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Mediating and perspective-taking manipulatives: Fostering dynamic perspective-taking by mediating dialogic thinking and bolstering empathy in role-play and reflection for microteaching

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Abstract

This study examined microteaching using computer-supported collaborative learning (CSCL) to assist student teachers in anticipating student voices and achieving authentic role-play. To achieve this, the design had two manipulatives: tangible puppets as "mediating manipulatives" that allow student teachers to elicit a variety of imaginary student voices in microteaching role-plays and three-dimensional animations as "perspective-taking manipulatives" that allow student teachers to dynamically switch viewpoints in reflection. This study aims to investigate how the combination of mediating and perspective-taking manipulatives helps student teachers foster the perspective-taking of imaginary students in their microteaching role-playing and reflection. We employed epistemic network analysis (ENA) to analyze discourse data collected both in the microteaching performances (including the tangible puppetry microteaching) and in the reflections. The results showed that the combination of the two manipulatives was effective for achieving the immediate transfer of imaginary students' perspectives. Further qualitative analysis enabled by ENA indicated that the perspective-taking manipulatives were effective in bolstering perspective-taking due to the nonverbal aspects of students' voices enacted in the role-play performances.

Keywords Perspective-taking · Role-play · Microteaching · Preservice teacher education · Tangible puppetry · 3D manipulable animation

Introduction

The present study addresses the use of computer-supported collaborative learning (CSCL) to improve microteaching. Microteaching is a worldwide form of teaching simulation used in the initial stage of professional development, enabling student or novice teachers to

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practice dialogic pedagogy (Amobi, 2005; I'Anson et al., 2010; Lee & Wu, 2006; McKnight, 1971; Parker & Heywood, 2013). Microteaching has been widely used in preservice teacher education for encouraging student teachers to practice perspective-taking in a range of possible interactions between teachers and students, with the aim of designing and conducting more effective lessons. In microteaching, student teachers collaboratively *role-play* a variety of roles (instructor and students) to form an inquiry-based dialogic discourse in a simulated classroom and then reflect on their performance from a variety of students' perspectives. Role-plays provide an effective approach to "dive into" (Ackermann, 2012; Resnick & Wilensky, 1997) and adopt different perspectives when responding to various simulated situations, which allows participants to collaboratively explore the meaning making associated with their roles, duties, and activities (Hontvedt & Arnseth, 2013).

To achieve meaningful role-playing in microteaching, student teachers have to overcome two challenges: first, role-playing various imaginary students (Lortie, 1975) for practicing dialogic teaching, and second, considering the viewpoints of the imaginary students when the student teachers reflect on their performances as they imagine better classroom discourse (Rosaen et al., 2008; van Es & Sherin, 2002). In the present paper, we will outline these challenges and then describe role-play "puppetry" as a *mediating manipulative* to facilitate emergent role-play as a possible solution to the first challenge described above. Furthermore, we will target the second challenge with an examination of a three-dimensional (3D) animation as a *perspective-taking manipulative* to enable student teachers to shift their perspective to multiple first-person viewpoints of a variety of students. We will then analyze how student teachers' role-playing and reflection changed over time when they used a combination of mediating and perspective-taking manipulatives in order for us to see how student teachers could consider a variety of imaginary student voices, not only in puppetry but also in microteaching role-play and reflection. Finally, we will discuss the significance of combining mediating and perspective-taking manipulatives as artifacts in CSCL to support perspective-taking in collaborative role-play.

Background

Microteaching when preparing for dialogic teaching requires perspective-taking by imagining a variety of student voices

Designing an effective lesson through implementing dialogic pedagogy is an essential skill for schoolteachers (Mutton et al., 2011). Achieving this requires teachers to design dialogues to stimulate students' thinking without one-way knowledge transmissions; dialogues are carefully designed to achieve structured and cumulative questioning and discussion that promote learning and understanding (Alexander, 2017, 2018). Microteaching involves engaging in a role-play to develop dialogic teaching skills of student or preservice teachers. In microteaching role-play, a student teacher role-plays a teacher role, and the other student teachers role-play the students' roles in an improvisational way, that is, without a script, as realistic but imaginary students. Thus, student teachers can practice teaching, including managing dialogue, and those in the student role have opportunities for taking the perspectives of multiple imaginary students (Wilson & I'Anson, 2006).

This improvisation in microteaching role-play is essential to the acquisition of dialogic teaching skills because of the theoretical foundation of dialogic teaching—Bakhtin's theory of dialogism. Bakhtin (1986) argued that all utterances are produced as responses to the former and future voices of other people, because the speaker considers a listener's possible reactions

and avoids anticipated refutations (Wertsch, 1991). In other words, people's utterances are formed in anticipation of what the listener will say, while at the same time anticipating subsequent responses. In this sense, the utterance itself constitutes a dialogue. Bakhtin refers to this essential character of utterances as multivoicedness or dialogicality. In this dialogic view, classroom dialogue—in which the teacher's decision-making and negotiations with students are nested—is nothing other than the process of a) estimating students' responses, b) engaging in hypothetical dialogues, and c) incorporating them into students' learning while addressing various developments in the dialogue. This means that student teachers, even those who role-play the student role, must imagine the situation from another person's point of view, which is a key aspect of microteaching role-playing in professional training for dialogic pedagogy.

However, it is not easy, especially for student teachers, to envisage how students might react to classroom dialogue and draw on possible interactive discourse, because some participants cannot play their roles very well (Aubusson et al., 1997) due to being overly self-conscious (Ladousse, 1987) or prone to evaluation apprehension (Cottrell et al., 1968). Student teachers sometimes play the role of much younger students such as pupils; and thus they have to provide reactions and feedback as young students whose ways of responding are unfamiliar to the student teachers. Therefore, their feedback tends to be normative, which is sometimes unrealistic due to embarrassment or hesitation that they experience in role-playing nonnormative but possibly realistic situations. Such ineffective microteaching role-play is not likely to directly improve preservice teachers' ability to imagine learners' potential voices.

A further essential element of microteaching is reflection after each role-play (Amobi, 2005; I'Anson et al., 2010; Lee & Wu, 2006; Parker & Heywood, 2013). Student teachers usually hold discussions in small groups after each microteaching role-play, receiving plenty of feedback to reflect on their performances and exchanging ideas to improve future practice. As described above, student teachers need to discuss not only the explanation of difficult ideas from the perspective of pedagogical knowledge (Amobi, 2005; Parker & Heywood, 2013) but also possible classroom dialogue from imaginary students' perspectives to see how they would think and react in actual schools. This is key to improving the design and implementation of classroom discourse (Rosaen et al., 2008); using lesson recordings as a resource for reflection is very helpful (Gaudin & Chaliès, 2015; van Es & Sherin, 2002).

Puppets as mediating manipulatives for enhancing first-person perspectives on dialogic microteaching

As noted, achieving dialogic microteaching that incorporates imaginary students' perspectives is difficult for student teachers who lack experience. To address this issue, we employed an object-identification approach (Danish, 2014; Peppler et al., 2020a) to design a mediating artifact. The goal is for student teachers to enhance perspective-taking in possible classroom dialogues. Perspective-taking is the process of imagining the world from another's point of view or imagining oneself in another's position (Galinsky et al., 2005). To achieve this goal, we considered a specific mediation tool in order to make microteaching a better "transition space" (Wilson & I'Anson, 2006) so that student teachers can easily perform both teacher and student roles (Holzman, 2008).

We examined puppets as suitable mediating artifacts for the purpose of scaffolding participants' dialogic imagination in role-play (Mochizuki et al., 2013). Sakamoto (1980) used puppets as devices for a desktop teaching simulation game in a miniature paperboard classroom to make microteaching easy. Puppetry is a familiar form of cultural play for most

people from infancy through adulthood. Puppets may be used for play or may serve religious or ritual purposes, so people can easily anticipate and prepare for a number of possible, including unusual, roles as transitional objects between people and their emotions (Steinhardt, 1994). Puppetry is a creative performance for such practices so that people can easily imitate a variety of behaviors or practices conducted or culturally practiced by other people. This can elicit a social process essential for creating a zone of proximal development (Holzman, 2008; Vygotsky, 1978).

People can easily play a variety of roles with puppets by creating a clear separation between the self (puppeteer) and the nonself (puppet) while creating a story (Aronoff, 2005). Puppetry creates a psychological distance from the role-player's actual identity, meaning that the player's anxiety or apprehension is reduced. A puppet manipulated by the puppeteer (i.e., the role-player) is the nonself but also contains recognizable characteristics of the self, which the puppeteer can identify with. Such projection in puppetry can provide a psychological margin of safety to achieve a balance between under-distance and over-distance (Aronoff, 2005). For example, puppetry has been used to enable people from religious backgrounds to "talk" about sensitive topics, such as sex education, that would otherwise be unacceptable if they themselves played as actors (Panford et al., 2001). Thus, puppets can be powerful *mediating manipulatives* for participants to elicit various reactions or responses (multivoices) from multiple first-person perspectives (depending on the number of puppets). This is based on inner emotions or unconscious experiences in actual classrooms and can help student teachers to gain various perspectives by playing different roles that do not usually appear in a normal role-play and thus achieve dialogic microteaching.

Previously, we developed a tangible puppetry tabletop role-play simulation system (Sasaki et al., 2017) that enables student teachers to perform a puppetry microteaching role-play based on diverse student voices (Fig. 1) and to discuss their performance while watching a recorded bird-eye's view animation of the actions and conversations in the role-play performed by the student teachers (Fig. 2). A teacher puppet, student puppets, and associated table props are placed on the system tabletop for the role-play. Each puppet or prop is placed on a transparent box with a location indicator affixed on the bottom of the box (Fig. 1, right). As shown in Fig. 3, a web camera and a microphone are positioned under the semitransparent tabletop to capture the voices of the participating students and the movements and rotations of indicators attached to puppets and props during the role-play.

The student puppets can be assigned different visible states by using two colored LEDs, specifically to represent various mental states of the imaginary students. When the puppeteer operates a switch to change the color of the LED of a puppet to either red, blue, or off, this state (distracted, focused, or normal, respectively) of the imaginary student as shown in the puppetry is presented as their nonverbal form of embodied expression. As such, puppeteer
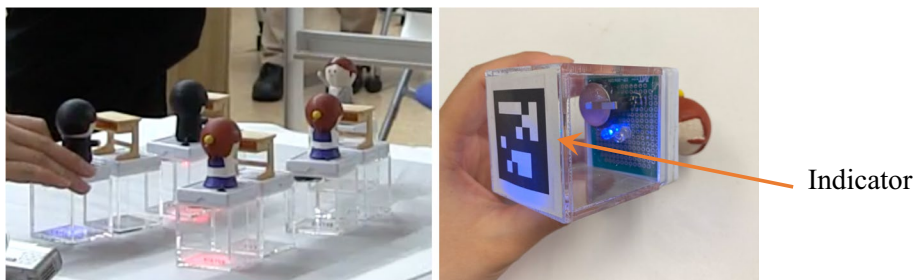

Indicator

Fig. 1 Puppets and props with attached indicators are placed on the tabletop

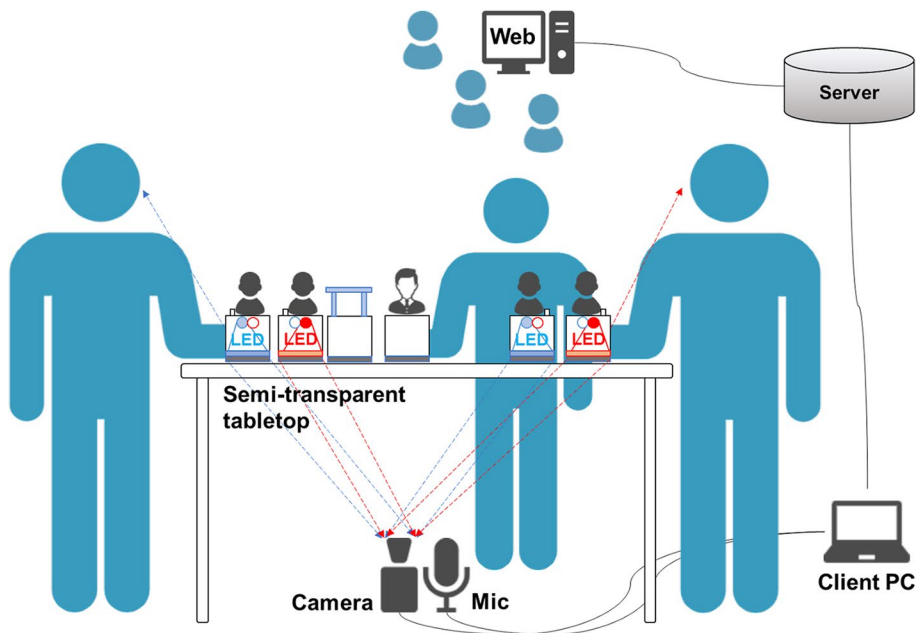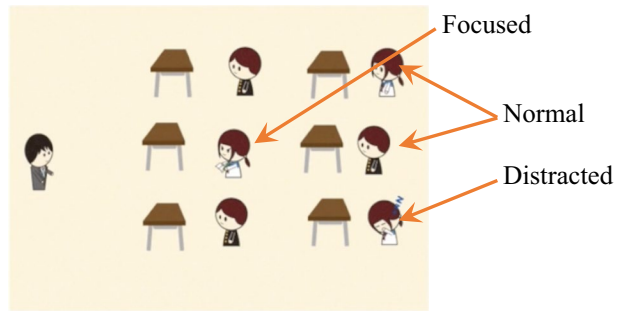**Fig. 2** Screenshot of a bird's-eye view of the role-play animation

Fig. 3 The tangible puppetry role-play system's architecture

operating the student puppet can imagine the student puppet's emotions and then share them with other puppeteers. By using the indicators and the LED colors (Fig. 1, right), the system generates an animation based on the recorded locations, rotations, and conditions of each puppet (see Fig. 2, there are several focused, distracted, or normal student characters). This shows how the imaginary students perceive the lesson provided by the student teacher, along with a dialogue among the imaginary students in the simulated classroom.

After the role-play, the system automatically uploads the captured and recorded role-play data to the server, after which the web interface generates the animation (Fig. 2), which is replayed for the reflective discussions. Therefore, the student teachers can discuss their microteaching role-play while watching the recorded animation and note the change in attitudes of those in the student role (which are represented by the LED colors); this enables them to examine either verbal or nonverbal voices of the imaginary students.

In a typical role-play, three student teachers perform the role-play by using the puppets and props. Two student teachers play the students' roles by using multiple student puppets, and the third student teacher plays the teacher's role by using the teacher puppet. To ensure that the microteaching role-play is more realistic, the student teachers playing the two students' roles are instructed to use their own school experiences to imagine a variety of students and situations. As they imagine the possible student voices in reaction to the teacher puppet's instructions, they improvise the role-play by moving the imaginary student puppets and manipulating their LED statuses. Before the performance, the student teacher who is role-playing the teacher prepares a one-class-period lesson plan for the microteaching role-play, for which they can choose their own topic or a subject if it is not defined by the instructor. They role-play the teacher by manipulating the teacher puppet and conduct the lesson dialogues as the student puppets' reactions are role-played by their peers. During the role-play, the student teachers who are role-playing the students' roles are seated around the table, with the student teacher who is role-playing the teacher standing alongside the table. The triad performs the interactive role-play based on their assigned roles. The system records the performance, and after the performance, it generates an animation of the performance. The triad then moves to a table and plays back the animation on a shared display attached to a computer, which forms the basis for their reflective discussion. To discuss their possible teaching performance improvements from the students' viewpoints, they sometimes stop the video or jump to a specific time in the animation.

In previous research, tangible puppetry elicited a variety of imaginary student voices through dialogic microteaching; further, student-role performances improved following the tangible puppetry role-play experiences (Mochizuki et al., 2019). However, in the reflection after the self-performed role-play, student teachers' discourse tended to return to the perspectives that were present before the puppetry microteaching role-play (Mochizuki et al., 2017). This indicates that student teachers were not able to appropriate diverse perspectives into their reflection. Therefore, a stronger intervention, in addition to the tangible puppetry role-play simulation, is necessary to make the student teachers' perspective-taking remain student centered in order to overcome the challenges to achieving high-quality dialogic microteaching.

Various first-person viewpoints of imaginary participants as a vehicle for driving the deep reflection

The bird's-eye view in the recorded microteaching role-play performance video gives the student teachers a third-person view to examine the student classroom activities. However, as described above, in previous research this intervention was not found to be sufficient for the student teachers to generate appropriately diverse student perspectives in their reflections (Mochizuki et al., 2017).

Because the 3D manipulable animation allows the student teachers to experience a variety of students' perspectives, we hypothesized that manipulating the viewpoints in the 3D animation would provide a viable representation for the reflective discussion that seems more authentic and fosters transfer of the perspective-taking (Dede, 2009). In particular, taking another person's perspective by changing viewpoints in the 3D animation allows us to empathize with that person's position (van Loon et al., 2018), learn ways of behaving from that person's perspective (Fiorella et al., 2016), and feel ourselves being in that person's unique visual perspective. This characteristic of the 3D manipulative animation is recognized as an element of "inter-identity technologies" that effectively combines a

person's perspective with the identity of a different first-person so that person can experience how a person performs important tasks (Lindgren, 2012; Lindgren & Pea, 2012). It is considered that this characteristic fosters transfer in later learning or to problem-solving in real settings (Dede, 2009). Most prior studies in perspective taking using 3D video or animation have shown the effects of switching between subjective and objective frames of reference (Ackermann, 2012; Dede, 2009; Fiorella et al., 2016; Ke et al., 2020; Lindgren, 2012). The manipulable nature of the 3D animation was considered an essential intervention for representing student perspective-taking in dialogic microteaching situations.

Therefore, we modified the animation format generated by our tangible puppetry role-play system to a 3D manipulable animation so that student teachers who have performed a puppetry role-play can examine how the class is viewed from the perspectives of the teacher and/or the perspectives of a variety of students (Mochizuki et al., 2019). As shown in Fig. 4, the animation starts from a bird's-eye view at the beginning of the reflective discussion (4a), and then student teachers can take different viewpoints by clicking on the heads of the teacher or each student as *perspective-taking manipulatives* while watching the animation (as shown in (4b) and (4c)). The teacher's or each student's viewpoint represents how each puppet turned and moved during the puppetry role-play. Each student's state (i.e., distracted, focused, etc.) is represented in the animation as shown in Fig. 5. We designed this animation to allow student teachers to appropriate a variety of students' perspectives in a classroom where student teachers manipulate the tangible puppets. Thus, we expected the student teachers to use diverse perspectives in order to achieve better dialogic microteaching.

Combining the self-performed microteaching role-play performance and the reflective discussion with the 3D animation was further expected to have a bifocal modeling function (Bilkstein et al., 2016) in which the learners refer to both physical and virtual learning environments in order to conduct investigations into similar phenomena; however, the 3D animation in this study did not allow the learners to simulate anything like computational models of scientific phenomena on their computers (e.g., Bilkstein et al., 2016; Peppler et al., 2020a); the 3D animation in this study merely replayed the role-play and allowed them to reflect on their role-play performance from *multiple first-person viewpoints*. Nevertheless, the 3D animation maintains a potential to be a valuable resource for training student teachers to investigate the phenomena regarding dialogic teaching when they find discrepancies between their perceptions during the performance and their reflections when they change their viewpoints between a teacher's viewpoint, a bird-eye's viewpoint and multiple students' viewpoints.

Research questions

As noted, our goal was to overcome the challenges that student teachers encounter while attempting to achieve high-quality dialogic microteaching where they role-play interactions
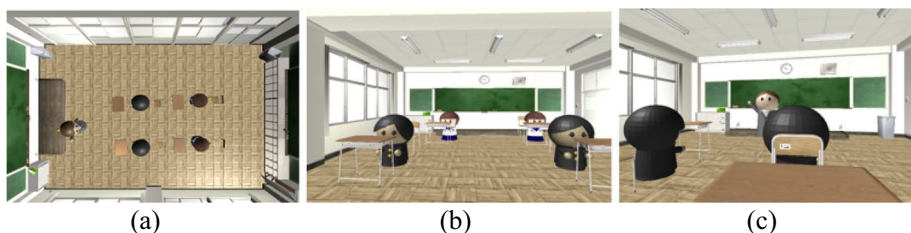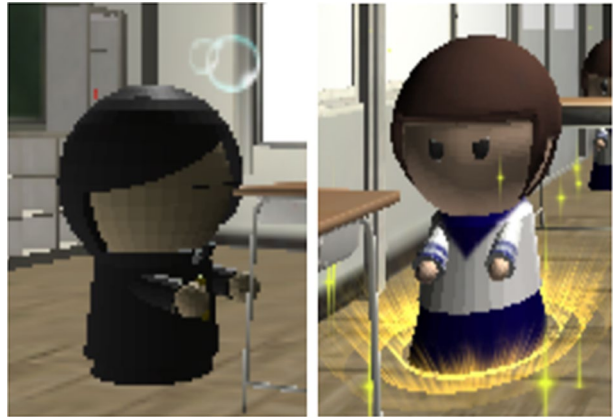

| (a) | (b) | (c) |

Fig. 4 The 3D manipulable animation for the reflective discussion on the puppetry role-play

Fig. 5 Distracted (left) and focused (right) students represented in the animation by their respective LED color status

between a teacher and a variety of students and to reflect on their performance from the students' perspectives. To address this goal, we had iterated the designs of our tangible puppetry role-play system before achieving the current design. The current design combines *mediating manipulatives* (i.e., tangible puppets) and *perspective-taking manipulatives* (i.e., perspective taking of roles in the recorded role-playing by clicking characters that appear in the 3D manipulable animation). Thus, we asked the following questions: (1) Is the combination of the tangible puppetry and the 3D manipulable interface, which allows perspective-taking in microteaching, effective in fostering diverse student perspectives that are necessary for achieving dialogic microteaching? (2) Do the effects remain in their subsequent microteaching even without the mediating and perspective-taking manipulatives?

Methods

Setting and participants

The study was conducted as part of a pedagogy course in which student teachers were studying to become elementary schoolteachers in a private university in Japan. This part of the course was designed to enable student teachers to practice microteaching so that they were able to consider how interactions in the classroom should be promoted through dialogic teaching. It was conducted as a three-hour class according to the schedule described below and in Table 1.

Seventy-nine student teachers enrolled in the course (females 77.2%) and were randomly assigned to groups of three, forming 25 triads, in addition to a group of four student teachers. Each triad had a teaching assistant who managed the time, recorded the microteaching, and facilitated the discussion. Before the class, every student teacher had to independently prepare a one-hour lesson plan in elementary arithmetic, selecting a suitable theme for their microteaching practice.

Following an introduction of the lesson plan by the student teacher, 10-min microteaching role-plays were performed in each group. The teaching assistant asked the student teachers to play the role of students as realistically as possible by thinking about students in a real classroom. After each microteaching role-play, the group moved to a different table to see the recorded animation of their performance.

Table 1 Design of the class in the present study

Sessions	Activity (time: minutes)	Description
Introduction	Introduction (20)	The class instructor explained how the participants should study in the consecutive class.
#1: Pretest. Normal microteaching role-play	Introduction of the lesson plan for the first microteaching role-play (5)	Student teacher A explained their lesson plan to B & C.
	Normal (self-performed) microteaching role-play, recorded by video cam (10)	Student teacher A taught (B & C role-played students).
	Reflection/discussion (20)	A, B, & C discussed how to improve their teaching while watching the video of the microteaching.
	Write an individual reflection on a worksheet (10)	Each student teacher wrote independently.
#2: Intervention. Puppetry microteaching role-play	Introduction of the lesson plan for the second microteaching role-play (5)	Student teacher B explained their lesson plan to A & C.
	Introduction to how to conduct puppetry (5)	A teaching assistant explained how to conduct puppetry.
	Puppetry microteaching, recorded by video cam (in the control condition) or the system (in the experimental condition) (10)	Student teacher B taught (A and C controlled multiple student puppets).
	Reflection/discussion (20)	A, B, & C discussed how to improve their teaching while watching the video (in the control condition) or the 3D manipulable animation (in the experimental condition).
	Write an individual reflection on a worksheet (10)	Each student teacher wrote independently.
#3: Posttest. Normal microteaching role-play	Introduction of the lesson plan for the third microteaching role-play (5)	Student teacher C explained their lesson plan to A & B.
	Normal (self-performed) microteaching, recorded by video cam (10)	Student teacher C taught (A & B role-played students).
	Reflection/discussion (20)	A, B, & C discussed how to improve their teaching while watching the video.
	Write an individual reflection on a worksheet (10)	Each student teacher wrote independently.
Wrapping up	Class reflection	Every group reflected on the class.

A group of four conducted the fourth session through self-performed microteaching before the wrap-up session. The group was excluded from the following analysis

Then they engaged in a 20-min discussion about how to improve classroom practice from the perspective of a variety of students in the class. One group member was assigned as a video controller, and the rest were encouraged to ask the controller to stop, play, and jump the video as desired. In the experimental condition (with the perspective-taking manipulatives for reflection), they were encouraged to click on the heads of the characters in the 3D manipulable animation so that they could shift to diverse first-person perspectives of students or teachers (Fig. 6). In the control condition (playing the video for the reflection without the perspective taking manipulatives), they watched the video only from the third-person perspective (i.e., from behind the performance, as captured in the images in Table 1).

The procedure was thus designed as a quasi-experimental study to allow for an examination of the pre- and post-microteaching role-play performances and the dialogue patterns in the subsequent reflective discussions. To ensure that all student teachers had the opportunity to experience perspective-taking by using the mediating manipulatives, the tangible puppetry role-play design included all student teachers (regardless of the conditions described later).

To investigate the effects of perspective-taking and examine the immediate transfer from the puppetry microteaching, three microteaching sessions were established: a pretest (Session #1), an intervention (Session #2), and a posttest (Session #3). Each student teacher participated in one microteaching puppetry role-play and two (regular) microteaching role-plays. All the student teachers played the role of the teacher once across the three sessions. Suppose student teachers A, B, and C participated in a triad of this class: In the first microteaching session, the student teacher A physically played the teacher role, while the student teachers B and C played the students' roles physically. Then they all reflected on their performances by watching the video that was shot from behind them while doing their role-playing. In the second microteaching session, the student teacher B played the teacher role and the rest of the student teachers played the students' roles using the tangible puppets. Then the student teachers all reflected on their performances, either by watching a 3D animation as described above in the experimental condition, or by watching the video in the control condition. The animation enabled the student teachers in the experimental conditions to watch multiple first-person viewpoints of characters that were role-played in the performance, while the video shot from behind them during their performance in the control condition enabled their reflections only from the third-person perspective,
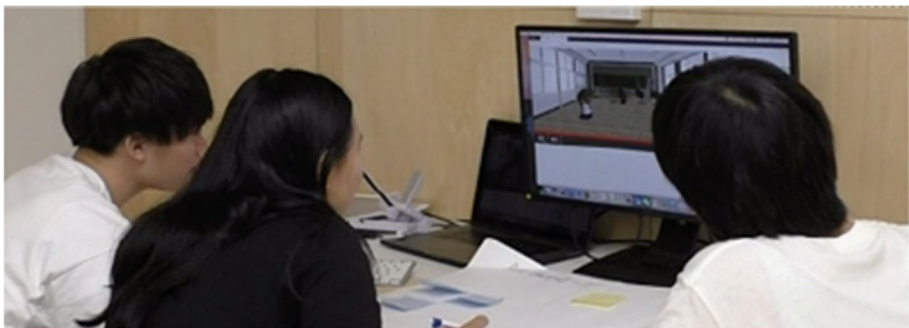

Fig. 6 Reflective discussion while watching a 3D animation that allows changing viewpoints

which past studies reported to be useful in making student teachers shift their focus to the students' roles instead of the teacher role (Rosaen et al., 2008). Finally, in the third session, the student teacher C physically played the teacher role, while the others physically played the students' roles. After that, they reflected on their performances by watching the video that was shot from behind them while they were doing their role-playing. After every reflective discussion, each student teacher wrote a short essay about what they had learned through each microteaching session as a learning resource for the next lesson (not covered in this study).

In this way, we examined the immediate transfer of the effect derived from the combination of the tangible puppetry microteaching and the 3D animation. Note that the triads and teacher roles were randomly assigned to each condition.

Data sources and analyses

Video transcripts of microteaching performances and reflections

We recorded and transcribed all the microteaching role-plays and reflections produced through the video cam or the tangible puppetry role-play system.

The microteaching role-play was treated as a data source in order to confirm whether the tangible puppetry role-play changed the simulated classroom discourse across the three sessions as consistent with previous studies, which is a prerequisite for the research questions. Recording the discussions during reflection was also necessary to offer visibility into the way the student teachers appropriated a variety of students' perspectives that were performed in the microteaching role-play—for example, noticing students' voices and actions, and utilizing such perspectives in the reflection to improve their dialogic teaching discourse. In addition, our focus was guided by our theory regarding how the perspective-taking manipulative affected the student teachers' collaborative examination of their microteaching role-playing. Therefore, we analyzed the peer discussion regarding microteaching role-playing (Donnelly & Fitzmaurice, 2011). This contrasts with most previous studies (e.g., Gelfuso, 2016; Rosaen et al., 2008; van Es & Sherin, 2002), which analyzed individual written responses after reviewing videos without any interaction with peers.

Note that, in the following analyses, we excluded the one group of four student teachers, in which three of them played the students' roles in every microteaching session. This is a significantly different condition from the other triads in the microteaching role-play performance. In addition, one triad was also excluded from the analysis because one facilitator significantly intervened in their discussion during the reflection, thus affecting the conversation. Therefore, we analyzed the transcripts and discussions of 24 triads—13 in the 3D animation condition (i.e., the experimental condition) and 11 in the video only condition (i.e., the control condition), while student teachers reflected on their performance.

Coding transcripts

We expected that the performance of student-role student teachers would be diverse due to the mediating effect of the puppets. To examine the expected changes, we

adopted Fujie's (2000) coding scheme for classroom discourse, which we had also used in our past studies (Mochizuki et al., 2015, 2017; Wakimoto et al., 2019). The coding scheme examined how the classroom discourse proceeded with *formal* and *informal* utterances; the *formal* utterances were expected in the lesson plan, which the teacher expected as an ideal flow. In contrast, the *informal* utterances were not expected in the lesson plan, such as irregular patterns of answers or different solutions, and reactions to the teacher's instructions such as wrong answers, misunderstandings, or distractions; all of them generally occur in actual classrooms. In particular, the informal utterances can be considered as an index of how much perspective-taking of student teachers occurred (i.e., they could imagine a variety of students) in the microteaching role-play. Thus, we considered this coding scheme as appropriate to investigate how the simulated classroom discourse was different from the lesson plan (from a teacher's perspective), that is, to what extent imaginary students' perspectives appeared and a teacher-role student teacher reacted spontaneously to such utterances to form a rich classroom discourse. Two researchers independently coded every utterance ($N = 11,986$) in the microteaching role-plays, referring to the coding scheme described in Table 2. We allowed more than one code when an utterance included a double meaning. Fillers, nodding, and other meaningless utterances were coded using a different category and were ignored in the following analyses because our focus was on the simulated classroom interaction. Inter-rater reliability was tested using Cohen's kappa ($\kappa = 0.823$) which indicates an almost perfect level of agreement (Landis & Koch, 1977). Social moderation was used to resolve any differences between the two raters (Frederiksen et al., 1998; Herrenkohl & Cornelius, 2013). They discussed the discrepancies by checking the transcript and the coding scheme and then determined the final codes reaching perfect agreement.

Further, we adopted the coding scheme that Rosaen et al. (2008) had developed to capture the preservice teachers' reflections while watching the recorded videos, a scheme that we had also used in our past studies (Mochizuki et al., 2015, 2017). This scheme was originally designed to code written responses to identify what topics preservice teachers noticed while remembering or watching their classroom practice, focusing on management and instruction from teacher and student perspectives. The coding scheme also included a "student achievement" code, which is difficult to observe in a 10-min microteaching role-play, and a "teacher move" code, which meant gaining insights from student utterances or seeking insights by asking students. To clearly identify how student teachers in the present study shifted their perspective in a simple way, we merged the teacher move codes into the "Focus on Student-Instruction (SI)" code, as shown in Table 3. Two researchers independently coded all the utterances ($N = 11,267$) in the reflection, referring to the coding scheme described in Table 3.

We allowed more than one code when an utterance included more than one meaning as well. Inter-rater reliability was tested using Cohen's kappa ($\kappa = 0.753$) which indicates a substantial level of agreement (Landis & Koch, 1977). Again, social moderation was used to resolve any differences between the two raters, with all discrepancies discussed by rechecking the transcript and coding scheme until reaching an agreement.

Epistemic network analysis (ENA)

The present study applied ENA (Shaffer, 2017; Shaffer et al., 2016) to our data to investigate changes in the discourse characteristics. ENA is a quantitative ethnographic method modeling the structure of chains in the qualitative characteristics of

Table 2 Definition of codes for utterances in the role-play microteaching simulation

Codes	Definitions	Examples
Teacher-Formal (TF)	Teachers' utterances that follow their lesson plans or teachers' utterances related to the matter that is being studied.	And who understands that angle [pointing to an angle in a rectangle]? So let's all write this in your notebook individually. So why don't you imagine for a moment how light it (an eraser) is?
Teacher-Informal (TI)	Teachers' utterances that do not follow their lesson plan. The utterance may be a reaction to an informal utterance from the students (to recover the planned lesson flow), or the utterance may be unexpected in the lesson plan but related to the matter being studied. Or the utterance is based on his or her individual experience instead of the matter that is being studied.	Hmmm, what do you not understand? I haven't taught any decimal divisions yet, but you've done an amazing job, Carl. [*Note*: some students in Japan study math in prep schools in advance of the school curriculum.] Kate, you made a shape that you like. This is also a great shape, but I think we just discussed that a triangle is a shape with three sides, so could you make a triangle…? I wonder if you can make a single shape out of three sticks.
Student-Formal (SF)	Student utterances that follow the teacher's instructions or the developed lesson plan by the student teacher role-playing the teacher. The utterance is a move toward the lesson goal.	Student: I think it's 10,000 cm square. [SF] Teacher: Yes, that's right.[TF] Teacher: Do you know where the fan-shapes are? [TF] Student: Here, here, here, here, and here? [SF] Teacher: If you use the unit of time, you can see how long it will take. [TF] Student: So, you can't tell how long it will take unless you think about it in your head? [SF] Teacher: That's right. [TF]

Table 2 (continued)

Codes	Definitions	Examples
Student-Informal (SI)	Student utterances that are not expected in the lesson plan, such as irregular answer patterns or different solutions or reactions to the teacher's instructions, such as unexpected wrong answers, misunderstandings, or distractions. These are utterances based on the individual experiences and intentions of the student teacher role-playing the possible students.	Student: May I make many of these? [SI] Teacher: Amy, what did I say just now? [TI] Teacher: How many did I say you would make first? [TI] Student: I don't know. [SI] Teacher: You don't know? [TI] Teacher: If you don't know, you can ask Max, but let's make two pieces first. [TI & TF] Student: Oh, yes. [SF] Teacher: Is it a rectangle? [TF] Student: Angle …[SI] Teacher: But in today's calculation, let's make sure to write and calculate the zeroes as well. [TF] Student A: Yes. [SF] Student B: I've got tired…[SI] Teacher: Tired? [TI]

Table 3 Definition of codes for utterances in the reflective discussions

Codes	Definitions	Examples
Focus on Teacher-Management (TM)	Managing students' behavior; playing a role in an organization for a smooth and coherent lesson flow.	I wondered if there would be time for students to write notes. It's true that silence is a waste of time, isn't it? I wanted to spend a lot of time measuring mats, so I wanted to do it quickly as it was the beginning.
Focus on Teacher-Instruction (TI)	Instructional strategy that facilitates the cognitive and social interactions around the goals of the lesson; focuses on the teacher's role.	I forgot to give instructions, but before reading the goals, I would have liked to change the group formation to an array formation, to read it, and to make students think individually and intentionally. If you ask them if they want to check it out, and tell them which is the correct answer, the order could be either. I felt it was difficult when the students didn't give me the answer I was expecting.
Focus on Student-Management (SM)	Managing students' behavior; organization for a smooth lesson flow; focuses on the children's behavior or attitudes.	The girls were quite shy, and only the boys raised their hands. It would be a good idea to tell them in advance to put down their pencils and wait for you when they are done. When I saw some numbers, I turned mine (LED) to red…yeah, (regarding the height of) a tower.
Focus on Student-Instruction (SI)	Instructional strategy that facilitates the cognitive and social interactions around the goals of the lesson; focuses on how the students responded to the instruction.	If the teacher did not say what should be calculated, the students could not have understood what they were asked to do. I thought that there were probably kids out there who were thinking differently, so I thought it would be better to take some action. I thought that if you said "it's the correct answer" right away, some other kids would be left behind if they didn't understand.

the discourse. It quantifies the co-occurrence of codes in a conversation, providing visualizations as networks that are aggregated for each unit of analysis. After normalization of the networks for all units of analysis and a dimensional reduction, the result generates two coordinated representations for each unit of analysis: a plotted point which represents the location of that unit's network in the low-dimensional projected space, and a weighted network graph. The network node positions can be used to interpret the dimensions of the projected space and to explain the positions of the plotted points.

ENA was applied because it could effectively capture the discourse changes between the sessions. Because the data were temporal, using a connected network approach to measure the learning over time had higher fidelity to the learning being modeled than flattened aggregated coding-and-counting models (Csanadi et al., 2018). Epistemic frame theory (Shaffer, 2012, 2017), which is the background theory to ENA, states that learning involves a transformation of an epistemic frame, that is, learning is a combination (linked and interrelated) of the values, skills, epistemology, and identities within a community to make decisions and take action (Shaffer, 2012, p.411). Epistemic networks, which are simplified representations of epistemic frames, are expressed in discourse and change over time during the learning process. ENA allows us to observe fine-grained changes to interdependent phenomena occurring through the sessions in different conditions by applying ENA (Shaffer, 2018). Therefore, ENA was considered an appropriate approach for assessing and identifying the discourse changes in the three microteaching role-plays and reflective discussions. Furthermore, because ENA is based on social network analysis (Shaffer, 2012), it assumes relationships between the variables and thus avoids violating the statistical independence assumptions for each variable (Cress, 2008).

ENA offers a variety of calculation functions to compare units of analysis in terms of plotted point positions, individual networks, mean plotted point positions, and mean networks, averaging the connection weights between individual networks. The networks can also be compared using network difference graphs. These visual network comparisons revealed how the student teachers' epistemic frames related to the possible students' perspectives changed over time.

Furthermore, ENA's web-based analysis platform, WebENA (Marquart et al., 2018), allows us to extract specific lines of utterances in the discourse which represent the characteristic differences between the networks. Therefore, we considered ENA to be a promising way of identifying the effectiveness of student teachers' appropriation of imaginary students in their microteaching as well as in their reflections. Furthermore, the WebENA tool can extract the specific qualitative data from the result of the comparisons to investigate the extent to which the perspective-taking remained in Session #3.

Results

Descriptive results of coding utterances

Table 4 shows per-group averages and standard deviations of the number of utterances classified as each code (from Table 2) for each microteaching role-playing session in each condition. Table 5 displays per-group averages and standard deviations of the

number of utterances classified into each reflective discussion code (from Table 3) for each microteaching role-play session in each condition.

Changes in discourse patterns during microteaching role-plays with mediating manipulatives

At first, we examined how the tangible puppetry as a mediating manipulative affected the perspective-taking of the student teachers in their role-play performances. Thus, we conducted ENA on the data of the microteaching role-play discourse to compare the data between the three sessions, regardless of the conditions, because the procedures in the microteaching role-plays were the same in both conditions.

Figure 7 shows the network graphs with colored squares that are the mean of the plotted points for each microteaching session (regardless of the use of perspective-taking manipulatives). ENA explains 25.9% of the variance in coding co-occurrences along the x-axis and 56.6% of the variance on the y-axis. We interpreted the x-axis as an indicator of formal vs. informal and the y-axis as student vs. teacher centered, in accordance with the plots. Two sample t-tests (assuming unequal variance) were conducted along the x-axis, showing that there was a significant difference between Session #1 ($M = -0.16$, $SD = 0.62$, $N = 72$) and Session #2 ($M = 0.06$, $SD = 0.59$, $N = 72$; t (141.81) = 2.17, $p = 0.03$, $d = 0.36$) and another two sample t-tests (assuming unequal variance) were conducted along the x-axis, showing that there was a significant difference between Session #1 and Session #3 ($M = 0.09$, $SD = 0.64$, $N = 72$; t (141.70) = 2.38, $p = 0.02$, $d = 0.40$), while there was no significant difference between Sessions #2 and #3.

According to Fig. 7, the discourse patterns shifted from linkages connecting to the *Student-Formal (SF)* code to linkages connecting to the *Student-Informal (SI)* or *Teacher-Informal (TI)* codes. This finding indicates that, after experiencing the tangible

Table 4 Per-group averages and standard deviations of the number of utterances classified as each code (from Table 2) in the microteaching role-plays

Sessions	TF	TI	SF	SI	TF+TI (Overlapping within columns on the left)	SF+SI	Not coded
Experimental Condition (13 groups)							
#1	94.54 (39.56)	25.46 (25.59)	51.62 (25.69)	29.62 (22.90)	19.38 (20.11)	12.00 (11.80)	0.31 (0.85)
#2	98.54 (22.92)	35.54 (21.88)	40.92 (14.06)	24.92 (15.36)	22.38 (15.06)	7.38 (4.75)	0.00 (0.00)
#3	97.54 (23.10)	27.92 (18.83)	45.00 (19.87)	34.54 (19.75)	20.23 (14.25)	12.00 (10.20)	0.08 (0.28)
Control Condition (11 groups)							
#1	71.36 (27.63)	16.09 (10.79)	48.09 (23.73)	29.00 (24.40)	11.36 (8.81)	9.64 (8.38)	0.45 (0.93)
#2	91.36 (19.76)	31.27 (20.24)	54.73 (22.16)	29.73 (14.54)	22.55 (16.71)	12.91 (8.86)	0.09 (0.30)
#3	86.00 (14.26)	27.36 (11.81)	53.73 (17.39)	32.18 (16.49)	19.45 (8.96)	12.82 (8.47)	0.45 (0.82)

TF Teacher-Formal; *TI* Teacher-Informal; *SF* Student-Formal; *SI* Student-Informal

Table 5 Per-group averages and standard deviations of the number of utterances classified as each code (from Table 3) in the reflective discussions

Sessions	TM	TI	SM	SI	TM+TI	TM+SM	TM+SI	TI+SM	TI+SI
					(Overlapping within columns on the left)				
Experimental Condition (13 groups)									
#1	79.85 (49.97)	33.00 (29.13)	30.31 (23.86)	24.77 (18.51)	9.54 (13.41)	4.08 (5.65)	1.23 (2.01)	0.69 (2.21)	1.69 (2.78)
#2	68.92 (41.21)	23.77 (16.80)	71.69 (46.34)	13.77 (11.88)	8.54 (9.28)	3.46 (3.41)	1.62 (1.85)	0.46 (0.97)	0.85 (1.41)
#3	71.46 (41.51)	27.15 (24.66)	37.08 (40.19)	26.77 (14.53)	5.85 (6.52)	2.92 (3.66)	1.23 (3.09)	0.08 (0.28)	1.08 (2.25)
Control Condition (11 groups)									
#1	67.91 (38.54)	35.73 (26.39)	36.18 (31.77)	32.64 (10.66)	10.82 (8.10)	2.18 (2.99)	1.09 (1.64)	0.09 (0.30)	1.82 (1.72)
#2	64.55 (47.27)	38.36 (16.35)	57.00 (21.52)	32.91 (13.47)	13.36 (10.14)	3.91 (2.88)	2.36 (3.47)	0.64 (1.50)	2.45 (2.58)
#3	71.73 (42.04)	39.18 (35.87)	32.27 (19.88)	39.36 (25.46)	12.18 (12.78)	2.64 (4.18)	1.55 (2.70)	0.18 (0.40)	2.00 (1.79)

Sessions	SM+SI	TM+TI+SM	TM+TI+SI	TM+SM+SI	TI+SM+SI		All Coded		Not Coded
(cont.)			(Overlapping within columns on the left)						
Experimental Condition									
#1	2.85 (4.63)	0.62 (2.22)	0.69 (1.70)	0.54 (1.39)	0.38 (1.39)		0.38 (1.39)		0.00 (0.00)
#2	1.92 (4.50)	0.31 (0.85)	0.15 (0.55)	0.15 (0.38)	0.00 (0.00)		0.00 (0.00)		0.00 (0.00)
#3	3.54 (4.65)	0.08 (0.28)	0.62 (2.22)	0.00 (0.00)	0.00 (0.00)		0.00 (0.00)		0.08 (0.28)

Table 5 (continued)

Control Condition						
#1	3.45 (4.32)	0.00 (0.00)	0.36 (0.92)	0.00 (0.00)	0.00 (0.00)	0.09 (0.30)
#2	7.55 (7.26)	0.09 (0.30)	0.64 (1.43)	0.00 (0.00)	0.00 (0.00)	0.18 (0.40)
#3	1.09 (1.45)	0.09 (0.30)	0.36 (0.67)	0.09 (0.30)	0.09 (0.30)	0.09 (0.30)

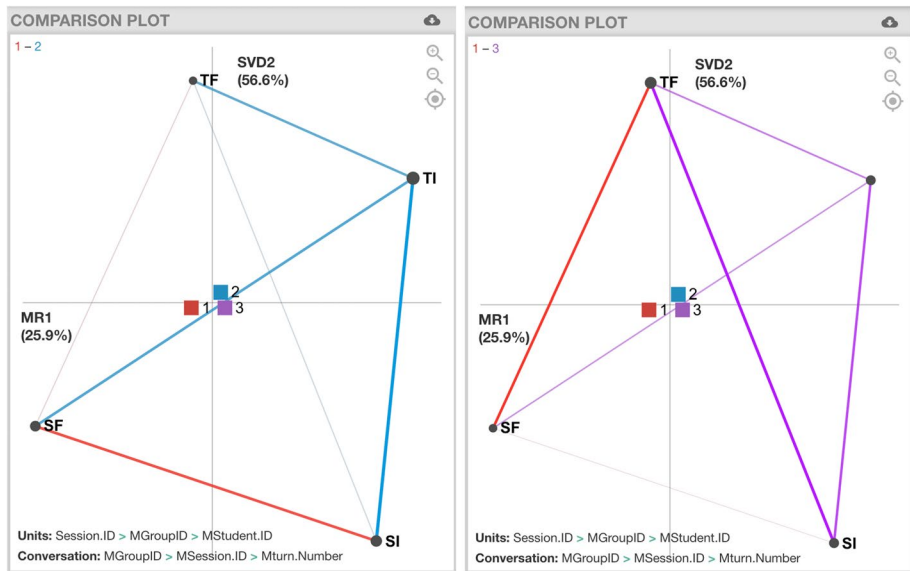*TM* Focus on Teacher-Management; *TI* Focus on Teacher-Instruction; *SM* Focus on Student-Management; *SI* Focus on Student-Instruction
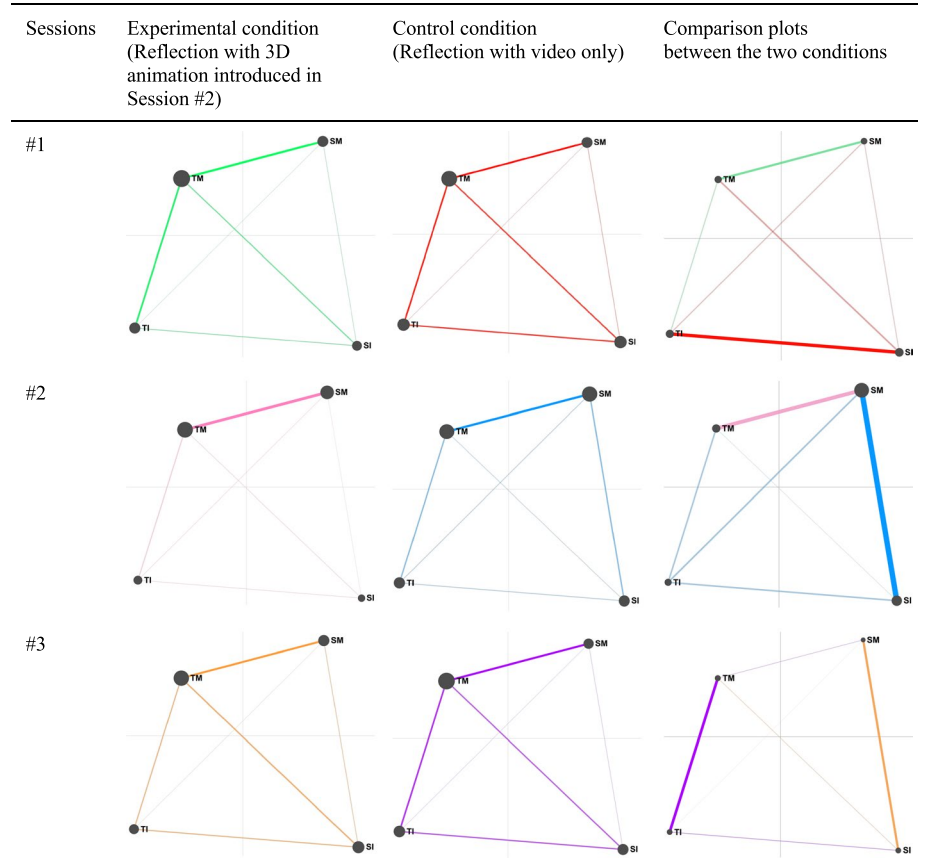
Fig. 7 Comparisons of microteaching role-plays between Sessions #1 and #2 (left) or #3 (right). *Note*: The colored linkages indicate the stronger connections in each of the sessions (Red: Session #1, Blue: Session #2, Purple: Session #3). A thicker linkage indicates a larger difference between the sessions. The colored squares around the origin are the mean plots for each session

puppetry role-play, the student teachers in both conditions are able to simulate more realistic classroom situations even in the self-performed microteaching role-plays.

The following is an excerpt of how the linkages connecting the *Student-Informal (SI)* and *Teacher-Informal (TI)* codes engendered a more realistic role-play in Session #3, which was also good practice for achieving dialogic teaching.

(1674) Olivia (teacher role): There is a teacher, two students, and one other student, then, how many candies should Nicolas hold out of these 12 candies so that everyone has the same number of candies?	[TF]
(1675) Olivia: Guess your estimate for one person.	[TF]
(1676) Olivia: I'd like you to think about how many you think you'll have, do you understand?	[TF]
(1677) Nicolas (student role): I got it, but I don't understand.	[SI]
(1678) Olivia: You got it, but you don't understand?	[TI]
(1679) Nicolas: I don't know how many there will be.	[SI]
(1680) Karen (student role): It's so easy.	[SI & SF]
(1681) Olivia: Easy?	[TI & TF]
(1682) Olivia: Are you sure?	[TI & TF]
(1683) Olivia: It's okay if you're wrong, it's just a guess.	[TI & TF]
(1684) Olivia: Don't worry.	[TI & TF]

Table 6 Epistemic networks for the reflective discussions in each session in each condition and comparison plots between the two conditions in each session

Sessions	Experimental condition (Reflection with 3D animation introduced in Session #2)	Control condition (Reflection with video only)	Comparison plots between the two conditions
#1			
#2			
#3			

Each color in the graphs was assigned to the number of sessions in the two conditions. In the left two columns, the thicker linkages indicate stronger connections between the codes, whereas the thinner linkages indicate relatively weaker connections. In the far-right column, the colored linkages indicate stronger connections in the condition corresponding to each color when comparing the two conditions

As described in the excerpt, Olivia responded to Nicolas, who was unsure about the estimation, by creating a psychologically safe space, although the student teacher, Karen, displayed a more normative student role. Olivia's utterances from lines 1681 to 1684 showed an excellent performance that encouraged all students to estimate the number without hesitation and helped Nicolas relax to achieve the lesson goal. As such, the student teachers who were role-playing the students acted from nonnormative or unpredictable student perspectives in Session #3 rather than only being the normative students assumed in the lesson plan (as in Session #1). The student teacher role-playing the teacher reacted to these students and attempted to manage the situation to achieve the instructional goals in light of these student responses.

Changes of discourse pattern in reflections after microteaching

The first research question addressed how the combination of mediating and perspective-taking manipulatives affected the diverse perspectives of students. Thus, we conducted ENA on the discourse data of the reflections in order to compare the two conditions as well as the transitions through the three sessions.

Table 6 shows the network graphs and comparison plots between the two conditions generated from the analysis described above. ENA explains 21.5% of the variance in coding co-occurrences along the x-axis and 39.1% of the variance on the y-axis. We interpreted the x-axis as an indicator of being teacher or student centered and the y-axis as that of instruction or management centered, in accordance with the visualized plots.

To pursue the first research question, we conducted two sample t-tests (assuming unequal variances) between the two conditions in Session #3, showing that there was a significant difference along the x-axis (the experimental condition ($N=39$): $M=0.12$, $SD=0.48$; the control condition ($N=33$): $M=-0.14$, $SD=0.36$; $t(69.05)=2.61$, $p=0.01$, $d=0.60$). Based on the interpretation of the two axes, as shown in the comparison plots in Session #3, the student teachers who reflected on their role-play with the perspective-taking manipulatives tended to focus more on the student-centered perspective, while those who reflected with the video tended to focus more on the teacher-centered perspective. For example, the following excerpt illustrates a triad of student teachers in the experimental condition discussing whether children might ask questions when they get a remainder in a division problem:

(9372) Kevin (student role): Kids may not ask what to do with (the remainder) one.	[SM & SI]
(9373) Nancy (student role): Well, they would ask, wouldn't they?	[SM & SI]
(9374) Kevin: They would say?	[SM & SI]
(9375) Nancy: It seems that the kids would say it.	[SM & SI]
(9376) Nancy: It's like...there's something left over.	[SM & SI]
(9377) Anne (teacher role): It's not zero.	[SM & SI]
(9378) Nancy: Personally, I was wondering if it would be okay to rephrase "how many sheets are left?"	[SI]
(9379) Anne: What do you mean?	[SI]
(9380) Nancy: If you used a word that children often use, such as "left over," then when they would say, "Teacher, there's one left over," it would be better for you to say, "Yes, there's one left over. This is the remainder, one."	[SI]

In this excerpt, the triad discussed possible questions regarding remainder when teaching division. Interestingly, they imagined various possible children in the discussion and utilized these children's perspectives to think about the words they could use when teaching the remainder concept. Nancy suggested introducing an everyday expression for children, such as "left" (lines 9376 and 9378), and then connecting the everyday term "left over" to the math concept "remainder." The discussion in the other triads in Session #3 in the experimental condition exhibited similar patterns of discourse when discussing how to achieve dialogic teaching.

To address the second research question, we examined the discourse pattern changes in the reflections after each microteaching role-play, especially before and after the introduction of the mediating and perspective-taking manipulatives (i.e., puppetry and 3D

Table 7 Comparison plots between the sessions in each condition

Sessions	Experimental condition (that used "3D")	Control condition (that used "Video")
#1 VS #2		
#1 VS #3		
#2 VS #3		
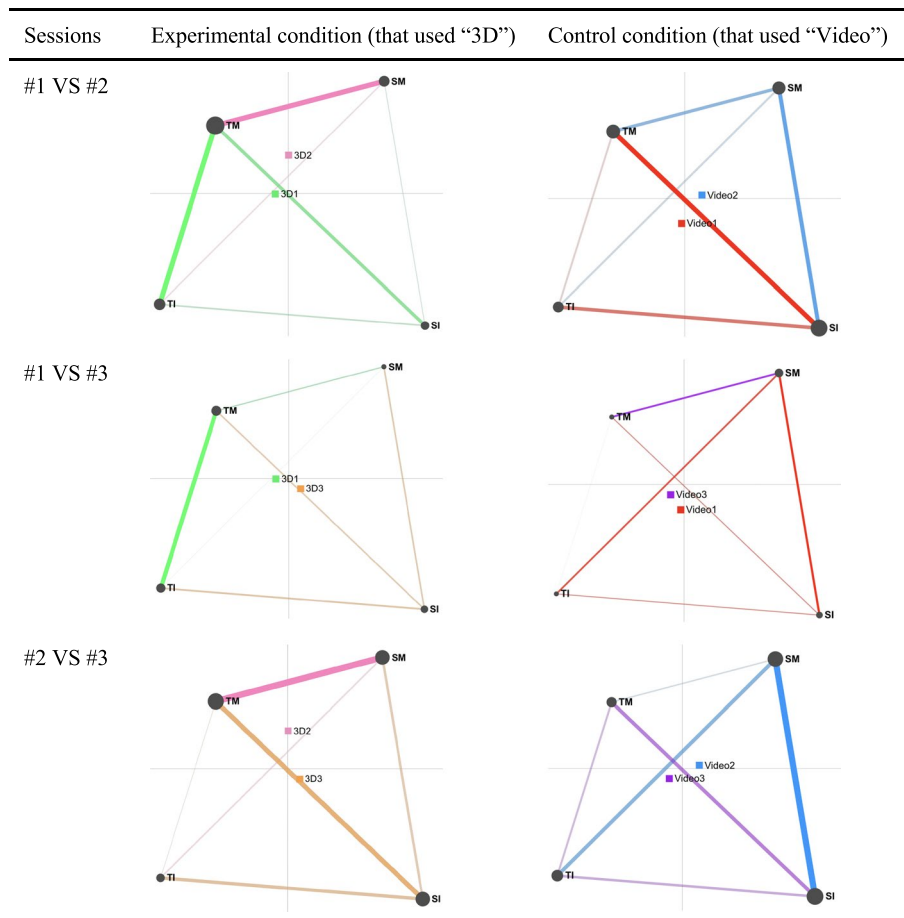
3D: reflection on the 3D animation condition; Video: reflection on the video only condition. The number indicates the session number. Each comparison plot shows linkages that show the differences between two sessions; the colored linkages indicate stronger connections in the session corresponding to each color. A thicker linkage indicates a larger difference between the sessions

animation) by using two-sample t-tests (assuming unequal variance) between Sessions #1 and #2, Sessions #1 and #3, and Sessions #2 and #3 for each condition.

Table 7 shows the comparison plots for each condition as generated from WebENA. Table 8 shows the results of the t-tests, which examined how the mean plots in each condition moved significantly between the sessions in accordance with the axes. If a significant move was observed in a mean plot toward a certain direction in the x- or y-axis between the two conditions, it indicated an impact on the students' discourse based on the interpretations of each axis. In other words, a movement in the x-axis was an indicator of being teacher or student centered, and a movement in the y-axis was an indicator of being instruction or management centered. Table 8 shows that compared to Session #1, the reflective discussions in Session #2 moved along the y-axis and focused on management in both the experimental and control conditions. However, the reflective discussion in the experimental

Table 8 Statistical comparisons of the mean plots between the sessions for each condition

	Experimental condition ($N = 39$)		Control condition ($N = 33$)	
	x	y	x	y
#1	$M = -0.13, SD = 0.47$	$M = 0.00, SD = 0.64$	$M = -0.03, SD = 0.50$	$M = -0.26, SD = 0.50$
#2	$M = 0.00, SD = 0.45$	$M = 0.39, SD = 0.64$	$M = 0.18, SD = 0.52$	$M = 0.03, SD = 0.46$
#3	$M = 0.12, SD = 0.48$	$M = -0.11, SD = 0.68$	$M = -0.14, SD = 0.36$	$M = -0.11, SD = 0.72$
Comparisons between the sessions				
#1 VS #2	$t(75.90) = -1.31$, $p = .20, d = 0.30$	$t(75.99) = -2.73$, $p = .01, d = 0.62$	$t(63.91) = 1.67$, $p = .10, d = 0.41$	$t(62.52) = -2.34$, $p = .02, d = 0.61$
#1 VS #3	$t(75.91) = -2.37$, $p = .02, d = 0.54$	$t(75.76) = 0.67$, $p = .50, d = 0.15$	$t(58.17) = 0.96$, $p = .34, d = 0.24$	$t(57.45) = 1.01$, $p = .31, d = 0.25$
#2 VS #3	$t(75.63) = -1.13$, $p = .26, d = 0.26$	$t(75.65) = 3.33$, $p = .00, d = 0.75$	$t(57.04) = 2.85$, $p = .01, d = 0.70$	$t(54.68) = 0.95$, $p = .35, d = 0.23$

condition moved along the *y*-axis and focused more on instruction in Session #3 compared to Session #2, while the reflective discussion in the control condition returned to the teacher-centered perspective in Session #3. Finally, there was a significant shift between Sessions #1 and #3, which remained only in the experimental condition along the *x*-axis and focused more on student-centered perspectives with a medium effect size ($d = 0.54$). These results indicate that only in the experimental group was there a gradual enhancement in student-centered perspectives across the three sessions.

Characteristics of differences appearing in the discourse

We further investigated how the perspective-taking manipulatives were used in the discussions when the student teachers reflected on their performance, especially in Session #2. We analyzed the videos in the reflective discussions and identified 48 scenes in 13 discussions when they significantly manipulated the 3D animation to switch viewpoints to a variety of students. Then we extracted specific discourse by using the WebENA tool along with the abovementioned scenes, which matched the characteristic shift from Session #1 to Session #2 based on the comparison plot (Table 7)—the comparison plot in Table 7 showed a strong linkage between *Focus on Student Management (SM)* and *Focus on Teacher Management (TM)* in Session #2 in comparison with Session #1. As such, we tried to identify scenes in the dialogue showing how the student teachers internalized the student-centered perspectives when they manipulated the 3D animation.

As a result, we identified 25 discourse excerpts. These discourse excerpts shared the common characteristic that the student teachers paid attention to students' statuses (which were originally represented by the LED in the puppetry) and discussed how to deal with such students in the situation in the role-play or in actual teaching practice to improve dialogic teaching. The following is one representative excerpt that appeared almost at the end of one discussion:

(2210) Betty (student role): Ah, invincible mode.   [SM]
(2211) Cindy (teacher role): Invincible mode.   [SM]
(2212) Betty: Energy release visible.   [SM]
(2213) Cindy: I don't know, but maybe I should have asked
    questions more frequently.   [TI & TM]
(2214) Betty: Ah (agreeing).   [TI & TM]
(2215) Cindy: There were two big questions, and, you know, most
    of the lesson was my explanation.   [TM]
(2216) Cindy: Among the explanations, a question for example,
    what time is it here, or the light one like 9:10 here, what time
    is it here?   [TI & TM]
(2217) Betty: Uh-huh (agreeing).   [TI & TM]
(2218) Cindy: If I asked more questions, it's like…   [TI & TM]
(2219) Cindy: It's a grade where teachers ask more and more
    questions, and they want to answer them.   [SM]

The simulated lesson dealt with the calculation of time. Before the beginning of this excerpt (in line 2210), and while watching the 3D animation, Alice began to switch viewpoints of the 3D animation without saying a word (in line 2200), but Betty and Cindy held a discussion. Betty and Cindy later noticed that some student characters in the 3D animation entered the "invincible mode", which is a representation of the students' concentration as shown by the blue LEDs of the puppet indicators (in line 2210). Cindy said that she "should have asked questions more frequently" (in line 2213), because "most of the lesson was the teacher's explanation" and "it's a grade where you ask more and more questions and they want to answer them" (in line 2219). In fact, the role-playing students concentrated on the lesson according to the representations in the 3D animation. It is apparent that Cindy realized that she should have been able to conduct more dialogic teaching by asking "questions more frequently." This reflection was elicited when the student teachers observed that the student characters were in "invincible mode," which is a representation of a student character's concentration, in the 3D animation when the student teacher clicked on the characters and changed the viewpoints of those characters.

Discussion and conclusion

It is widely accepted that role-play is a useful educational intervention for learning a variety of topics by fostering perspective-taking. To bolster the potential of role-play with human-centric topics such as microteaching, we investigated a CSCL learning environment for microteaching, which is a common instructional practice in the field of education. Microteaching requires taking the perspective of various students to acquire dialogic teaching skills. In this paper, we conceptualized culturally meaningful mediating manipulatives, such as puppets, and perspective-taking manipulatives, such as characters appeared in the 3D manipulable animation, to allow learners to shift viewpoints in order to foster dialogic perspective-taking. Based on the findings in the study wherein both manipulatives were incorporated as mediating devices to support the perspective-taking in the CSCL, we discuss two clusters of findings below.

A combination of mediating and perspective-taking manipulatives in role-play-based learning

We proposed to employ the two manipulatives (mediating and perspective-taking) to enhance learners' perspective taking in role-play-based learning, which is challenging for learners in the absence of scaffolds. The mediating manipulatives were introduced to enhance learners' performances in the role-playing. The perspective-taking manipulatives enable learners to switch viewpoints while watching the animation of the role-play; these were introduced to support the learners in appropriating a variety of perspectives of envisioned students during the reflection.

The results showed that both manipulatives together significantly shifted the student teachers' perspectives to being more student centered, especially after the intervention. This immediate transfer did not occur when using only the mediating manipulatives without the perspective-taking manipulatives, even though the mediating manipulatives themselves significantly changed the discourse patterns in the improvisational microteaching role-plays and the reflections. This seems to correspond with the previous studies of bifocal modeling (Bilkstein et al., 2016; Peppler et al., 2020a).

According to the results, the mediating manipulatives worked well as intended to foster perspective-taking in the student teachers' performance and in their immediate reflection. This was potentially enabled by the puppets. The characteristics of the puppets provide psychological safety in role-playing, which is similar to the way these characteristics provide psychological safety in people's daily cultural practices such as playing or religious rituals such as praying. Kreijns et al. (2013) argued "[t]he tangible (i.e., the physical and technological) elements … do not by themselves influence the quality, content, and intensity of the socioemotional interaction, but these elements can be designed in such a way that it becomes more likely that they can exert that influence" (p.231). This study demonstrates how the characteristics of the tangible mediating manipulatives can influence the quality and content of the interaction, eliciting the potential of learners' imagination and performance. There are other possible applications using cultural or historical artifacts that human beings use to appropriate cultural situations (Vygotsky, 1978) and that can elicit human performances in CSCL (Peppler et al., 2020b). CSCL research should investigate such cultural aspects in order to find opportunities to elicit learners' potential performances, which in turn should offer the key to prospective semiotic turns with a focus on materiality, as Reimann has indicated (Ludvigsen et al., 2016). In addition, this study further suggests that it is essential to emphasize multiple first-person perspectives in the perspective-taking manipulatives in the virtual settings (i.e., the computer animation) to ensure the desired level of reflection.

Nonverbal representations in perspective-taking manipulatives to bolster empathy in imaginary roles

The results of this study show that the combination of mediating and perspective-taking manipulatives significantly shifted student teachers' perspectives to being more student centered, especially after the intervention (i.e., in the immediate transfer task). Interestingly, the additional qualitative analysis suggests that the characteristics of the second reflection were triggered by changes in the students' statuses represented in the 3D animation while the student teachers were manipulating the viewpoints. In such scenes, the

student teachers considered how the students felt in their lessons based on their representations of nonverbal aspects of the students' voices in the 3D animation and how imaginary students in actual classrooms would feel in their prospective lessons.

We believe that this kind of empathy grounded in the nonverbal performance in a role-play could play a role in fostering dynamic and steady improvements in learners' perspective-taking. Taking a first-person perspective through virtually manipulating viewpoints is able to foster empathy with characters appearing in the 3D animation (van Loon et al., 2018). However, as van Boven et al. (2013) argued, the "empathy gap" can affect perspective-taking because people tend to unconsciously underestimate the emotional situation of others (see also, Ioannou & Constantinou, 2018). Therefore, to foster perspective-taking in the reflections, visualizing nonverbal representations that bridge the empathy gap as mediators is crucial when using perspective-taking manipulatives. In fact, student teachers in the video reflection condition are able to watch the changes in the nonverbal status of puppets by looking at their LED colors. However, the impact was not significant as regards the student teachers' perspective-taking, whereas the perspective-taking manipulative was productive because it prompted more empathy, as observed in the qualitative analysis.

We need to further pursue how to utilize such nonverbal representations in perspective-taking manipulatives in the next steps of this research programme. For instance, recent studies using high-tech VR-based microteaching sometimes have reported less effectiveness than self-performed teaching simulations do (e.g., Ke et al., 2020). However, the abovementioned studies did not focus on nonverbal representations by which student teachers empathize with possible imaginary learners, so that the student teachers would consider the leaners' perspectives. Our study has confirmed that the nonverbal representations of characters represented in the virtual space was a possible key factor in achieving good dialogic thinking and performance during role-playing in CSCL by investigating the combination of mediating and perspective-taking manipulatives. Therefore, enabling student teachers to represent and recognize characters' emotions in nonverbal ways in virtual spaces is able to elicit more fruitful reflection by prompting empathy with a variety of imaginary students so that the student teachers are able to achieve more effective microteaching in CSCL.

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