Using Fitbits and heart rate variance (HRVa) to understand preservice teacher experiences in extended reality

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Abstract
Extended reality (XR) is increasingly used to support preservice and inservice teacher training. Its use in teacher education has shown promise in improving future educators' engagement, self-confidence, and noticing skills. Despite this evidence, the field lacks innovative measures to assess outcomes such as those offered through biometric data collection. This article addresses this gap by presenting the findings of a study involving 18 PSTs, who watched a 360 video of an elementary classroom while their heart rate data was gathered. Heart rate variance (HRVa) was calculated and then compared with both their feelings of presence as measured by the eXtended Reality Presence Scale (XRPS; to measure immersion) and recordings of where they looked in the video (to measure engagement). Results indicated that higher HRVa scores meant more engagement. While presence was not significantly correlated, some XRPS items showed positive and negative relationships with HRVa scores. The findings have implications for both future research and for teacher education use of health measurement tools.

Keywords: extended reality, heart rate variance, presence, virtual reality, preservice teacher training

Introduction

Extended reality (XR) is a broad term used to define various applications of technology to represent real or imagined/created realities (Guo, Guo, Liu, 2021). This can include situations where the person is completely immersed in virtual experiences (VR), those that rely on an augmented overlay of technology on real-life experiences (AR), or some combination of both in a mixed format (MR). There has been a significant growth in the use of XR for educational purposes ranging from medicine (Morimoto et al., 2022) to learning mathematics (Lai & Cheong, 2022).

Teacher educators have also been exploring the use of XR for engaging both in-service and preservice teachers (Cherner & Fegley, 2022). For instance, researchers have explored the use of 360 video and its impact on teacher noticing (Ferdig & Kosko, 2020; Gandolfi, Ferdig, & Kosko, 2022; Kosko, Heisler, & Gandolfi, 2022; Roche et al., 2021). Others have examined virtual reality for the improvement of reflection (Richter et al., 2022).

While individual studies have shown both successes and failures, a larger question for teacher educators is how to measure the impact of extended realities. Most researchers have either adopted or adapted existing rubrics or constructs. For instance, some have examined realism compared to clinical internships (e.g., Lamb & Etopio, 2019) or the impact of VR on teacher self-efficacy (e.g., Gundel et al., 2019). Other educators have pushed beyond traditional constructs to create new instruments. Gandolfi, Kosko, & Ferdig (2021), for example, created the eXtended Reality Presence Scale (XRPS) to examine presence in preservice teachers as they watched 360 videos.

While these studies—as well as the use of existing or newly created constructs and instruments—are promising, most are also all based on self-reported measures. There are, of course, exceptions, particularly those related to eye tracking (Wang, 2022) and significant work in virtual reality with electroencephalograms (EEGs) (e.g., Baceviciute, Terkildsen, & Makransky, 2021; Tauscher et al., 2019). The field of teacher education, however, lacks rich technologies and techniques to be able to understand preservice and inservice teacher experiences with XR. The purpose of this study was to add to the field by examining the use of personal health tracking devices (e.g., Fitbits)—and, more specifically, heart rate variance—in understanding XR-related teacher education outcomes.

Conceptual Framework and Research Questions

Personal fitness tracking devices like the Fitbit (Diaz et al., 2015) monitor various health factors ranging from heart rate to oxygen levels, and from sleep duration to steps taken. Such devices have been used frequently in teacher education. Not surprisingly, much of this work has related either to physical education teacher preparation (e.g., Keating et al., 2018; Phelps et al., 2021) or to studies about student data collection that could inform teacher action (e.g., Lee et al., 2015; Mooses et al., 2018).

There has been work on health trackers and XR. Some of this work is related to gathering health data of users' engagement in or with VR (e.g., Birckhead et al., Chae et al., 2021). And while this is not the first study to use health trackers (or Fitbits) for teacher training, very few studies have explored the use of health trackers for XR-based teacher education outside of heart rate (e.g., Stavroulia et al., 2019).

This is an important gap in the literature because there are other data points collected by health trackers that could facilitate a deeper understanding of teacher preparation. One such measure is called heart rate variability (HRV). Heart rate variability, at its simplest definition, is "the variation in the time interval between consecutive heartbeats in milliseconds" (Hoffman, 2018, pp. 3). In medicine, some argue it is "the single most important predictor of those patients who are at high risk of sudden death or serious ventricular arrhythmias" (Malik & Camm, 1990, p. 570). Theoretically, HRV should go up during rest and should go down during stressful times. Thus, people who have consistently lower HRV rates might be considered chronically stressed.

Again, it should be clear that HRV would be lower during things like exercise; moreover, not all stress is bad (Dhabhar, 2019). A preservice teacher, for instance, might have lower HRV when first stepping in front of a classroom or when feeling present during a virtual reality experience. However, preservice teachers who stayed at stressful levels would produce lower HRVs that would be worthy of further exploration. Conversely, higher HRV might indicate a teacher being able to navigate the ebbs and flows of stress in a classroom; it may also help indicate when teachers were engaged with the content they were watching.

There were two research questions guiding this study:

1) Are teacher education participants with higher HRV scores also more engaged in the virtual reality experience?

2) Are teacher education participations with higher HRV scores more present in virtual reality experiences?

Methods

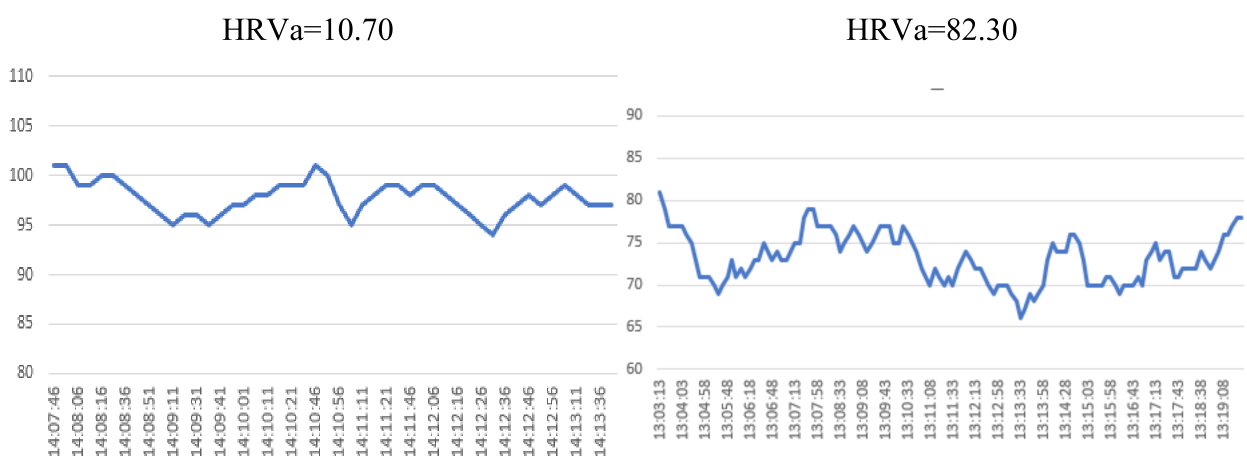
Data were collected from 18 preservice teachers enrolled at a university in the Midwest United States. Preservice teachers used Oculus Go headsets to watch a classroom recording of a 4th grade mathematics lesson (~6 minutes). The videos were 360 videos, which allowed the user to look around the classroom as they watched the lesson take place. Participants watched the video twice and wrote down what they noticed related to mathematics teaching and learning. They also marked a classroom map indicating where they focused their attention in the video. Throughout the duration of these experiences, they wore Fitbit Charge 5 devices that collected their heart rate approximately every two seconds. Finally, participants completed the XRPS (Gandolfi et al., 2021), a survey that attempted to measure presence felt in the interactions.

Results

There are questions as to whether devices like the Fitbit can truly measure HRV accurately (e.g., Chalmers et al., 2021). The more important challenge for teacher educators or TE researchers is that even if Fitbit data is a legitimate representation of HRV, it often requires users to wear devices for extended periods of time. This is a luxury many researchers do not have if they have limited interactions with participants. In consultation with cardiology staff from a partner hospital, heart rate *variance* (HRVa) rather than *variability* (HRV) was calculated from heart rate scores produced by the Fitbit. In this manner, less focus was put on the accuracy of the Fitbit and more emphasis was put on the high or low variance in the heart rate scores. The standard calculation for the standard deviation of normal-to-normal heat rate (SDNN) as well as example final scores of two teacher education students are included in Figure 1.

Figure 1: Heart rate data and HRVa for two participants during the VR experience.

$$SDNN = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N} RR_i - \bar{RR}^2}$$



The first research question examined the correlation between HRV (now HRVa) scores and engagement. Engagement here was measured by where participants reported that they looked in the classroom. Research has provided evidence that expert teachers tend to look at more students across the classroom, where novice teachers tend to keep their focus in one location—often in the direction of where the video started (Kosko, Ferdig, & Zolfaghari, 2021). In particular, with VR headsets, many novice teachers focus only on what is in front of them, and not at students behind them. Data results showed that there was a significant correlation (ρ=.509; p = .037) between HRVa scores and how many times the participants watching the video looked at the back tables in the video. In other words, the better the HRVa, the more likely participants were to look around the room in the video—a trait of expert teachers.

The second research question asked about the relationship between HRVa and presence using XRPS scores. The correlation was not statistically significant (ρ=.016; p = .951). Said differently, in this study, HRVa was not associated with how much presence was felt by the participants. However, recent scholarship suggest some subconstructs of the XRPS may associate with VR engagement differently (Gandolfi et al., 2021). In examining item-by-item correlations, there were several items that were more highly (>.3) and positively correlated with HRVa. There were also several items that were more highly (>.3) and negatively correlated.

- More than .3 correlated and positive between HRVa and:
  - i7 – While I was watching the video, I had a sense of "being there".
  - i9 - I felt part of the lesson as if I had been there in the classroom.
  - i12 - I felt immersed in the lesson.
  - i15 - I had a sense that I was in the classroom with the students, rather than watching a video of the students.
  - i19 - I had a sense that I was dealing with other people in the 360 video rather than just observing a recorded video.
  - I26 - I felt like what my eyes were seeing in the 360 video was the same as what my eyes would see if I were physically in the classroom.
  - i28 - I felt emotionally influenced by what was happening in the 360 video.

- More than .3 correlated and negative between HRVa and:
  - i11 - I felt that my actions could affect what was happening in the classroom.
  - i14 - I felt the people in the video were aware of my presence.
  - i16 – I felt that the people in the 360 video environment were aware of my presence.
  - i29 - Observing the 360 video was an emotional experience.

Implications

Biometric tools like EEG, eye tracking, and other health monitors might be able to positively influence both our understanding of teacher education and our ability to engage current and future teachers. They may also allow us to intervene earlier with students who post results abnormal to what we expect. This study set out to examine heart rate variance (HRVa) as an indicator of both engagement and presence.

Engagement was measured by correlating variability in where users looked in the video and HRVa scores. Results were highly and positively correlated, indicating that higher HRVa scores meant more engagement with the content in the video. Future research should replicate this work, particularly given the lower sample size. However, teacher educators could have future teachers wear Fitbits and use HRVa scores to determine if there were potential concerns moving forward. These concerns could obviously be health-related, but they could also indicate a preservice teacher who was overstressed by the learning environment.

Presence was measured by correlating XRPS and HRVa scores. The correlation coefficients were neither statistically meaningful nor significant. However, there were individual items that seemed to show positive or negative relationships. Future research should dive deeper into factors making up the XRPS to determine whether there is an emotional or stress-related aspect to presence that can be more sufficiently explained by HRVa scores. Teacher educators could then use that data to create more engaging extended reality TE projects.

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