2010; Wong et al., 2017), the combination and magnitude of distractions in the classroom might matter. Given that collaborating with parents, as well as managing student misbehaviour often caused substantial stress on many teachers (Pang, 2011), on top of that "being observed by colleagues, student teachers, college tutors, inspectors or parents" was among the top-five stressors among some schoolteachers (Wong et al., 2017, p. 7), it was hypothesised that, with the interaction effect between students' class performance and parents' attention on teachers, VR classrooms containing both misbehaving students and attentive, observing parents would cause the most anxiety among teachers, especially when classroom discipline was a major concern of many parents (Lewis, 1999).

Besides, teachers' familiarity with using VR might be an experiential factor influencing their emotional response, as the novelty of VR might lead to anxiety in first-time users, while repeated exposure to VR might result in progressive desensitisation to the immersiveness, building up users' tolerance or attenuating their responsiveness towards the stimuli (Regan, 1995). This could be explained as a manifestation of ICT (information and communication technology) anxiety (or computer anxiety), which was apparently inversely

correlated with digital literacy, for experienced computer users often had a more secure and positive view, and hence, less fear towards the usage of technology (Mac Callum et al., 2014). There were several underpinnings of computer anxiety, namely computer self-efficacy, which was negatively correlated with, and the most significantly impactful (Wilfong, 2006). Self-efficacy was an indispensable component of digital literacy, of which perception aligns with teachers' self-assessed level of digital literacy (Yang & Lou, 2024).

3. Methodology

3(a). Participants

Eight participants, including one Bachelor of Education (BEd) student and seven schoolteachers, were recruited through convenience sampling and mass email promotion.

Table 1. Profile of participants

Participant ID	Age (years) and gender	Teaching experience (years)	Occupation	Self-report digital literacy score (out of 35)
1	25.6, male	2	In-service Direct Subsidy Scheme primary school Science and STEAM teacher	25
2	60.8, male	37	In-service aided secondary school Physical Education teacher	8
3	53.9, female	30	In-service aided primary school Mathematics teacher	8
4	60, female	37	In-service aided primary school Chinese teacher	29
5	57.8, female	36	In-service aided primary school Chinese teacher	19
6	17.8, male	N/A	Pre-service teacher (BEd student majoring in Mathematics and Mathematics Education)	22
8	33.7, male	13	In-service government secondary school Chemistry teacher	23
11	32.3, male	5	In-service Direct Subsidy Scheme secondary school Mathematics teacher	29

The participants were further classified based on their formal teaching experience, so as to address our research question regarding the impact of teaching experience.

For a schoolteacher who has received a bachelor's degree and teaching training before being employed as a fresh graduate, their typical age of career commencement is around 23. While the official retirement age for schoolteachers is 60 (Education Department, HKSAR, 1999), the number of teachers leaving before retirement age was increasing (Research Office, Legislative Council Secretariat, HKSAR, 2024), and early retirement was becoming the norm. As such, the career span for a schoolteacher was estimated to be approximately 35 years. In order to compare teachers at the very beginning and the final few years of their

career, the groupings included: 1. Novice teachers (Participants 1, 6, 11, with formal teaching experience shorter than or equal to 5 years), 2. Intermediate-experience teachers (Participant 8, formal teaching experience between 6 and 29 years), and 3. Veteran teachers (Participants 2, 3, 4, 5, with formal teaching experience equal to or longer than 30 years).

3(b). Data Collection

Ethical approval had been obtained from the Human Research Ethics Committee, Faculty of Education, HKU (Reference number: EAU25091) prior to data collection. When signing up to join the experiment, the participants were invited to fill out a background questionnaire, from which information regarding multiple variables would be collected for moderator analysis. General information included the participants' age, gender, and their current school/work settings (teaching in primary/secondary schools, BEd programme institutions, etc).

There were three foci regarding the participants' background: 1. Their teaching experience (in years), and 2. Whether the school they taught at organised regular class observation activities for parents, for these two might lead to variation in their performance towards the virtual parents and students of different behavioural standards, given previous exposure; 3. Self-report digital literacy of teachers, which was assessed based on self-ratings of their knowledge towards a list of innovative teaching strategies (Zoom classes, flipped classrooms, gamification, 360-degree videos, Augmented Reality, Virtual Reality and Mixed Reality), derived from materials by the HKSAR Education Bureau (2024). From teachers' self-perceived digital literacy, we gauged their potential ICT anxiety, as well as readiness and acceptance of relatively newer or less common technological products, such as the VR device in this project.

After background information collection, one individual lab session was carried out with each participant at the Voice Research Lab, HKU.

During the lab session, first, the participants' baseline psychophysiological indicators, pulse rates and oxygen saturation (SpO2), were recorded by placing a Wellue FS20F fingertip photoplethysmographic oximeter on the participants' ring fingers of their non-dominant hands for around 2 minutes. Second, their baseline voice qualities (F0, intensity, shimmer, jitter, noise-to-harmonics ratio) were measured through a voice recording of them reading aloud a standardised paragraph "North Wind and the Sun" (Yiu & Chan, 2014) thrice, while the participants were instructed to use their typical teaching voice and tone, as if they were leading a class to read that story. The participants' voices were captured by a hand-held microphone, held in the participants' dominant hands, with a cotton swab stick that touched the participant's chin. This was to simulate teachers' day-to-day hand-held microphone use with a certain degree of freedom of body movement, for appropriate microphone use was a highly recommended practice among teachers for voice protection (Yiu & Chan, 2014), while maintaining a fixed microphone-to-mouth distance for amplitude calculation. Based on their feelings while reading aloud the standardised paragraph, the participants completed an 11-point OMNI scale (Van Leer & Van Mersbergen, 2016) to provide their baseline self-perceived vocal effort (0 = minimum vocal effort, 10 = maximum vocal effort).

With baseline data collection completed, participants proceeded to decide the VR classroom viewing order, which was randomised by the participants randomly drawing folded pieces of alphabet (A, B, C, D, E, F) paper without replacement.

There were 6 VR classroom settings included in this setup. To reduce sequential effects that might impact affective valence (Kosonogov, 2020), as well as to avoid giving hints to the teachers regarding the contents of each classroom, the VR classroom settings were coded with alphabets by increasing distraction levels as follows:
Classroom A – Attentive students, no parents
Classroom B – Inattentive students, no parents
Classroom C - Attentive students, inattentive parents
Classroom D - Attentive students, attentive parents
Classroom E - Inattentive students, inattentive parents
Classroom F – Inattentive students, attentive parents

After confirming the viewing order, the experimenter briefed the participants on the speaking task to be completed: When watching each VR classroom, the participants carried out 2 to 3 minutes of teaching, with whatever subject or topic preferred by the participants, best in the form of unidirectional introduction of new knowledge or concepts, with less classwork or interaction involved, as the classrooms were in the form of pre-recorded 360-degree videos, so the virtual students and parents could not offer real-time feedback. Such spontaneously produced content in these mock lecture tasks mimicked real-life situations, addressing the "not normally teaching" limitation in Rodríguez et al. (2024).

The participants then had a try with the Meta Quest 3 VR goggle and the AKG K612 Pro open headphone through a “Practice” 360-degree video to familiarise themselves with the operation of the VR goggle (opening, pausing and exiting the VR classrooms with their hands in the real trials) and adjust the volume of audio input delivered through the open headphone, which was to prevent VR classroom noises from leaking and interfering the voice recordings without causing accidental Lombard effect with echoes typical with the use of closed headphones.

When the participants were sufficiently familiar with the VR goggle and open headphones, the experimenter instructed the participants to take the hand-held microphone again in their dominant hands, placed the fingertip oximeter on their non-dominant ring fingers, and told them to open the first VR classroom and start teaching while the recording of their voice and psychophysiological indicators began. Upon reaching 2 to 3 minutes, the participants were stopped by the experimenter when they came to a prolonged pause or finished a sentence. Subsequently, the participants were instructed to exit the classroom, return to reality and remove the goggle and headphone. Referring to their experience in the VR classroom they just taught in, the participants completed two questionnaires - an 11-point OMNI scale (0 = minimum vocal effort, 10 = maximum vocal effort) for vocal effort needed to speak in that classroom, and a self-report emotion questionnaire on their emotional intensity experienced in that classroom, in 10-point scales (1 = minimal intensity, 10 = maximum intensity), especially on calmness, anxiety and fear (Aljabri et al, 2020; Atal & Kizilişikoğlu, 2022), plus any other emotions reported and rated by participants. This first formal trial of VR classroom viewing concluded with a 3-minute break for the participant to rest, because microbreaks could foster recovery from certain incivility-induced feelings, such as anger and frustration (Harrington, 2020), as well as mitigate stress from emotional labour, which was common when facing a crowd of possibly misbehaving students and parents. As the 3-minute break was over, the second trial began with the experimenter helping the participant put on the equipment, and restarting the voice and psychophysiological recording as the participant entered the second classroom to teach. The above procedures were repeated until all six trials were completed by the participant in the session.

After finishing the experiment session, the participants were offered an optional round of First Encounters, a single-person shooting game on the VR goggle, as compensation for their participation.

4. Results and Discussion

The data were analysed using Praat (Spectrogram settings: 0 to 14000 Hz), Microsoft Excel and SPSS.

The results are presented in the following line graphs. In Figures 1a to 9c, warm-coloured lines (reds and oranges) represent veteran teachers, cool-coloured lines (blues) represent novice teachers, and the grey line represents the intermediate-experience teacher. Results from all teachers are pooled together in Figures 10a to 10c.

Fig. 1a: Average F0 (Hz) by classroom

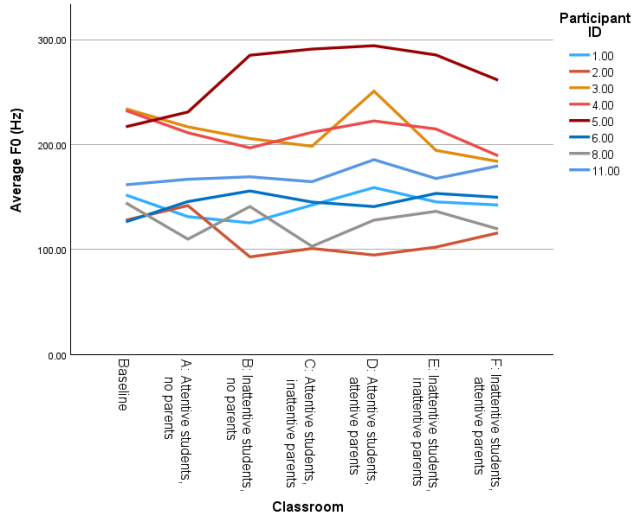


Fig. 1b: Minimum F0 (Hz) by classroom

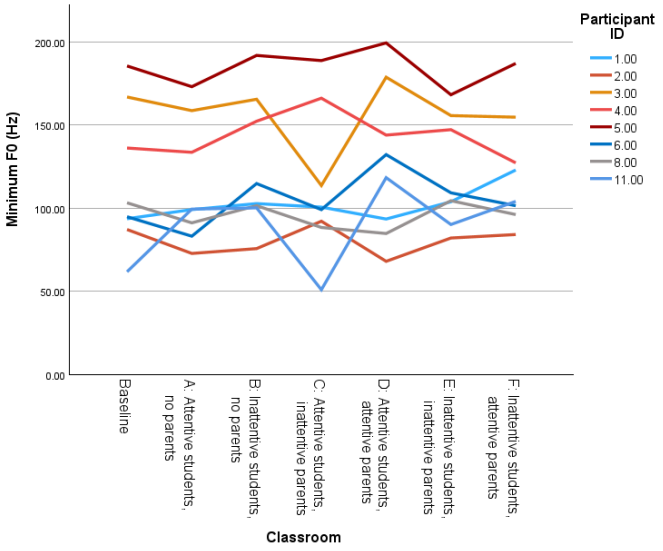


Fig. 1c: Maximum F0 (Hz) by classroom

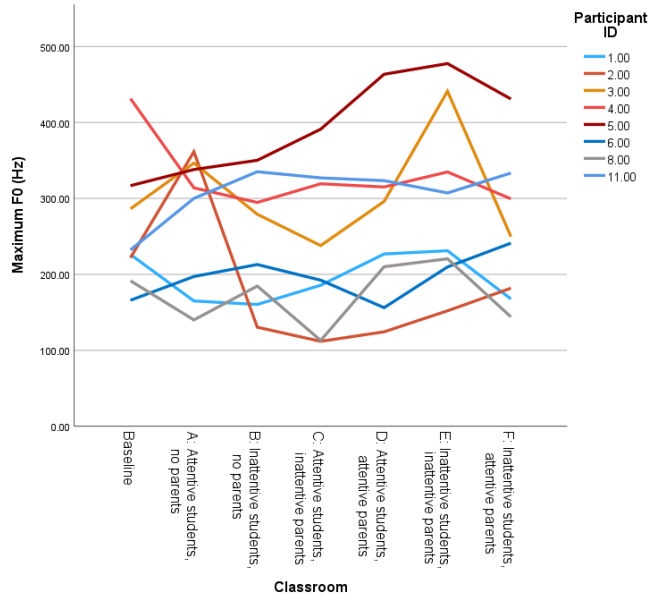


Fig. 2a: Average intensity (dB) by classroom

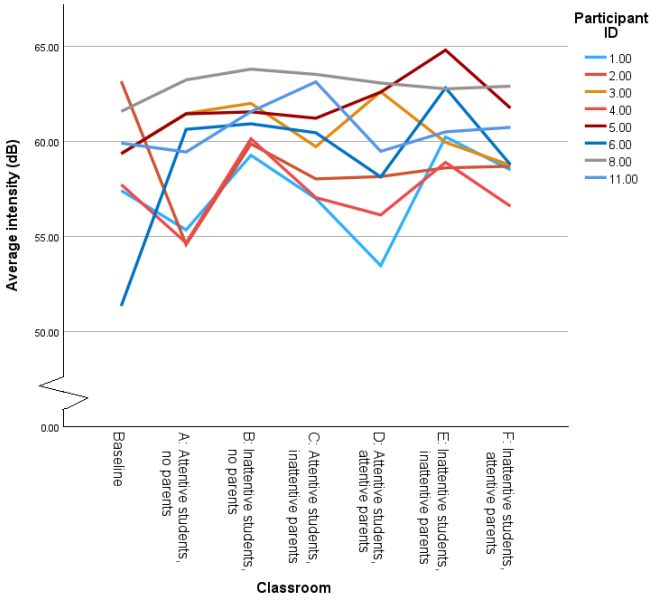


Fig. 2b: Maximum intensity (dB) by classroom

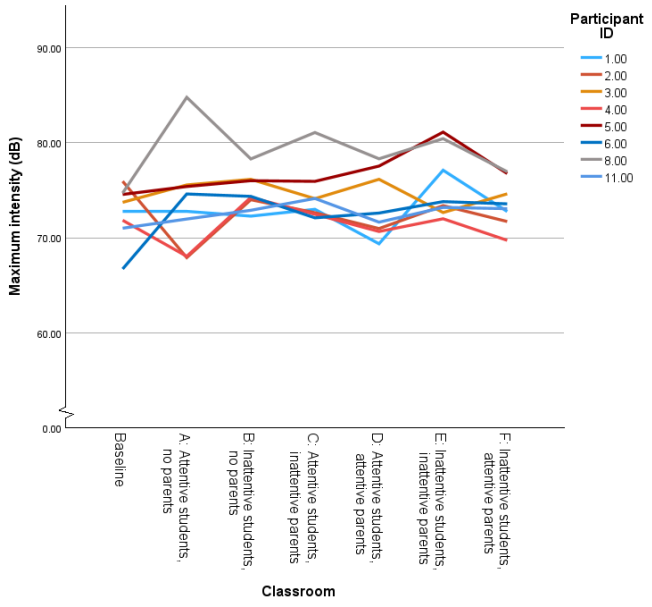


Fig. 3: Shimmer (%) by classroom

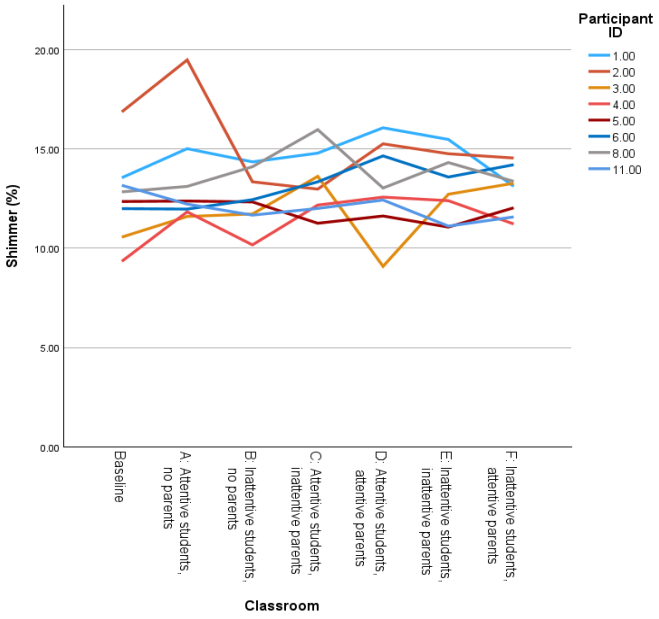


Fig. 4: Jitter (%) by classroom

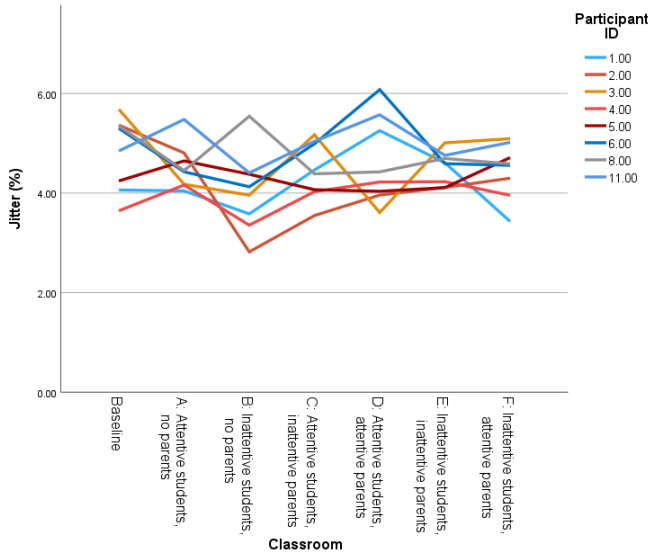


Fig. 5: Noise-to-harmonics ratio by classroom

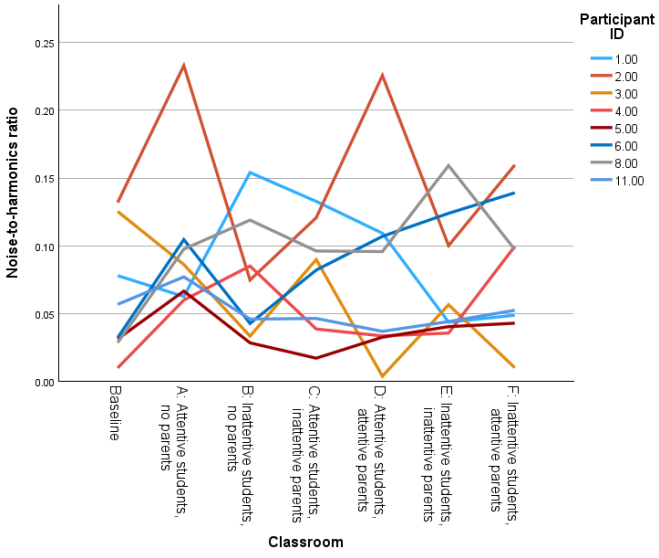


Fig. 6a: Average pulse (BPM) by classroom

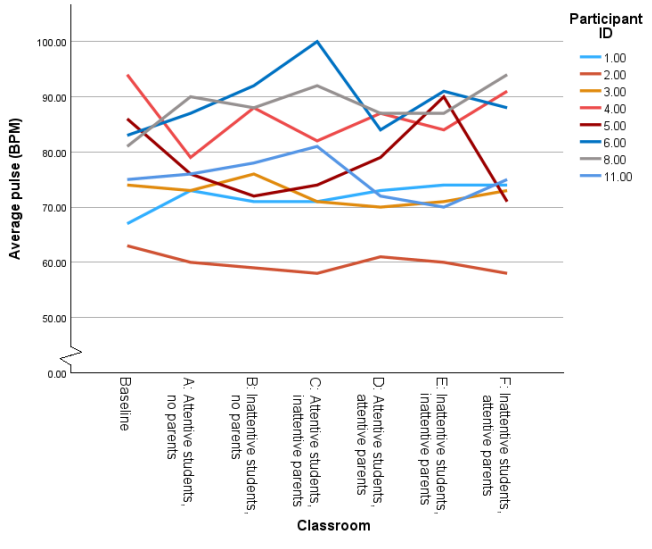


Fig. 6b: Minimum pulse (BPM) by classroom

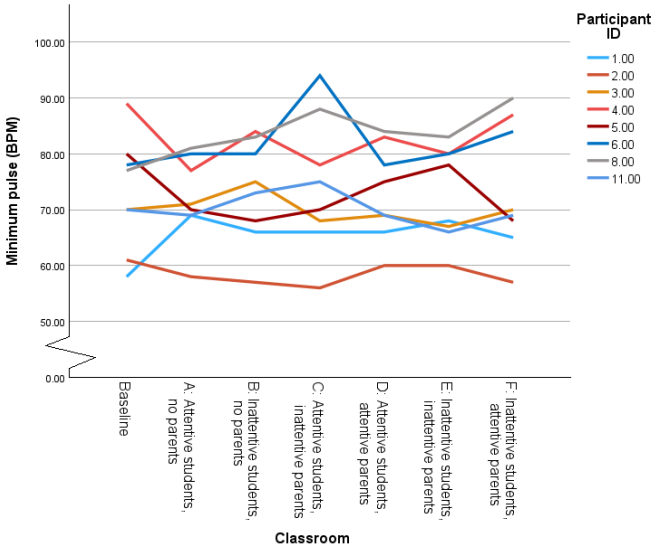


Fig. 6c: Maximum pulse (BPM) by classroom

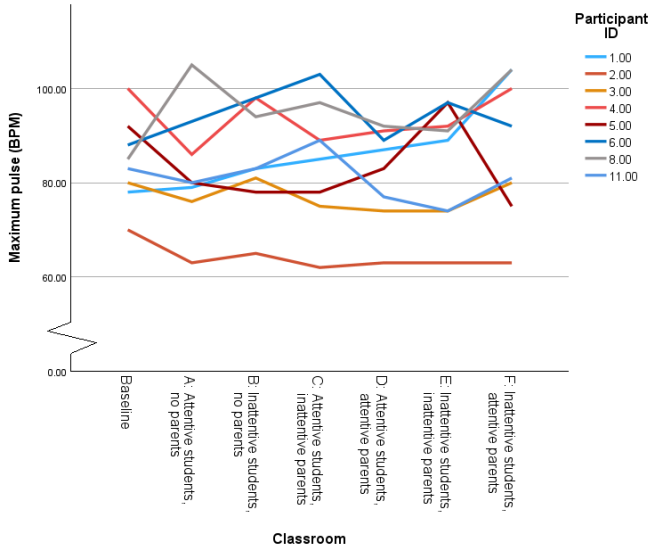


Fig. 7a: Average SpO2 (%) by classroom

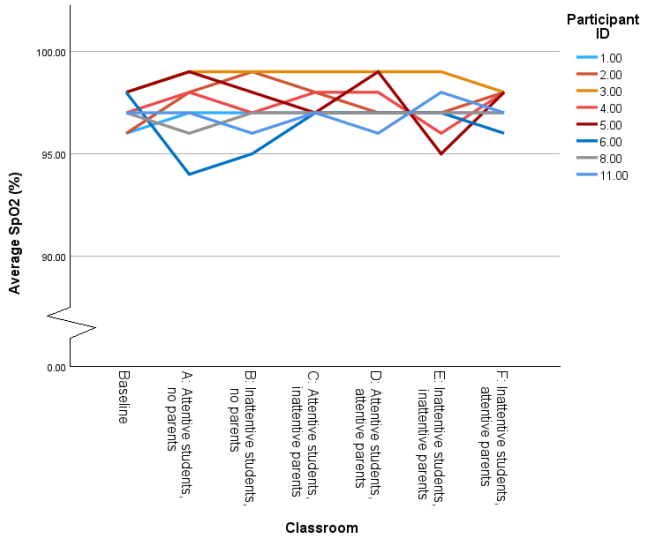


Fig. 7b: Minimum SpO2 (%) by classroom

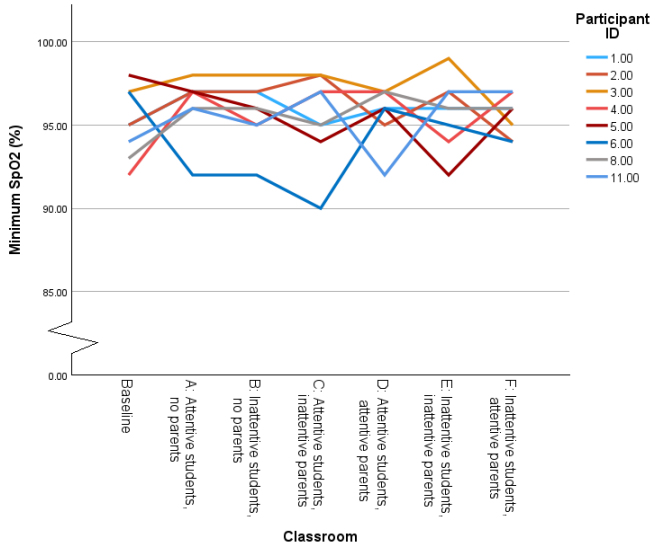


Fig. 7c: Maximum SpO2 (%) by classroom

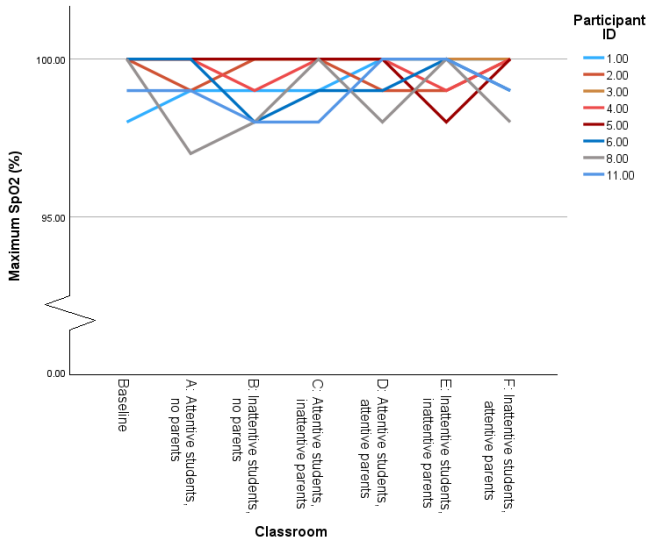


Fig. 8: OMNI scale rating by classroom

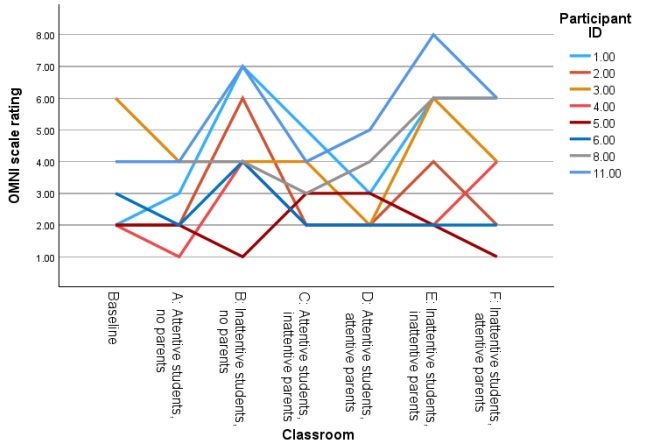


Fig. 9a: Calmness intensity by classroom

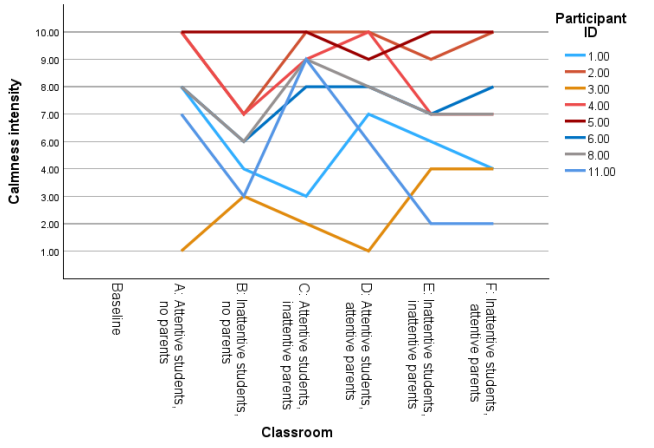


Fig. 9b: Anxiety intensity by classroom

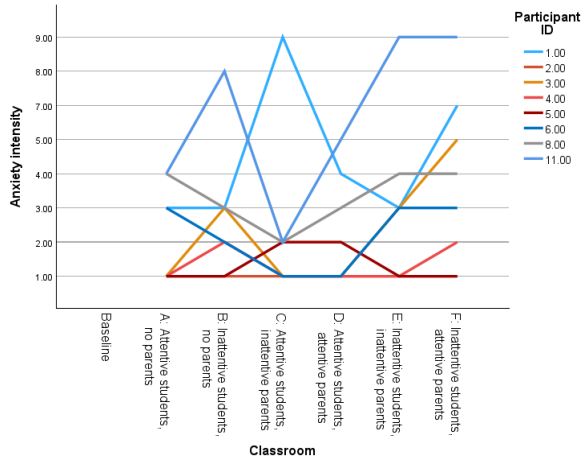


Fig. 9c: Fear intensity by classroom

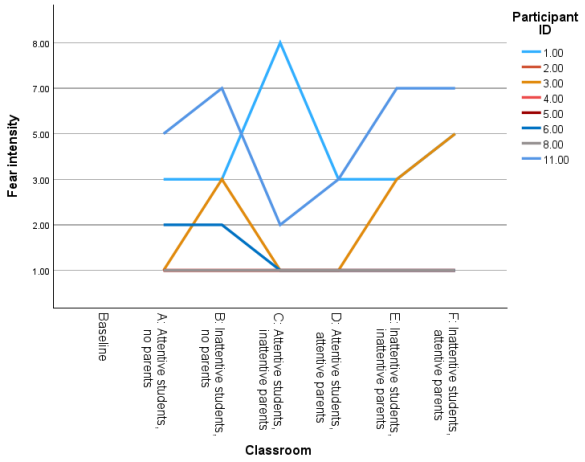


Fig. 10a: OMNI scale rating by calmness intensity

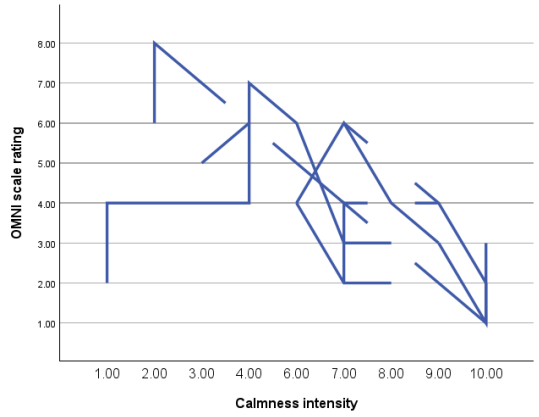


Fig. 10b: OMNI scale rating by anxiety intensity

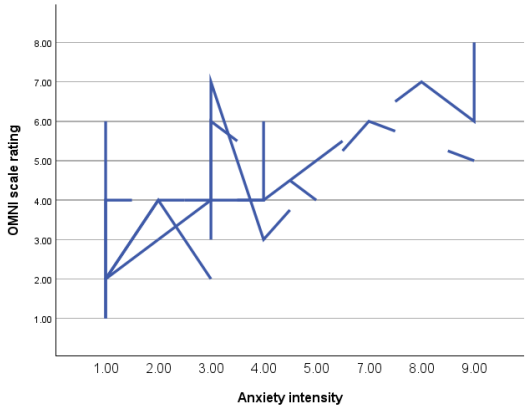
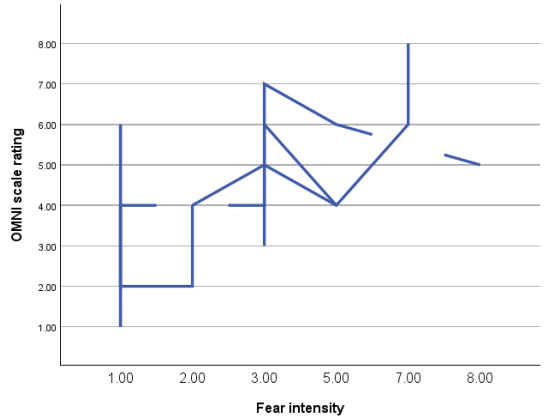


Fig. 10c: OMNI scale rating by fear intensity



Due to a small sample size and huge individual variance, especially in biological and raw acoustic data, major trends of objective data by classroom were hardly observed (Figures 1a to 9c). Nevertheless, a few trends in self-report data were identified. By visual analysis of Figures 9a, 9b and 9c, except Participant 3, veteran teachers exhibited more calmness, with less fear and anxiety, as well as more emotional stability, whereas novice teachers reported higher degrees of fear and anxiety, and lower degrees of calmness, with more fluctuations in intensity ratings. The intermediate experience teacher was sandwiched in between. This points to the fact that the longer the teaching experience, the less affective influence received from the VR classrooms in general.

Figures 10a, 10b and 10c presented correlations between subjective data. First, a strong negative correlation was observed between self-reported calmness intensity and vocal effort rated by OMNI scores (Spearman $\rho = -0.709$, p-value < 0.001). The calmer the teachers felt, the less vocal effort they experienced in a classroom. Second, a strong positive correlation was observed between self-reported anxiety intensity and vocal effort rated by OMNI scores (Spearman $\rho = 0.694$, p-value < 0.001). The more anxious the teachers felt, the greater the vocal effort they experienced in the classroom. Third, a moderate positive correlation was observed between self-reported fear intensity and vocal effort rated by OMNI scores (Spearman $\rho = 0.594$, p-value < 0.001). The more fearful the teachers felt, the greater the vocal effort they experienced in a classroom.

Assuming that high pulse rates are correlated with anxiety and stress (Trotman et al., 2019), only the maximum pulse rate of Participant 1 (Figure 6c) fully matched our hypothesis on the physiological and emotional impact of increasing distractions, as his pulse rate increased from baseline onwards and finally topping at classroom F (inattentive students, attentive parents), in which he reported embarrassment on top of heightened anxiety and fear as he felt being questioned by parents. In addition, participant 5 had maximum F0, average and maximum intensity (Figures 1c, 2a and 2b) rising from baseline to peaking at classroom E, indicating the hypothesised heightening of emotional activity, but dropping slightly at F, which deviated slightly from the predicted trend. She mentioned getting used to the sensation as she viewed classroom F last.

As seen from above, habituation, together with a sense of virtuality, might lead to reactions differing from actual classroom teaching. Apart from Participant 5, most veteran teachers mentioned becoming accustomed to the setup and not feeling much emotionally in the subsequent classrooms (Participants 2 and 3). Most veteran teachers, plus the BEd student, even explicitly said that they were not affected mainly due to knowing that the students were fake (Participants 2, 4, 5, 6), which also pointed towards the higher emotional stability in veteran teachers, as in Figures 9a, 9b and 9c. Furthermore, veteran teachers applying disciplinary measures (Participants 2, 4, 5) in classrooms containing inattentive students reported a lack of immersiveness due to the absence of interaction, as the 360-degree classroom videos were pre-recorded.

Overall qualitative feedback from participants indicated that subjectivity was a major cause of the variability. Teachers might notice details in the classroom, e.g. Participant 8 remarked that he was scared in the supposedly calming classroom A (attentive students, no parents), as the students were “eerily well-behaved”, a description echoed by Participants 6 and 11. Besides, Participant 1 was extremely aware of the parents taking photos in classroom C, which increased his anxiety and fear. Apart from having varying focuses on nuances, teachers assessed the situations differently. The binary levels of attentiveness were considered not contrastive enough, as even the behaviour of inattentive students was still deemed very orderly, as Participant 6 noted that they stayed quietly in their seats and did not bring about much disruption, while Participant 4 claimed that the students were clearly pretending to be naughty. On top of that, to some veteran teachers, parents as inspectors were not taken as a stressor, for Participant 3 stated that it would be more frightening if there were principals or mentors and lecturers from teacher-training institutions.

5. Conclusion

The analysis of vocal, psychophysiological, and self-report data from pre-service and in-service teachers doing mock lectures in 360-degree VR classrooms with different combinations and degrees of distractions revealed large individual variance, especially due to subjective influences. Despite an absence of significant differences in biology and acoustic data across classrooms, notable trends in self-report data were found, linking teaching experience with affective responses in VR classrooms, with greater emotional stability in veteran teachers, while elevated fear and anxiety were correlated with increased perceptual vocal effort.

Qualitative feedback from participants signified limitations of the setup, including the pre-recorded nature of the VR classrooms, and the insufficient contrast between variable levels, leading to awareness of the artificial settings, as well as inadequate immersiveness and stimulus strengths. Further research may incorporate a larger participant pool, in combination with artificial intelligence, to allow common classroom incidents and real-time teacher-student interactions, making the environment less static and more realistic.

6. References

Aljabri, A., Rashwan, D., Qasem, R., Fakeeh, R., Albeladi, R., & Sassi, N. (2020). Overcoming Speech Anxiety Using Virtual Reality with Voice and Heart Rate Analysis. 2020 13th International Conference on Developments in eSystems Engineering (DeSE), 311–316. https://doi.org/10.1109/dese51703.2020.9450783

Atal, D., & Kizilişikoğlu, G. (2022). Comparison of the anxiety levels of teacher candidates during actual and 360° video virtual reality presentations. Journal of Educational Technology and Online Learning, 5(4), 981–999. https://doi.org/10.31681/jetol.1164117

Barreda-Ángeles, M., Aleix-Guillaume, S., & Pereda-Baños, A. (2019). Users' psychophysiological, vocal, and self-reported responses to the apparent attitude of a virtual audience in stereoscopic 360°-video. *Virtual Reality, 24*(2), 289–302. https://doi.org/10.1007/s10055-019-00400-1

Chan, A. H. S., Chen, K., & Chong, E. Y. L. (2010). Self-reported Stress Problems among Teachers in Hong Kong. IAENG Transactions on Engineering Technologies Volume 5, Special Edition of the International MultiConference of Engineers and Computer Scientists 2010, 420–434. https://doi.org/10.1063/1.3510566

Chong, E. Y. L., & Chan, A. H. S. (2010). Subjective health complaints of teachers from primary and secondary schools in Hong Kong. *International Journal of Occupational Safety and Ergonomics, 16*(1), 23–39. https://doi.org/10.1080/10803548.2010.11076825

Education Bureau, HKSAR. (2024, December 17). IT in Education e-Leadership Series: e-Leadership Empowerment Workshop (EI0020230223 / EI0020230224): Examples and cases of school-based implementation plans for e-learning. Past Events of Commissioned Courses Offered by Tertiary Institutions / Professional Bodies - Education Bureau. Retrieved July 1, 2025, from https://www.edb.gov.hk/attachment/tc/edu-system/primary-secondary/applicable-to-primary-secondary/it-in-edu/rtc/202324/04_Examples%20and%20cases%20of%20school-based%20implementation%20plans%20for%20e-learning.pdf

Education Department, HKSAR. (1999, November). *Information Paper: Retirement of Teachers and Principals of Aided Schools*. Retrieved September 11, 2025, from https://www.legco.gov.hk/yr99-00/english/panels/ed/papers/ed0511_2.pdf

Fehlmann, B., Mueller, F. D., Wang, N., Ibach, M. K., Schlitt, T., Bentz, D., Zimmer, A., Papassotiropoulos, A., & De Quervain, D. J. (2023). Virtual reality gaze exposure treatment reduces state anxiety during public speaking in individuals with public speaking anxiety: A randomized controlled trial. *Journal of Affective Disorders Reports, 14*, 100627. https://doi.org/10.1016/j.jadr.2023.100627

Harrington, N. T. (2020). Rudeness and Recovery: The Effect of Micro-Breaks in Reducing Negative Consequences of Workplace Incivility. [PhD dissertation]. The University of North Carolina at Charlotte.

Kosonogov, V. (2020). The effects of the order of picture presentation on the subjective emotional evaluation of pictures. *Psicologia, 34*(2), 171–178. Https://doi.org/10.17575/psicologia.v34i2.1608

Lewis, R. (1999). Teachers Coping with the Stress of Classroom Discipline. *Social Psychology of Education, 3*, 155–171.

Mac Callum, K., Jeffrey, L., & Na, K. (2014). Factors impacting teachers' adoption of mobile learning. *Journal of Information Technology Education Research, 13*, 141–162. https://doi.org/10.28945/1970

Pang, I.-W. (2011). Teacher stress in working with challenging students in Hong Kong. *Educational Research for Policy and Practice, 11*(2), 119–139. https://doi.org/10.1007/s10671-011-9109-6

Pirker, J., & Dengel, A. (2021). The Potential of 360° Virtual Reality Videos and Real VR for Education - A Literature Review. *IEEE computer graphics and applications*, *41*(4), 76–89. https://doi.org/10.1109/MCG.2021.3067999

Reeves, R., Elliott, A., Curran, D., Dyer, K., & Hanna, D. (2021). 360° Video virtual reality exposure therapy for public speaking anxiety: A randomized controlled trial. *Journal of Anxiety Disorders, 83*, 102451. https://doi.org/10.1016/j.janxdis.2021.102451

Regan, E. (1995). Some evidence of adaptation to immersion in virtual reality. *Displays, 16*(3), 135–139. https://doi.org/10.1016/0141-9382(96)81213-3

Research Office, Legislative Council Secretariat, HKSAR. (2024). *Statistical Highlights: Manpower of teachers* (ISSH14/2024). The Legislative Council Commission. Retrieved September 11, 2025, from https://app7.legco.gov.hk/rpdb/en/uploads/2024/ISSH/ISSH14_2024_20240618_en.pdf

Rodríguez, D., Guzman, M., Brito, P., & Llorens, R. (2024). Ecological Validity of Self-Perceived Voice Quality and Acoustic Measures during Voice Assessments: An Observational Study on Faculty Teachers. *Journal of Speech Language and Hearing Research*, 1–13. https://doi.org/10.1044/2024_jslhr-24-00524

Šalkevicius, J., Damaševičius, R., Maskeliunas, R., & Laukienė, I. (2019). Anxiety level recognition for virtual reality therapy system using physiological signals. *Electronics, 8*(9), 1039. https://doi.org/10.3390/electronics8091039

Trotman, G. P., Van Zanten, J. J. C. S. V., Davies, J., Möller, C., Ginty, A. T., & Williams, S. E. (2019). Associations between heart rate, perceived heart rate, and anxiety during acute psychological stress. *Anxiety Stress & Coping, 32*(6), 711–727. https://doi.org/10.1080/10615806.2019.1648794

Van Leer, E., & Van Mersbergen, M. (2016). Using the Borg CR10 Physical Exertion Scale to measure patient-perceived vocal effort pre and post treatment. *Journal of Voice*, *31*(3), 389.e19-389.e25. https://doi.org/10.1016/j.jvoice.2016.09.023

Wong, M. W., Chik, M. P., & Chan, E. S. S. (2017). Stressors and stressor response levels of Hong Kong primary school music teachers. *International Journal of Music Education, 36*(1), 4–16. https://doi.org/10.1177/0255761417689923

Yiu, E., & Chan, K. (2014). *A Simple Guide To Better Voicing: For Teachers and Professional Voice Users* (3rd ed.) [E-book]. Voice Research Laboratory, Faculty of Education, The University of Hong Kong.