More I-talk in student teachers' written reflections indicates higher stress during VR teaching

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ABSTRACT

Video-based reflection on one's own teaching represents a crucial tool in teacher education. When student teachers reflect on negative classroom events, it elicits "self-focused attention," which has been associated with more intense negative emotionality. Self-focused attention can be quantitatively captured using first-person singular pronouns ("I," "me," "my") in written reflections by, for instance, student teachers. What is unclear is whether student teachers' use of these first-person singular pronouns in their written reflections is linked to and predicts their negative affective experiences during teaching. For the present study, a fully immersive virtual reality (VR) classroom was implemented in which student teachers taught a lesson, provided written reflections on their teaching, and then taught a second lesson. We measured $N = 59$ student teachers' self-reported stress and heartrate responses while teaching in the VR classroom and determined the percentage of first-person singular pronouns in their written reflections. Firstly, our results showed that the use of first-person singular pronouns provides incremental information on manual ratings of student teachers' foci in their written reflections. Secondly, student teachers' heartrates during instruction—a measure of physiological stress—were associated with the use of first-person singular pronouns in subsequent written reflections. Thirdly, the use of first-person singular pronouns predicted the increase in physiological stress from the first to the second round of VR teaching. We discuss implications for automated feedback and for designing reflective tasks.

1. Introduction

Teaching is often seen as a challenging profession (Chang, 2009; Westphal et al., 2022; . The transition to school practice, at least when it takes place in real school classrooms, is especially demanding for student teachers[1] (Goddard et al., 2006; Hultell et al., 2013; Voss & Kunter, 2020). Fully immersive virtual reality (VR) classrooms provide a safe environment for student teachers to gain hands-on teaching experience (Gold & Windscheid, 2020; Lin, 2023; Lugrin et al., 2016; Pendergast et al., 2022; Remacle et al., 2023; Richter et al., 2022; Seufert et al., 2022). Ke and Xu (2020) suggested that active learning processes ("diving in") and reflective

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[1] In our study, the term "student teachers" refers to those prospective teachers who have not yet begun the supervised teaching portion of their teacher education program.

learning processes ("stepping out") can be easily combined in VR classrooms. Thus, it may be useful to practice reflecting on classroom situations from a more distanced perspective using VR classrooms early on in teacher education to help student teachers make a smooth transition into the classroom. Because the setting is standardized and similar for all student teachers, VR classrooms allow us to more accurately research the contributing factors and consequences of student teachers' self-reflection; the highly controllable setting increases the internal validity of research findings (Huang et al., 2021; Richter et al., 2022). This is of particular interest for research looking at the interrelationships between student teachers' affects in relation to their classroom experiences and their reflections upon those experiences. VR classrooms allow us, for instance, to apply a finding from experimental psychology to the field of teacher education. Research in the fields of experimental psychology and clinical psychology has shown that self-focus after negative events is accompanied by greater negative affect (e.g., Mor & Winquist, 2002). This finding has been explained by dysfunctional emotion-regulation strategies (e.g., Nook et al., 2017). Applied to the context of teacher education, these findings may imply that student teachers who are less skilled at transitioning between a more immersed perspective and a more distanced perspective on challenging classroom events may experience more negative affect. The degree of a person's self-focus can be determined based on the frequency with which they use first-person singular pronouns (e.g., "I," "me," "my"); this has also been called "I-talk" (Tackman et al., 2019). It would be highly relevant to examine this link between self-focused attention in written reflections—as reflected by more frequent I-talk—and negative affect during instruction in the field of teacher education, because knowledge about the link between the use of first-person singular pronouns and negative affect could be implemented in automated feedback systems to help identify student teachers at risk of intense stress and burnout, allowing them to be offered personalized feedback and support. To date, however, these questions have not been explored.

To examine whether student teachers' use of first-person singular pronouns is an indicator of the stress level they experience in the classroom, and whether it can predict changes in a student teachers' stress, a highly standardized teaching situation is preferable, because it ensures that all student teachers under study are reflecting on the same learning environment and on similar classroom events at all measurement occasions. A VR classroom creates just such a setting. In the present study, class size in the VR classroom was manipulated to induce higher levels of stress (large-class-size condition with a higher number of student avatars) and lower levels of stress (small-class-size condition with a lower number of student avatars). Initially, we checked whether the use of first-person pronouns in written reflections provides incremental information about subsequent manual ratings of student-teachers' foci (whether on their own actions vs. student actions vs. the learning environment) in these reflections. In addition, we examine whether student teachers who experience more self-reported stress and physiological stress (as measured by heartrate response) while teaching in a VR classroom use more first-person singular pronouns in written reflections on their teaching. We also explore whether student teachers' use of first-person singular pronouns in written reflections predicts the increase in stress in a subsequent VR lesson.

1.1. Reflection in teacher education: Technological advances

"Reflection" has been defined as "deliberate, purposeful, metacognitive thinking and/or action" (Košir et al., 2015, p. 113) that is believed to enhance instructional quality (Chernikova et al., 2020) by improving student teachers' "noticing" and "knowledge-based reasoning" (Stürmer et al., 2013; van Es & Sherin, 2008). Noticing is understood as a teachers' ability to focus their attention on relevant classroom events (van Es & Sherin, 2002). Knowledge-based reasoning is defined as teachers' ability to apply their professional knowledge in order to interpret these classroom events (Borko, 2004; van Es & Sherin, 2002). In teacher education programs, reflection is implemented in different ways, with student teachers reflecting on classroom videos of other teachers or on video recordings of their own teaching (Kleinknecht & Schneider, 2013). Technological advances have made it possible to design VR classrooms that student teachers experience as realistic and authentic classroom settings (Huang et al., 2021; Wiepke et al., 2019, allowing them to practice and subsequently reflect on video recordings of their own teaching. Beyond the practical advantages for student teacher education (e.g., the approval of students, parents, educators, and administrators is not required), an important benefit of VR classrooms is the standardized classroom setting in which all student teachers experience similar classroom events for which they can be prepared in advance. This enables teacher educators to more easily provide relevant professional knowledge tailored to managing critical classroom events in the VR classroom; when reflecting on video recordings of their own teaching in the VR setting, student teachers may thus be more able to apply relevant professional knowledge.

Video-based reflection generally involves written or oral reflections after viewing classroom videos; it is recommended that these reflections follow a three-step process (e.g., Prilop et al., 2021). Firstly, student teachers are instructed to describe the relevant classroom events; secondly, they are asked to evaluate and interpret these events; and, thirdly, they are required to identify alternative classroom behaviors (e.g., Prilop et al., 2021). When describing relevant classroom events, student teachers may focus either on their own actions, students' actions, or on the learning environment as a whole (Kleinknecht & Schneider, 2013; Lohse-Bossenz et al., 2019). Previous research has been resoundingly positive on the benefits of video-based reflection for student teachers' professional vision (e. g., Stürmer et al., 2013; Weber et al., 2020). Very few studies shed light on the affective experiences associated with video-based reflection (Kleinknecht, 2021). Although Kleinknecht and Schneider (2013) suggested that reflecting on other teachers' videos can induce more negative affect than reflecting on one's own teaching videos, several studies have shown that reflecting on one's own videos elicits intense emotional involvement (Borko et al., 2008; Seidel et al., 2011; Zhang et al., 2011). What is unclear, however, is to what extent student teachers' attentional focus (i.e., focusing on own thoughts, actions, or emotions) in the video-based reflection of their own videos relates to their experiences of negative affect or stress.

1.2. "I-talk" as a linguistic marker of self-focused attention and negative affect

In the fields of experimental psychology and clinical psychology, there is increasing empirical evidence indicating that there is a relationship between self-focused attention and greater negative affect (e.g., Mor & Winquist, 2002; Nook et al., 2017). For instance, studies using correlational designs showed that self-report measures of self-focus—such as the Public and Private Self-Consciousness Scale (Fenigstein et al., 1975), but also sentence completion tasks (Exner, 1973; Wegner & Giuliano, 1980)—are associated with self-report measures of state or trait negative affect in non-clinical and clinical samples (for an overview, see the meta-analysis by Mor & Winquist, 2002). Other studies showed that self-referential language (so-called "I-talk")—as a linguistic marker of an individual's self-focus—is associated with more intense negative emotionality in non-clinical samples (Kern et al., 2014; Mehl et al., 2006; Yarkoni, 2010; Yee et al., 2011; see also meta-analysis by Edwards & Holtzman, 2017) and is a marker of depression (Dunnack & Park, 2009; Rude et al., 2004; Zimmermann et al., 2016). An extensive multi-lab multi-language study with data from more than 4700 participants recently confirmed that the use of first-person singular pronouns is linked to more intense negative emotionality and depression (Tackman et al., 2019). The association between I-talk and depression has been explained to some extent by negative emotionality (Tackman et al., 2019). This indicates that "I-talk" might reflect a broader dispositional tendency towards feelings of distress, but "[t] his possibility is a topic of ongoing research" (Berry-Blunt et al., 2021, p. 5).

Although frequent I-talk is seen as maladaptive, it may be a way of processing negative affect (e.g., after receiving deprecatory information about oneself), as a recent literature review concluded (Berry-Blunt et al., 2021). This would suggest that greater negative affect provokes I-talk. Experimental research did not find any evidence that inducing negative affect by showing participants negative pictures led to more I-talk (e.g., Bernard, Baddeley, Rodriguez, & Burke, 2016). In line with Bernard, Baddeley, Rodriguez, and Burke (2016) suggestion, it may be the case that negative affect only leads to more I-talk when elicited by self-deprecating information. This proposition is consistent with research on the negative affective experiences of teasing and ostracism, which do lead to more frequent I-talk (Klauke et al., 2020; Kowalski, 2000).

The reverse may also be true, however. Taking a more distanced perspective—as indicated by less I-talk—may over time change an individual's dispositional negative emotionality (Berry-Blunt et al., 2021). Distancing, i.e., shifting one's perspective to be more "distant" from or less immersed in a negative event, is an adaptive emotion-regulation strategy that is characterized by a lower level of self-focused attention and can help reduce negative affect (Kross & Ayduk, 2008). The suggestion that repeated distancing may reduce an individual's tendency to experience negative affect (Berry-Blunt et al., 2021) would explain why I-talk predicts future depressive symptoms in patients (Dunnack & Park, 2009; Zimmermann et al., 2016). Even in the short term, less I-talk may lead to less negative affect: Experimental research confirmed that distancing—i.e., using no I-talk when talking about one's own emotions while preparing a stressful speech—can lessen negative affect after having given the speech (Kross et al., 2014, Study 3). Thus, the causal direction of the link between I-talk and negative emotionality is less clear, but there may be a bidirectional relationship.

1.3. Gender differences in the association between self-focus and negative affect

Based on meta-analytical findings that women exhibit a greater tendency to ruminatively self-focus than men when experiencing depression (Johnson & Whisman, 2013), it has been suggested that the positive association between negative emotionality and the use of first-person singular pronouns is larger for women than it is for men (e.g., Tackman et al., 2019). When examining these gender differences, Tackman et al. (2019) underlined that the use of first-person singular pronouns seems to be driven by low-arousal negative distress in women. In contrast, it appears that men's use of first-person singular pronouns is driven by high-arousal negative distress (Tackman et al., 2019). Thus, the use of first-person singular pronouns may be an indicator of different affective experiences in women and men (Fast & Funder, 2010) and, thus, gender should be taken into account when studying the relationship between self-focus and negative affect.

1.4. Distinguishing different forms of self-focus in written reflections

Different strands of research differ in their operationalization of self-focus. In research on reflection in teacher training, *manual ratings* indicate the extent to which student teachers focus on their own actions and thoughts, on students' actions, or on the learning environment (e.g., Kleinknecht & Schneider, 2013). In experimental psychology, self-focus is often operationalized via *the use of first-person singular pronouns* (Berry-Blunt et al., 2021; Mor & Winquist, 2002). This strand of research has argued that individuals can take a more or less immersed or distanced perspective on their *own* actions and thoughts by using more or fewer first-person singular pronouns (Kross & Ayduk, 2008; Kross et al., 2014). When reflecting on their own teaching, some student teachers may distance themselves from the experience and therefore rarely use first-person singular pronouns, while others may immerse themselves in the experience and use first-person singular pronouns more frequently. As such, both indicators of self-focus (qualitative ratings vs. first-person singular pronouns) should provide incremental information about student teachers' self-focus in their written reflections.

For student teachers taking a more immersive perspective on their own teaching, objective first-person singular pronouns (i.e., "me," "myself") may reflect a more dysfunctional form of self-focus than subjective first-person singular pronouns (i.e., "I") (Zimmermann et al., 2016). While subjective pronouns reflect an "active or self-as-actor form of self-focus," objective pronouns reflect a "passive or self-as-target form of self-focus" (James, 1890; Tackman et al., 2019, p. 819) that may indicate an even more detrimental style of processing self-relevant information (Zimmermann et al., 2016; see also more and less dysfunctional questions in Ehring, 2020). This poses the question of whether the relationship between the use of first-person pronouns and negative affect is driven mainly by objective first-person pronouns (Zimmermann et al., 2016). As such, "it is important to evaluate whether and how the

association between depression and I-talk varies as a function of first-person singular pronoun type" (Tackman et al., 2019, p. 819). Previous evidence on whether subjective and objective first-person pronouns differentially relate to negative affect is mixed (there is support in the study by Zimmermann et al., 2016; but no or inconsistent differences in the studies by Dunnack & Park, 2009; Tackman et al., 2019). But the distinction between subjective and objective first-person singular pronouns appears to be essential in our study, in which the relationship between the use of first-person pronouns and negative affect is examined for the first time in the context of teacher training.

1.5. Present study

Negative emotionality may be critical for student teachers when they reflect on their own teaching, yet research has rarely concentrated on the role of negative emotionality for reflective processes (Kleinknecht, 2021). Meanwhile, research in the field of experimental psychology indicates that negative affect may provoke self-focused attention as indicated by the use of first-person singular pronouns (Berry-Blunt et al., 2021). Moreover, self-focused attention may also increase the tendency towards experiencing negative affect (Berry-Blunt et al., 2021). What we do not know is whether this applies to the context of teacher education where student teachers reflect on their own teaching. Studying this link between self-focus and negative affect in the context of student teachers' written reflections can provide valuable cues for diagnostic tools, automated feedback systems, and the improvement of student teachers' professional self-regulation. We used a VR classroom setting, and thus a highly standardized teaching situation, to ensure that student teachers were reflecting on similar classroom events as we examined the following research questions:

(1) Do student teachers who exhibit a greater focus on their own actions (instead of students' actions or the classroom environment) use more subjective and objective first-person singular pronouns in written reflections on their teaching?

Here, the assumption could be that those student teachers who use subjective and objective first-person singular pronouns more frequently also tend to focus on themselves rather than on the students in class or on the classroom environment. However, there is no previous research combining manual ratings of student teachers' foci (whether on their own actions vs. student actions vs. the learning environment) with student teachers' subjective and objective use of first-person singular pronouns when reflecting on their own teaching. Thus, it is unclear to what extent manual ratings of student teachers' foci correspond to the subjective and objective use of first-person pronouns in written reflections on their teaching. We seek to address this research gap as an exploratory question.

(2) Do student teachers who experience more self-reported stress and physiological stress (as measured by heartrate response) while teaching in a VR classroom use more subjective and objective first-person singular pronouns in written reflections of their teaching?

Building on empirical evidence showing that negative affect may provoke self-focused attention, we analyze whether student teachers who experience higher levels of negative affect when teaching in the VR classroom more frequently use subjective and objective first-person singular pronouns in their written reflections. The class size in the VR classroom, i.e., the number of student avatars, was manipulated to evoke higher levels (large-class-size condition) and lower levels of negative affect (small-class-size condition) (Huang et al., 2022). We hypothesize that student teachers who experience more negative affect—operationalized via self-reported and physiological stress—when teaching in the VR classroom for the first time will use more subjective and objective first-person singular pronouns in their written reflections.

(3) Does student teachers' use of subjective and objective first-person singular pronouns in written reflections of their teaching predict their increase in stress in a subsequent VR lesson?

We postulate that student teachers who use more subjective and objective first-person singular pronouns in their written reflections will experience a greater increase in self-reported and physiological stress in the second VR classroom (as compared to the stress levels experienced when teaching in the VR classroom for the first time).

2. Material and methods

2.1. Sample and procedure

Participants were $N = 65$ student teachers enrolled at the University of (anonymized for review) in Germany. Four of the participating students did not hand in their written reflection and two additional students did not participate in the second VR practice session, limiting our analyses to $n = 59$ students. Student teachers were on average 24 years old ($SD = 4.57$) and 49% identified as female, 51% as male, none as diverse. Most students were third-year bachelor students (58%; second-year: 27%; fourth-year: 14%). These student teachers participated in a weekly seminar on classroom management. The seminar included two 10-min practice sessions in a VR classroom that took place two weeks apart. Both VR practice sessions followed a standardized procedure. Participants were first given a brief standardized audio introduction on how to interact with the VR environment. Participants were then given a brief lecture about an a priori determined topic in the VR classroom to deliver to avatar students. During the first VR teaching experience, participants taught about the US electoral system and the 2020 US election. For the second VR teaching experience,

participants taught about sustainability. All the instructional materials that participants needed to accomplish the teaching task were prepared and provided by the course instructor one week before the teaching exercise. During their VR teaching session, participants were exposed to various on-task and off-task behaviors from the avatar students, such as asking topic-related questions, chatting, or throwing paper balls. All avatar student actions were prescribed and therefore the same for all participants in both the class with 10 student avatars and the class with 30 student avatars. Immediately after their teaching experience in the VR classroom, the student teachers reported on their stress levels in an online questionnaire. In addition, the student teachers handed in a written reflection on their VR teaching session in the week following the first VR practice session.[2] Prior to writing their reflections, the student teachers received guidance on the three-step reflection process. In this process, they were instructed to describe three relevant classroom situations (Step 1), evaluate and interpret these situations based on their professional knowledge (Step 2), and outline alternatives for classroom situations that they evaluated negatively (Step 3). Before writing their reflections, student teachers were given time to repeatedly watch the video of the VR classroom situation in which they had taught.

2.2. Design of the VR classroom

The VR classroom was designed to resemble an upper secondary school classroom in Germany (e.g., Wiepke et al., 2021). It was set up with five rows and three columns of school desks and chairs with avatar students (see Appendix). Avatar students' names were displayed on name tags placed on their desks and had a wide range of physical characteristics, such as skin tone, hairstyle, and clothing.

Student teachers were randomly assigned to teach a class of either 10 or 30 student avatars when teaching the VR classroom for the first time and again when teaching it for the second time. The avatar students engaged in a range of behaviors that included both on-task and off-task actions. These actions ranged from constructive activities, such as writing in a notebook, to less productive actions, such as throwing a paper ball. The avatar students maintained a natural seated posture and a neutral demeanour, occasionally redirecting their attention by shifting their gaze or adjusting their body orientation in response to the participants' movements. The selection of off-task behaviors was based on a compilation of common disruptive behaviors documented in the academic literature (Borko, 2016; Wolff et al., 2016). All parameters governing the avatar students' behaviors, including initiation time, duration, spatial location, and behavior type, were carefully scripted to maintain uniformity across experimental conditions. This ensured that the behaviors enacted by the avatar students remained consistent between the scenarios with 10 avatar students and those with 30 avatar students in the classroom.

We were using the HTC VIVE headset which has a resolution of 1080 x 1200 pixels per eye with a 108° field of view and a refresh rate of 90 Hz. The headset was connected to a laptop (Alienware) with a 2.2-GHz Intel Core i7-8750H processor, with 16 GB of RAM, and a NVIDIA GeForce RTX 2060 with 6 GB of VRAM graphic card, where the VR classroom software was operated. Essentially, participants could move around in reality while experiencing multisensory feedback in the VR classroom. Previous studies have confirmed that the technical setup in our VR classroom created an immersive soundscape which student teachers experienced as realistic and authentic (Wiepke et al., 2019, 2021).

Student teachers were equally distributed across the four conditions (small class size VR1, small class size VR2: 21%; small class size VR1, large class size VR2: 23%; large class size VR1, small class size VR2: 25%; large class size VR1, large class size VR2: 28%).[3] Thus, some teachers taught under the same conditions twice, while other teachers taught one VR session in the small class size condition and the other VR session in the large class size condition. Student teachers teaching in the VR classroom were instructed to teach their lesson as they would in a real classroom i.e., walking around the room and using similar observational and nonverbal behavior when interacting with the avatar students as they would with non-virtual students.

2.3. Measures

2.3.1. Self-reported stress in the VR classroom

We measured the stress that student teachers experienced during the VR scenario using two items ("How tense did you feel in the VR classroom?" and "How did you feel emotionally during the VR classroom?"; e.g., Delaney & Brodie, 2000). Items were answered on a 9-point Likert-type scale ranging from 1 (*calm, relaxed, composed*) to 9 (*tense*). The internal consistency was good ($\alpha_{T1} = 0.83$; $\alpha_{T2} = 0.85$).

2.3.2. Physiological indicator of stress in the VR classroom

We operationalized student teachers' physiological stress reactions based on their heartrate (beats per minute, BPM). Student teachers' BPM was measured using an armband optical HR sensor (Polar OH1) at 0.3s intervals when teaching in the VR classroom. Prior to starting the VR scenarios, each student teachers' baseline heartrate was measured at 0.3s intervals while student teachers were asked to sit quietly and stay still. These baseline measures were used to control for individual differences in cardiovascular activity. We then aggregated both heartrate measurements during the baseline phase and heartrate measurements during the VR teaching. The differences between student teachers' heartrate during teaching and student teachers' baseline heartrate was used as a physiological

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[2] Students also reflected on the second VR classroom three months afterwards based on a video recording. Given the time span between this VR classroom and the written reflection, we didn't include these written reflections in our analyses.
[3] Percentages do not total 100 because of rounding.

indicator of student teachers' stress response.

2.3.3. Self-referential language

We used the R package stringr (Wickham, 2019) to estimate the frequency of subjective and objective first-person singular pronouns. For each written reflection, we computed the percentage of subjective first-person singular pronouns (German: "ich"; English: "I") and the percentage of objective first-person singular pronouns (German: "mich," "mir"; English: "me," "myself").[4]

2.3.4. Manual ratings of focus and depth in written reflections

Two independent raters manually rated the focus (as either student teachers' own actions, student avatars' actions, learning environment, or no focus) and depth (description, evaluating/explaining, or reflecting on alternatives) in student teachers' written reflections using the software MAXQDA and following the procedure of Lohse-Bossenz et al. (2019; Kleinknecht & Gröschner, 2016). Interrater agreement was good ($\kappa = 0.75$). For our analyses, we used the coverage percentage, i.e., the number of characters in the coded segment in relation to the total number of characters in the text.

2.4. Statistical analyses

To test the hypotheses, we conducted regression analyses using the R package MplusAutomation (Hallquist & Wiley, 2018) and MLR as the estimation method. A manipulation check on our data was conducted by Huang et al. (2022) who probed whether student teachers experienced more self-reported and physiological stress when teaching a VR classroom in the large-size condition than in the small-size condition. We initially examined whether student teachers who used more subjective and objective first-person singular pronouns focused more frequently on themselves rather than on the avatar students in class or on the classroom environment (RQ1). To do so, we distinguished between student teachers who used subjective first-person singular pronouns with low frequency (i.e., ≤ 0.5 *SD* below *M*), average frequency (≥ 0.5 *SD* below *M* and ≤ 0.5 *SD* above *M*), and high frequency (≥ 0.5 *SD* above *M*). A multivariate analysis of variance was conducted with the subjective use of first-person singular pronouns (low, average, or high) as the between-person factor and the relative frequency of the student teachers' reflection focus (the student teacher, student avatars, or learning environment) as the dependent variable. The analysis was then repeated for the objective use of first-person singular pronouns. To examine our second research question, we then regressed subjective and objective first-person singular pronoun use in the written reflections of the first VR classroom on self-reported stress in these VR sessions (RQ2). We controlled for gender.[5] Within this model, we allowed the use of subjective and objective first-person singular pronouns to correlate. We specified an analogous model with physiological stress as the predictor. In a second step, we regressed self-reported stress during the second VR classroom teaching session on the subjective and objective use of first-person singular pronouns while controlling for self-reported stress during the first VR classroom teaching session (RQ3). Gender and class size in the second VR classroom teaching session were used as covariates. Thus, regression coefficients of pronoun use and gender indicate whether these variables explain changes in self-reported stress in the second, as compared to the first, VR classroom teaching session. Analyses were conducted separately for the use of subjective and objective first-person singular pronouns to probe whether subjective and objective first-person pronouns differentially relate to negative affect (instead of examining incremental effects). Analogous models were computed for physiological stress. Due to technical difficulties when transferring the heartrate data onto the storage device, heartrate while teaching in the VR classroom was only available for 40 students. There were only 29 students for whom heartrate responses were present in both VR classrooms. We examined whether values were missing completely at random using the MCAR-Test (Little, 1988) implemented in the R package naniar (Tierney et al., 2021). The test yielded non-significant results ($\chi2 = 17.5$, $df = 25$, $p = 0.864$) indicating that the values were missing completely at random. We applied the full-information maximum-likelihood approach (FIML; Enders, 2001) to obtain appropriate estimates and standard errors.

3. Results

A manipulation check on our data (Huang et al., 2022) showed that student teachers experienced more self-reported and physiological stress when teaching a VR class in the large-size condition than in the small-size condition. Descriptive results (Table 1) and a dependent *t*-test showed that self-reported stress was greater in the first VR session than in the second VR session, $t(54) = 4.89$, $p < 0.001$. In contrast, physiological stress did not differ statistically significantly between the two VR sessions, $t(28) = 0.68$, $p = 0.503$.

3.1. Subjective and objective first-person singular pronouns and manual ratings of focus in written reflections

Pertaining to our first research question, we checked whether student teachers with a more frequent use of subjective and objective first-person singular pronouns focused more often on themselves rather than on the avatar students in class or on the classroom environment (Fig. 1a and b). A multivariate analysis of variance with the subjective use of first-person singular pronouns (low, average, or high) as a between-person factor and relative frequency of student teachers' focus of reflection on their own actions (as opposed to focus on student avatars or the learning environment) as a dependent variable showed no statistically significant effect, F(6,

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[4] The objective first-person singular pronoun "meiner" is rarely used and was not considered here—following the suggestion by Tackman et al. (2019)—because it overlaps with the more frequently used possessive pronoun "meiner".

[5] We did not look for interaction effects between the use of first-person singular pronouns and gender as our sample was small.

Table 1
Descriptive statistics.

	N	M	SD	Min	Max
Psychological stress VR1	58	5.22	1.70	2.00	9.00
Psychological stress VR2	55	3.97	1.78	1.50	9.00
Physiological stress VR1	40	60.36	22.25	21.56	108.38
Physiological stress VR2	46	56.88	24.40	7.86	97.90
Subjective pronouns VR1	59	3.61	2.16	0.00	9.18
Objective pronouns VR1	59	1.13	1.12	0.00	5.10

Note. Physiological stress = difference between heartrate (BPM) while teaching and baseline heartrate (BPM). Subjective pronouns = relative frequency of subjective first-person singular pronouns in written reflection. Objective pronouns = relative frequency of objective first-person singular pronouns in written reflection. Gender: 0 = female.

108) = 0.59, p = 0.74. Similarly, we found no statistically significant difference between students with low, average, or high frequency of the objective use of first-person singular pronouns on the relative frequency of student teachers' reflection being focused on their own actions, F(6, 108) = 1.18, p = 0.32. Thus, high subjective or objective first-person singular pronoun use was not reflected in a greater focus on student teachers' own actions in written reflections (as indicated by manual ratings).

3.2. Do student teachers who experience more stress in the VR session use more subjective and objective first-person singular pronouns in their written reflections?

To answer our second research question regarding the relationship between student teachers' stress in the VR session and the use of subjective and objective first-person singular pronouns, we conducted cross-sectional regression analyses. Our results showed that self-reported stress experienced during the first VR teaching session was not statistically significantly associated with the use of subjective and objective first-person singular pronouns (Table 2). Gender showed a statistically significant association with subjective and objective pronoun use, indicating that student teachers who identified as male used subjective and objective first-person singular pronouns more frequently than student teachers who identified as female. In contrast, physiological stress experienced during the first VR teaching session was statistically and positively associated with both the use of subjective and the use of objective first-person singular pronouns. Thus, student teachers who experienced greater physiological stress when teaching in the VR classroom used more subjective or objective first-person singular pronouns in their written reflections. Beyond physiological stress, associations between gender and the use of subjective or objective first-person pronouns were not statistically significant.

3.3. Do student teachers who use more subjective and objective first-person singular pronouns in their written reflections experience a greater increase in stress in the second VR session?

Concerning our third research question, we examined whether student teachers who used more subjective and objective first-person singular pronouns in their written reflection experienced a greater increase in stress in the second VR session. When regressing the self-reported stress that participants experienced during the second VR teaching session, the use of subjective first-person singular pronouns was not a statistically significant predictor when controlling for self-reported stress in the first VR teaching session, gender and class size during the second VR teaching session (Table 3, Model 3a). The use of objective first-person singular pronouns emerged as a statistically significant predictor of self-reported stress during the second VR teaching session (Table 3, Model 3b). This was not in line with our cross-sectional findings and we therefore conducted additional analyses, which revealed that the association between the use of objective first-person singular pronouns and self-reported stress was explained by the level of physiological stress in the first VR teaching session (Table A2 in Appendix). Concerning the covariates, gender and class size were not statistically significant predictors of self-reported stress in both models (Models 3a-b, Table 3). Associations between self-reported stress experienced in the first and in the second VR teaching session were statistically significant, indicating that student teachers who experienced more self-reported stress in the first VR teaching session reported more self-reported stress in the second VR teaching session.

Associations between physiological stress during the second VR teaching session and the use of subjective first-person singular pronouns were statistically significant when controlling for physiological stress experienced during the first VR teaching session and class size in the second VR session (Table 3, Model 4a). Thus, student teachers who used more subjective first-person singular pronouns in their written reflections of the first VR teaching session experienced a stronger increase in physiological stress during the second VR teaching session. We found no association between physiological stress during the second VR teaching session and the use of objective first-person singular pronouns (Table 3, Model 4b). Regarding the covariates, gender was not a statistically significant predictor of physiological stress in either model, while a greater class size for the second VR classroom was associated with greater physiological stress (Models 4a-b, Table 3). Student teachers who experienced greater physiological stress in the first VR teaching session exhibited more intense physiological stress in the second VR teaching session.

4. Discussion

Negative affect can play a crucial role in student teachers' reflection, but it has barely been studied (Kleinknecht, 2021). The
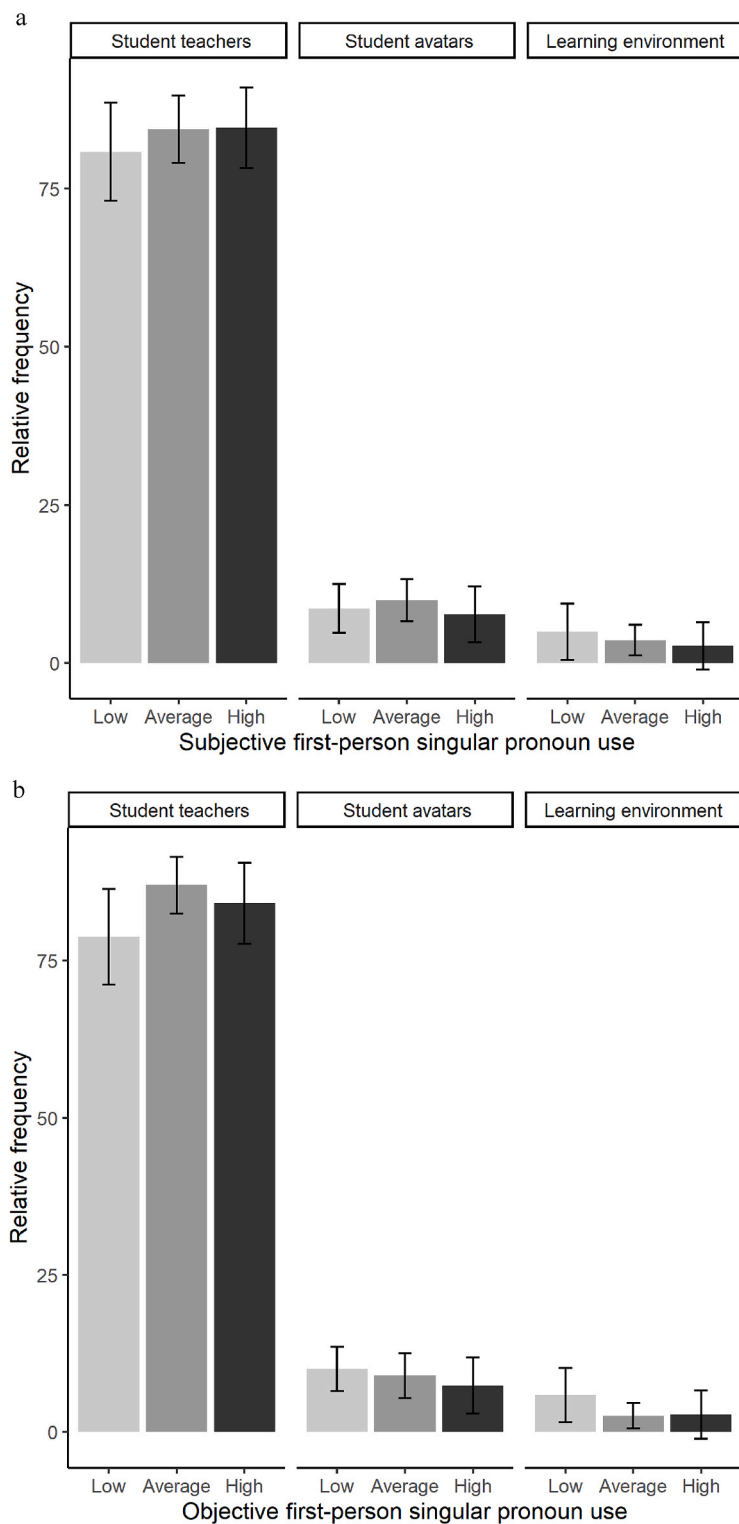
Fig. 1. a) Focus in written reflections from content analysis by use of subjective first-person singular pronouns *Note.* Low use of subjective first-person singular pronouns ≤0.5 *SD* below *M*. Average use of subjective first-person singular pronouns ≥0.5 *SD* below *M* and ≤0.5 *SD* above *M*. High use of subjective first-person singular pronouns ≥0.5 *SD* above *M*. b) Focus in written reflections from content analysis by use of objective first-person singular pronouns.

Table 2
Predicting first-person singular pronoun use in written reflection by self-reported and physiological stress in first VR teaching session.

	Subjective pronouns			Objective pronouns		
	β	p	95% CI	β	p	95% CI
Model 1						
Intercept	0.74	0.110	[-0.16, 1.65]	0.17	0.700	[-0.68, 1.02]
Self-reported stress	0.21	0.100	[-0.04, 0.45]	0.20	0.160	[-0.08, 0.47]
Gender	0.28*	0.020	[0.05, 0.51]	0.23*	0.040	[0.01, 0.45]
R^2		0.12			0.09	
Model 2						
Intercept	0.47	0.240	[-0.31, 1.24]	−0.06	0.850	[-0.66, 0.54]
Physiological stress	0.35***	0.000	[0.13, 0.57]	0.32*	0.010	[0.09, 0.55]
Gender	0.24	0.030	[0.02, 0.47]	0.20	0.110	[-0.04, 0.44]
R^2		0.18			0.14	

Note. Coefficients are standardized. Gender: 0 = female.

Table 3
Predicting self-reported and physiological stress in subsequent VR teaching session by use of first-person singular pronouns in written reflection of previous VR teaching session.

	β	p	95% CI	β	p	95% CI
Self-reported stress VR2		*Model 3a*			*Model 3b*	
Intercept	1.38*	0.020	[0.24, 2.52]	1.20*	0.040	[0.05, 2.34]
Self-rep. stress VR1	0.37***	<0.001	[0.12, 0.61]	0.33*	0.010	[0.10, 0.57]
Class size in VR2	−0.16	0.190	[-0.39, 0.08]	−0.10	0.410	[-0.35, 0.14]
Subj. pronouns VR1	0.06	0.650	[-0.22, 0.35]			
Obj. pronouns VR1				0.29*	0.030	[0.02, 0.55]
Gender	0.07	0.590	[-0.19, 0.34]	0.04	0.770	[-0.20, 0.27]
R^2		0.18			0.23	
Physiological stress VR2		*Model 4a*			*Model 4b*	
Intercept	−1.29***	<0.001	[-1.89, −0.69]	−1.17***	<0.001	[-1.74, −0.60]
Phys. stress VR1	0.26***	<0.001	[0.09, 0.42]	0.25***	<0.001	[0.09, 0.41]
Class size in VR2	0.83***	<0.001	[0.75, 0.92]	0.84***	<0.001	[0.75, 0.93]
Subj. pronouns VR1	0.18*	0.040	[0.01, 0.35]			
Obj. pronouns VR1				0.17	0.060	[-0.01, 0.35]
Gender	0.05	0.560	[-0.12, 0.22]	0.05	0.510	[-0.11, 0.21]
R^2		0.72			0.71	

Note. Coefficients are standardized. Gender: 0 = female. Class size: 0 = small.

present study applied psychological research on the relationship between negative affect and self-focus—which would potentially be valuable for diagnostic tools, automated feedback systems, and the improvement of emotion regulation—to the context of student teachers' reflections. Initially, we looked at whether student teachers who used more subjective and objective first-person singular pronouns focused more frequently on themselves rather than on the avatar students in the VR class or on the classroom environment as a whole. In addition, we examined whether student teachers' negative affect while teaching in a VR classroom—in terms of higher self-reported stress and heartrate—affected their self-focus in written reflections operationalized via the subjective and objective use of first-person singular pronouns. We also explored whether the use of subjective and objective first-person singular pronouns relates to stress in a subsequent teaching session in a VR classroom.

Initially, we found that there were no differences in manual ratings of focus between student teachers with a low, average, or high subjective or objective use of first-person singular pronouns. This is in line with findings illustrating that individuals can regard their *own* actions and thoughts from a more or less immersed or distanced standpoint, which is reflected in their more or less frequent use of subjective and objective first-person singular pronouns (Kross & Ayduk, 2008; Kross et al., 2014). While one student teacher, for instance, described classroom disruptions during his lesson from a more immersed perspective, pointing out how it made him feel ("Some classroom disturbances made me upset […]. The interruptions kept me from getting back to where I started and from finishing properly."), another student started his reflection by taking a more distanced perspective, describing his own actions from a third-person perspective ("There is a recurring loss of the common thread due to class disruptions and the teacher trying to address every minor disruption."). Thus, the use of subjective and objective first-person singular pronouns provides incremental information to manual ratings of focus in written reflections. Future research examining student teachers' focus when reflecting on their own teaching could therefore benefit from incorporating different measures of self-focus.

Our results also indicate that student teachers who experienced more physiological stress when teaching in the VR classroom used more subjective and objective first-person singular pronouns in their written reflections. This finding is consistent with research showing that negative affective experiences may provoke the use of subjective and objective first-person singular pronouns as a way to process negative self-relevant information (Berry-Blunt et al., 2021; Klauke et al., 2020; Kowalski, 2000). However, given their cross-sectional nature, our results could also indicate that student teachers who use less linguistic distancing—i.e., who are more immersed into a situation, indicated by a greater use of subjective and objective first-person singular pronouns—experience higher

levels of negative affect, which is also in line with previous findings (Shahane et al., 2023). Our study is the first to confirm that this association can be replicated in the context of student teachers' reflections on their own teaching. Our results further amplify existing research by revealing that this relationship generalizes to a physiological indicator of negative affect, namely to individuals' heartrates.

In terms of gender differences, our results suggested that student teachers who identified as male used more subjective and objective first-person singular pronouns than student teachers who identified as female. These gender differences disappeared when controlling for physiological stress experienced during the VR teaching session. The finding that men used subjective and objective first-person singular pronouns more frequently than women is not in line with related research that shows a greater tendency in women to ruminatively self-focus when depressed, and thus experiencing high levels of negative affect (Johnson & Whisman, 2013). It has, however, been suggested that men's use of subjective and objective first-person singular pronouns is an indicator of high-arousal negative distress, while women's use of first-person singular pronouns is driven by low-arousal negative distress (Tackman et al., 2019). In our study, student teachers were reflecting on a teaching situation that had the potential to elicit high-arousal negative distress. Indeed, we found that, when controlling for physiological stress experienced during the VR session, gender differences in the use of subjective and objective first-person singular pronouns disappeared. These results further support the notion that the use of first-person singular pronouns may be an indicator of different affective experiences in women and men (Fast & Funder, 2010).

In addition, we found that greater use of subjective first-person singular pronouns led to higher physiological stress in the subsequent VR session. Thus, we found some indication that student teachers who took a more distanced perspective experienced reduced future stress (as suggested by Berry-Blunt et al., 2021; Zimmermann et al., 2016). This is in line with research showing that individuals who spontaneously use more linguistic distancing when reflecting on negative and positive events report lower levels of stress in these and in subsequent situations, and overall greater well-being (Shahane et al., 2023). Despite the fact that the use of subjective and objective first-person singular pronouns may be a strategy that student teachers use to process negative teaching experiences, this strategy—referred to as rumination—is considered maladaptive (e.g., Mor & Winquist, 2002). Rumination—i.e., the strategy of regulating negative mood by repeatedly focusing one's attention on one's own negative experiences, and the causes and effects (Nolen-Hoksema, 1991)—has been associated with depression (Hong, 2007), inefficient problem-solving, and lower self-efficacy (Lyubomirsky et al., 2003; Reindl et al., 2020). Teachers who ruminate more experience higher levels of stress in the classroom and are more susceptible to burnout (Košir et al., 2015). We assessed naturally occurring differences in the use of subjective and objective first-person singular pronouns and may therefore have underestimated the benefits of taking a more distanced perspective. Future studies with greater sample sizes and power should aim to explore whether a similar effect might emerge for objective first-person pronouns, for which we found a marginally significant *p*-value.

In contrast, our data did not support the association between self-reported negative affect and the use of subjective and objective first-person singular pronouns. Berry-Blunt et al. (2021) proposed that some psychometric units, i.e., "facets, nuances, and items" (p. 8) might capture I-talk better than others; our self-report measure of stress may not have been ideal in this respect. Moreover, the self-report was assessed after the VR session, which potentially led to lower congruence between physiological and self-reported stress responses than when self-report is assessed continuously during the stressful situation (Campbell & Ehlert, 2012).

4.1. Pedagogical implications

While reflection can improve student teachers' professional vision, and is therefore seen as an important tool in teacher education (e.g., Stürmer et al., 2013; Weber et al., 2020), less is known about its potential to assist adaptive emotion regulation strategies that teachers need in order to be able to cope with challenging classroom events (Chang, 2009). Reappraising a challenging situation is seen as an effective strategy (Gross, 2002) by which teachers change how they think about an event and thereby decrease its emotional impact (Chang, 2009; Gross, 2022). When engaging in reappraisal, teachers may reduce their use of first-person singular pronouns, indicating their greater psychological distance to a challenging situation (Nook et al., 2020). Our findings indicate that an increased self-focus in student teachers' written reflections—as indicated by a more frequent use of subjective first-person singular pronouns—is associated with greater physiological stress. Automated feedback systems could build on this finding by identifying student teachers who repeatedly experience elevated stress and are thus at risk for depression and burnout. This could complement feedback on the quality of their written reflections (Wulff et al., 2022, 2023). We found some indication that taking a more distanced perspective—as indicated by less frequent use of subjective first-person pronouns—reduces future stress (as suggested by Berry-Blunt et al., 2021; Shahane et al., 2023; Zimmermann et al., 2016). Practicing taking a more distanced perspective on negative events is not only seen as an adaptive emotion-regulation strategy (Kross & Ayduk, 2008), it may over time change a student teacher's tendency to experience stress (for a similar suggestion outside the context of teacher education, see Berry-Blunt et al., 2021). A structured practice of reappraisal can facilitate adaptive emotion regulation (Christou-Champi et al., 2015). Thus, training student teachers to use more reappraisal and put more distance between themselves and challenging classroom situations when reflecting on their teaching could be a viable strategy to help them cope with stress. In addition, Ehring (2020) suggests that ruminative thinking, i.e., focusing one's attention on one's own negative experiences, can be transformed into more adaptive information processing by focusing attention on physical reactions and emotions in a specific situation and fostering self-compassion, which has been shown to be incompatible with ruminative thinking (Watkins, 2016). Combining video-based reflection on one's own teaching with reappraisal and mindfulness-based strategies could be a promising way to foster student teachers' professional vision, as well as their well-being and stress-resistance.

4.2. Limitations and future research

The current study has some limitations. The sample size of the study was small. Our results should therefore be replicated using a larger sample, which could more effectively detect small effects. By providing a highly standardized setting, the VR classroom increases the internal validity of our research findings, which may come at the cost of ecological validity. It has been argued that VR creates a perceptual illusion and "the real power of VR […] [is that] even though you know it is an illusion, this does not change your perception or your response to it" (Slater, 2018, p. 2). Some features of the VR environment, such as a realistic display of the environment, a smooth display of motion and view changes, and control of behaviors, are seen as essential to increase the likelihood of optimal learning in VR (Dalgarno & Lee, 2010; Delamarre et al., 2021). Prior studies showed that student teachers perceived our VR classroom as realistic and authentic (Wiepke et al., 2019, 2021). Student teachers trained in our VR classroom showed similar reflection processes compared to students reflecting on real classroom videos and showed a substantial increase in reflection-related self-efficacy over time (Richter et al., 2022). Nevertheless, more validation studies are needed to evaluate the transferability of the positive results of the participation in a VR learning setting to authentic classrooms. Moreover, future studies should investigate whether our findings are generalizable to non-virtual classroom environments and to in-service teachers. Studies should also incorporate further self-report measures of negative affect to "identify […] the smaller psychometric units (e.g., trait facets, nuances, and items) that best capture I-talk" (Berry-Blunt et al., 2021, p. 8). To better understand the temporal dynamics between negative affect and self-focused attention, a longitudinal study with multiple measurements is necessary. Such a study design could help explain the extent to which situation-specific and personal characteristics play a role in the interplay between the use of subjective and objective first-person singular pronouns and negative affect. The extent to which student teachers can be trained to more professionally process negative events could be explored by experimentally manipulating the ways in which student teachers describe and evaluate negative classroom events—taking either a distanced or a self-immersed perspective—by prompting student teachers to use distanced vs. self-referential language or by instructing them to reframe negative events vs. self-immerse in their emotions (see also Nook et al., 2017). Intervention studies could be a promising approach to help identify how reflection could be implemented in a way that is beneficial for student teachers' professional vision and their emotion regulation, without overwhelming them.

5. Conclusions

Thanks to a standardized VR classroom environment, our study is the first to provide evidence that student teachers' self-focus in their written reflections is linked to the stress they experience while teaching. Our multimodal assessment of stress—based on student teachers' self-reports and heartrate responses—allowed for a differentiated approach to studying emotions in the VR learning environment. Not only can we show that the association between negative affect and self-focus—measured via I-talk—holds in student teachers' written reflections on their own teaching, but our study also adds to previous findings by showing that this link can be generalized to individuals' heartrates, representing a physiological indicator of negative affect. These results point to the potential that reflecting on one's own teaching may have for practicing adaptive emotion regulation strategies in teacher education programs.

Credit author statement

AW: Conceptualization. Formal analysis. Writing – original draft, Reviewing and Editing, ER: Conceptualization. Investigation. Data curation. Project administration. Writing- Reviewing and Editing, RL: Writing- Reviewing and Editing, YH: Investigation, Project administration.

Declaration of competing interest

None.

Data availability

The authors do not have permission to share data.

APPENDIX

Table A.1
Descriptive statistics for baseline heartrate and heartrate in VR teaching session

	N	M	SD	Min	Max
Baseline BPM T1	42	96.92	30.88	44.41	173.62
Baseline BPM T2	50	102.37	30.03	40.34	175.88
BPM in VR session T1	57	161.14	20.44	125.02	196.45
BPM in VR session T2	55	160.65	20.00	115.57	196.59

Note. Measures used to compute physiological stress, i.e., difference in heartrate between baseline and VR session.

Table A.2

Predicting self-reported stress in subsequent VR teaching session by physiological stress and use of first-person singular pronouns in written reflection of previous VR teaching session

	β	p	95% CI
Self-reported stress VR2	*Model 5a*		
Intercept	0.39	0.560	[-0.93, 1.71]
Self-reported stress VR1	0.31*	0.010	[0.06, 0.55]
Physiological stress VR1	0.29*	0.040	[0.01, 0.57]
Class size in VR2	−0.06	0.640	[-0.31, 0.19]
Objective pronouns VR1	0.24	0.110	[-0.05, 0.54]
Gender	0.06	0.620	[-0.18, 0.30]
R^2		0.28	

Note. Coefficients are standardized. Gender: 0 = female. Class size: 0 = small.

Fig. A1. VR Classroom from the perspective of student teachers.

Fig. A.2. Student teacher teaching in VR Classroom.

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