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RESEARCH ARTICLE

Representational guidance and student engagement: examining designs for collaboration in online synchronous environments

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Abstract In this paper we report the results of a study which investigated the affordances of multi-user virtual environments (MUVEs) for collaborative learning from a design perspective. Utilizing a mixed methods approach, we conducted a comparative study of the effect of varying representational and interactional design features on a collaborative design activity in three online synchronous environments. We compared environments featuring multiple modes of interaction (MUVEs), shared representations (text chat and 2D still images) and text-only features. Sixty-one students enrolled in an undergraduate course on Child Development participated in the study. Participants were asked to design a theoretically-based, developmentally appropriate, preschool classroom setting. Students were randomly assigned to one of three online learning environments that provided varying levels of representation and interaction. Significant differences in collaborative problem solving interactions were found. Participants in the shared representations + text condition evidenced stronger learning outcomes as regards substantive discussion and integration of child development concepts; while participants in the MUVE condition reported the most enjoyment with the experience. These findings are explained by the concepts of representational guidance, representational bias, educational affordances and interface design metaphors. Suggestions for the design of MUVEs for collaborative learning are provided.

Keywords Collaborative learning · Design of learning environments · Chat · Multi-user virtual environments · Representational guidance

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A recent technological advancement that will likely have an impact on collaborative learning in higher education contexts is multi-user virtual environments (MUVEs). A MUVE is an immersive, computer-based simulation that one navigates through manipulating an avatar. The design of many educational MUVEs is built on the theory of situated learning (Brown et al. 1989); such design centers on enabling participatory and interactive learning experiences for students (Barab and Dede 2007). Situated learning approaches may also include providing students the opportunity to actually build or design the environments themselves by manipulating provided 3D objects (Bers 2001; Bers and Chau 2010).

Social interaction is a key aspect of learning in MUVEs (Dickey 2005). This is not surprising, as MUVEs have evolved, in part, out of text-based, synchronous computer mediated communication environments (e.g., MUD and MOO and environments[1]). Therefore, the full educational value of MUVEs derives not only from the immersive and situated nature of the design of the simulation, but also from productive collaboration among students within the environment itself. The purpose of this paper is to investigate collaborative learning and interaction in MUVEs from a design perspective.

Facilitating online synchronous collaborative learning

As in co-present situations, collaborative learning in online synchronous environments relies upon the development of a shared understanding of the group undertaking (Roschelle and Teasley 1995). Establishing this shared understanding is aided by joint student interaction with shared representations such as graphical inscription (Suthers 1999). For example, in a study of the effects of varying graphical inscriptions (matrix, graph and text only) on online collaborative interactions, Suthers and Hundhausen (2001) found that students in the matrix condition spent more time-on-task discussing evidential relations than either the graph or text conditions. According to Suthers and Hundhausen, this may be so because matrices prompt students to consider all possible relationships through the display of empty fields. In further analysis of the same data set, Suthers and Hundhausen (2002) found differences in the level of elaboration students engage in as a result of the representation with which they are working. Moreover, based on the results of their study on representational guidance, Toth et al. (2002) argue that shared representations displayed on a computer screen act as referents that make salient the epistemic features of a topic of interest and serve to focus student's attention on relevant concepts for discussion and further elaboration. And, as demonstrated in their research on the importance of self-explanation to learning outcomes, Chi et al. (1989) have shown that elaboration is a key activity leading to positive learning outcomes for students.

The development of shared understanding in synchronous environments is also assisted by the provision of tools for multimodal interaction that result in varied representations of the concept(s) under study, for example, text chat for verbal exchanges and a whiteboard for drawn inscriptions (Çakir et al. 2009). Indeed, Sarmiento and Stahl (2007) have shown how mathematical inscriptions drawn on a Cartesian grid displayed on a shared whiteboard became referential artifacts around which virtual collaborators organized their discussions. The ability to draw ideas on the shared whiteboard is an *educational affordance* of the

[1] MUD (Multi-User Dungeon), MOO (Multi-User Dungeon Object Oriented): MUDs and MOOs are online, text-based virtual worlds.

technology that makes possible the learning of concepts in geometry (Kirschner et al. 2004).

Furthermore, based on a micro-analytic study of student interactions in an online collaborative math environment, Stahl (2007) argues that synchronous learning environments that provide for multiple modes of interaction promote student learning through the joint coordination and sequencing of both semantic and symbolic inscriptions. And as a result of a study of the mediating effects of a whiteboard on student interactions, Dillenbourg and Traum (2006) add that it is the persistence of the inscription on the computer screen itself that facilitates these student interactions.

MUVEs feature shared representations and they offer multiple modes of interaction. Therefore, they appear to have great potential for fostering collaborative learning online. MUVEs provide shared representations in the form of the metaphorical design of the 3D space itself (Gao et al. 2005). Metaphorical design refers to virtual instantiations of a concrete place or item. Gao et al. argue that metaphorical design provides students "a feeling of 'place' resulting in users of the system being more likely to relate to it and have sustained involvement in the online activities" (p. 70). MUVEs feature multiple modes of interaction in the form of text chat and the shared ability to manipulate objects within the environment (Sullivan 2009). In this paper, we argue that the shared ability to manipulate objects in a 3D world is an *educational affordance* of MUVEs that supports student learning in *collaborative design activities*. In other words, the ability of students to move objects in a virtual environment as part of a collaborative design activity will influence the course of their interactions, discussions and learning. Essentially participants' shared ability to manipulate objects operates similarly to drawn inscriptions contributed by collaborative group members (Sarmiento and Stahl 2007; Dillenbourg and Traum 2006). When participants in the MUVE move the virtual objects to a new position on the screen, they create a new representation of the problem under consideration. Much as a drawn inscription did in the above cited research, we hypothesize that this new, dynamic representation will serve to organize and sequence student collaborative interactions in the MUVE.

Our work investigates the affordances of 3D, manipulable representations (in-world, movable objects) for facilitating student discourse and collaborative learning while engaged in a design activity. Design is an important component of many disciplines. In this study, we focus on the design of a developmentally appropriate pre-school classroom by students enrolled in a child development course. Designing a pre-school classroom focuses on the creation of specific learning centers and requires comprehension of developmental aspects of human cognition (Kostelnik et al. 2004). Understanding the developmental underpinnings of the specific design of a pre-school classroom is an important competency for pre-school teachers to develop (Copple and Bredekamp 2009) and can serve as an authentic performance task in which students can demonstrate and apply their understanding of child developmental principles. We argue that MUVEs provide unique affordances for learning this competency due to the ability to manipulate and move objects within a simulated pre-school classroom environment.

As noted above, MUVEs provide both shared representations and multiple modes of interaction. Therefore, in order to distinguish the specific affordances of the 3D, manipulable representations in the MUVE environment we compared discussions in the MUVE with student discussions in a chat environment that features shared representations in the form of still, non-manipulable 2D images, and a chat environment that features only one representational mode: text. Based on the above cited research, we would expect both the shared representations and the 3D, manipulable objects to aid students in focusing and organizing their discussions towards productive dialogue. However, Suthers (1999) has argued that particular representations help in "expressing certain aspects of one's knowledge better than others" (p. 3). Since these two representations (2D *non-manipulable still image* and 3D, *manipulable object*) allow for different levels of interaction, it is possible that they will exert differential influences on student discussions. Our study examines this possibility. The inclusion of a text only condition allows us to expand upon previous findings on the impact of representations on collaborative learning. For example, Suthers and Hundhausen (2002) found that participants in their text-only condition were less likely to re-visit previously discussed ideas than those in the matrix or graph condition. By including a text-only condition in our study, we are able to expand on this finding as regards specific problem solving aspects of collaborative interactions in these environments. This comparison is meaningful as many readily available online synchronous communication environments provide for text interaction only and are therefore, likely to be used in many educational settings. Understanding the learning affordances and constraints of such environments is important.

At the heart of our analysis is student talk. Student talk, as arguably most talk, can be best understood through the theory of speech genres. We now briefly explain the theory of speech genres in order to clearly ground our analytical approach.

Speech genres

Through literary analysis, Bakhtin (1986) has developed a theory of communication centered on the dialogic character of individual utterances and the notion of speech genres. In his theory, the utterance is the basic unit of speech communication. Dialogic in nature, an utterance is a link in a complex chain of utterances that have come before and those that will come after. According to Bakhtin, one's speech is shaped by consideration of the addressee, the possible responses of the addressee and the context of the conversation. Speech genres are characterized by relatively stable types of utterances occurring within a particular sphere of human activity (e.g., home life, work life, social life, etc.).

Bakhtin (1986) emphasizes the "extreme heterogeneity of speech genres" (p. 60), meaning that there are many and varied types of speech genres from everyday talk to various forms of writing (e.g., the novel, scientific reports, social commentary, business documents) to verbal military commands to poetry. The social and symbiotic nature of speech genres may be regarded as tools that help us act in and make sense of the world, and as products of our acting in and making sense of the world (Varelas et al. 2002). Speech genres serve to organize a sequence of interactions in a culturally recognizable situation (Wells 1999). For example, the well known classroom discourse pattern of initiation, response, evaluation (IRE) (Sinclair and Coulthard 1975) is called a micro-genre by Wells (1993). This educational speech micro-genre sequentially organizes the culturally recognizable situation of a teacher eliciting a specific response from a student and then evaluating the accuracy of that statement. In this way, speech genres accomplish specific rhetorical tasks in specific communities, reflecting the practices and ideological positions of those communities (Bakhtin 1981; Kamberelis and Bovino 1999).

In this paper, we define a collaborative problem solving genre based on Poole and Holmes' (1995) decision function coding system. This system includes types of utterances such as orienting to the task, analyzing the problem, developing solutions, discussing solutions, agreeing or disagreeing, critiquing solutions, and seeking alternative solutions. The problem the students are trying to solve in this activity is how to design a developmentally appropriate pre-school classroom. Analysis of student talk in the three environments using the collaborative problem solving speech genre allows us to develop our understanding of the meaning making process at work in the environments and to examine the role of representational design in this process.

Research questions

Towards that end, we developed the general research question: what is the impact of representational design on student collaborative problem solving in online synchronous learning environments? To specifically address this question, we developed the following sub-questions: (a) are there differences in the collaborative problem solving talk across three representational designs (3D, manipulable objects + shared representations + text (MUVE); shared representations + text (SR + T); and TEXT (TEXT)? (b) How may these differences be characterized? In addressing these questions, we utilized a mixed methods approach to explore the convergence of data drawn from a qualitative analysis of the types of collaborative problem strategies employed at the level of the individual and group, as well as quantitative analysis based on the perceptions of the individual participants themselves and an independent evaluation of learning outcomes.

Methods

Participants and setting

This study took place at a large public university in the Northeastern.

United States. Sixty-one participants were recruited from three sections of an undergraduate course on Child Development (total enrollment across all sections was 180 students) to take part in the study. This course fulfills a General Education requirement and is also a prerequisite for some majors (e.g., Communication Disorders). The second author routinely teaches this course; though she did not teach during the semester the study was conducted. Participants in the study were similar to those typically enrolled in child development in terms of the gender distribution (81% female), ethnicity (78% were European American), and class standing (35% sophomores, 29% juniors or seniors, and 5% freshman). As is a common practice in social and behavioral sciences classes, instructors of each section offered participants extra credit for their participation.

Activity and materials

The activity the students were asked to engage in was to design a classroom environment that would best support the learning and development of preschool children aged 3–5 years. Participants were asked to discuss what toys, materials or equipment they might choose for the classroom and to provide rationales or reasons for their choices based on the theories, research, concepts and ideas they have been learning about in class. A similar version of this activity has been typically given to child development students as part of small group asynchronous online discussions. From a pedagogical perspective there is no "right answer" or final product expected. Instead students are evaluated in terms of their participation in the discussion, their reference to concepts covered in the course, and their ability to generalize the text material to their personal or professional experience. In this activity, students were not learning new information, but synthesizing content they had already read about and discussed in their respective sections. Here, we use the term synthesis as defined by Bloom et al. (1956) as an aspect of higher order thinking that includes originating, integrating and combining ideas into a plan, project or proposal that is new to the student. Synthesis is an important aspect of higher learning in any domain.

Online discussion tools and setting

Three online discussion tools were used in the study. Students in the TEXT condition utilized the iChat utility available on Apple computers (see Fig. 1). Students in the SR + T condition used the Yahoo! Messenger chat utility (see Fig. 2). They also had access to a stand-alone web page that displayed images of various toys and preschool equipment which served as shared representations. The site was created by the researchers specifically for this study and did not contain links to other web sites. The items displayed there were labeled object 1, object 2, etc., (see Fig. 3). The SR + T condition necessitated toggling between two open windows—the chat utility window and the web page displaying the images. While some may be concerned with the extra effort needed to toggle between the two windows, our results (reported below) do not indicate that this was an undue burden on

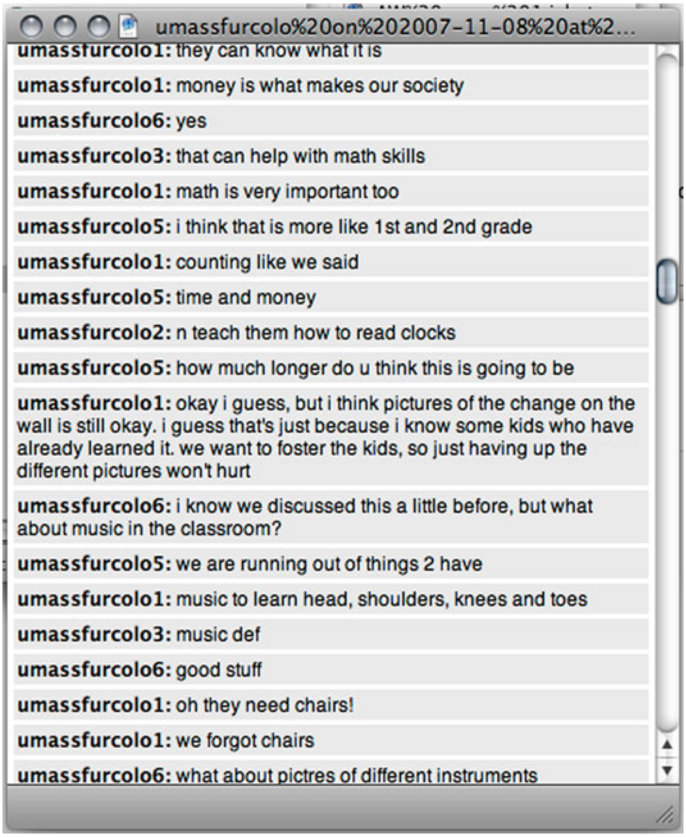

Fig. 1 iChat utility screen shot (text-only condition)

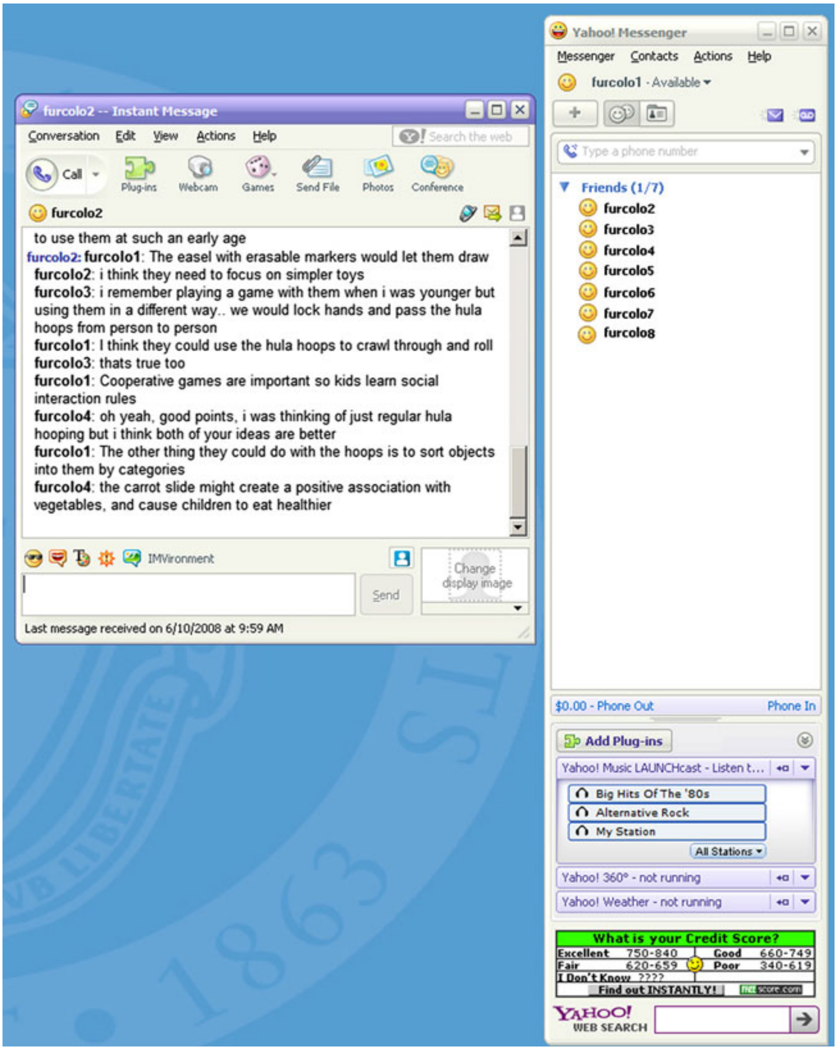

Fig. 2 Yahoo! Messenger utility (SR + T condition)

the students in this condition. The available computer labs at the university contained both Macs and PCs; iChat runs on the Mac and students who participated on Macs worked in iChat. Yahoo! Messenger runs on PCs, students who participated on PCs utilized Yahoo! Messenger. In terms of function, these utilities are isomorphic. We used these two chat utilities because they were available in the computer labs where the study took place.

The MUVE was created using the windows-based program, Active Worlds (Fig. 4). The MUVE design featured a shared representation in the form of a virtual instantiation of a preschool classroom with four walls and a rug in the center of the room and multiple modes of interaction in the form of a text chat utility embedded in the MUVE and 3D, manipulable objects (toys and preschool equipment) we created for the study. Participants in the MUVE condition selected representations of themselves ("avatars") to act in the 3D space.

Fig. 3 Web site of objects screen shot (SR + T condition)

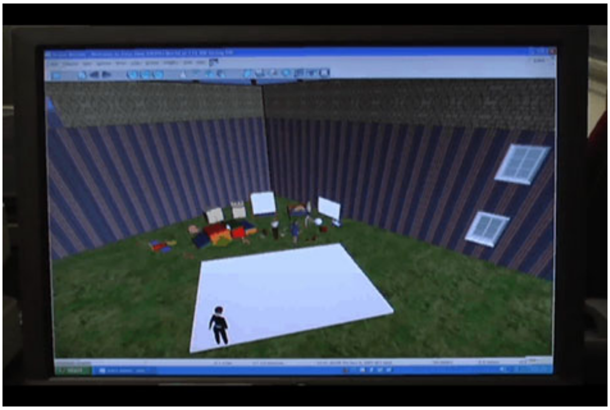

Fig. 4 Active Worlds screen shot (MUVE condition)

Participants in the SR + T and the MUVE conditions were provided with the same 18 objects that served as shared representations and could be used to facilitate their discussion. Participants were free to suggest additional objects to use in the design task. The TEXT group was provided with no visual materials with which to consider the task. Table 1 provides a summary of the three conditions by tools used and the representational design of each environment.

Table 1 Design elements of chat environments by condition

Condition	Tool(s)	Representational design
TEXT	iChat	Text chat
SR + T	Yahoo! Messenger and Web Page Display	Text chat and shared representations (images of toys, materials and pre-school equipment)
MUVE	Active Worlds	Text chat, shared representations (virtual instantiation of preschool classroom) and 3D, manipulable objects

Procedures

The study took place in two computer labs at the university. Project sessions lasting approximately 90 min were scheduled over four evenings with two sessions offered each evening. Participants were randomly assigned to one of three online discussion formats based on their arrival for the session; as each participant signed in for the session they were assigned in turn to a discussion group. This procedure was utilized in part to minimize participants' prior familiarity with each other; students arriving together were placed in different discussion groups. When all participants had arrived the researchers explained the human subject's protocol and collected student consent. Next, the participants all completed a demographic survey. Then each of the three different groups of students went to separate training rooms where they engaged in a 15 minute chat utility training session, after which they convened in the respective computer labs. In the computer labs, students were instructed on the task and they were also asked not to speak with one another during the chat sessions. At this point, the students engaged in the design task for 30 minute. At the end of the task period, the students re-convened in the larger classroom to complete the 15 minute post surveys. Four to five participants worked within each group to complete the online activity. A total of 13 online discussion groups met (four TEXT, four MUVE, five SR + T). Logs for 12 of the chats were retained for analysis; one SR + T log was incomplete because of technical errors and was not included in the study.

Instruments

Frohlich (1993) has argued that simulative environments have a greater capacity to engage students due to the ability to directly manipulate objects in the environment. The agency afforded by these environments is augmented by the ability to involve students in authentic learning activities, which is also hypothesized to lead to more engaged students and more meaningful learning (Barab and Dede 2007). Indeed, Annetta et al. (2008) found that pre-service teachers utilizing a MUVE in one of their courses were enthusiastic about the educational potential of MUVEs particularly as regards their ability to engage and motivate students. Higher levels of engagement with an activity have been shown to lead to better learning outcomes for students, in for example their ability to solve problems (Dweck and Leggett 1988).

Therefore, in order to examine whether or not participants in our study experienced different levels of engagement by condition, we developed and administered a post-survey. In the post surveys, we asked participants to rate, on a four-point scale, their overall experience during the activity, level of engagement in the online activity, their perceptions about the usefulness of the particular online discussion format they used in terms of child development as well as for future coursework, and their general perceptions about the experience. Two participants declined to provide survey information but did participate in their discussion groups.

An instructional rubric (Appendix) was used to individually evaluate participant learning outcomes as would be expected for students enrolled in this course. This rubric was developed by the second author to evaluate student performance on similar tasks conducted through asynchronous discussion groups and typically assigned for course credit in this child development course (though not assigned to any of the sections from which participants in this study were drawn). While this rubric is used routinely to evaluate student performance in course related tasks there is no external validation. Two graduate teaching assistants who had each assisted in the child development course for 1 year, but not in the class sections from which the participants were drawn, reviewed the transcripts of each chat group and evaluated the performance of the individual participants. These graduate students were blind to the chat condition and to the study design; the rubric was used as in grading previous student assignments. Given that the grading rubric was based on a rating scale, inter-rater reliability was calculated using Goodman and Kruskal's Gamma. The values across the rubric indicators ranged from .714 to 1.00.

We also used a brief survey at the beginning of the study period to gather demographic data about the students (i.e., gender, ethnicity and class standing).

Data analysis

In our data analysis we explored how different sources of data, converged to present a picture of the potential affordances offered by the three designs including qualitative content analysis of the individual and group problem solving strategies, as well as quantitative analysis of participant perceptions as recorded on the post survey and student performance as measured by the instructional rubric. We present our analyses by data source. First, we examine the session logs of each chat to address differences in the collaborative problem solving talk across the three representational designs. Second, we explore, qualitatively, differences in problem solving talk found in the session logs. Finally, we present the data from the post-surveys and instructional rubric which provide information about student perceptions and learning outcomes associated with the three designs.

For each group and across conditions we used content analysis to examine student interactions. The decision function coding system (DFCS) created by Poole and Holmes (1995) is a method that specifically addresses the speech genre of collaborative problem solving. The DFCS offers two levels of analysis. The first level regards the individual utterance. At this level each utterance is coded into one of the categories or sub-categories as listed in Table 2. A sample of our coded data using this first level of coding is presented in Table 3.

The second level of analysis considers individual utterances in relation to other utterances to identify specific problem solving phases that a group may pass through as they collaboratively make decisions. According to Poole and Holmes (1995) "A phase is defined as a coherent period of group interaction and activity that serves an identifiable function, such as a period of problem definition, solution evaluation, or conflict" (p. 102). Table 4 summarizes these phases. A particular phase is identified when three adjacent comments elicit the same category or sub-category code. For example, three orienting comments in a row would indicate an orientation phase in the dialogue.

As can be seen here, phases and individual interaction codes may have a one-to-one correspondence (orienting comments indicate an orientation phase). However, some phases

Table 2 The decision function coding system—level one categories Poole and Holmes' (1995)

Decision function coding system categories
1. Problem definition
1a. Problem analysis: Statements that define or state the causes behind a problem
1b. Problem critique: Statements that evaluate problem analysis statements (may be assigned positive [+] or negative [−] valence)
2. Orientation
2a. Orientation: Statements that attempt to orient or guide the group's process. These also include simple repetitions of others' statements or clarifications
2b. Process reflection: Statements that reflect on or evaluate the group's process or progress
3. Solution development
3a. Solution analysis: Statements that concern criteria for decision making or general parameters for solutions
3b. Solution suggestion: Suggestions of alternatives
3c. Solution elaboration: Statements that provide detail or elaborate on a previously stated alternative. They are neutral in character and provide ideas or further information about alternatives
3d. Solution evaluation: Statements that evaluate alternatives and give reasons, explicit or implicit, for the evaluations. They may be assigned positive (+) or negative (−) valence. Statements that ask for evaluations or are bivalent are coded as neutral (/)
3e. Solution confirmation: Statements that state the decision in its final form or ask for final group confirmation of the decision. They may be assigned positive (+) valence if they argue for confirmation, or a neutral (/) valence if they merely ask for confirmation
Negative responses to 3e statements are coded 3d−
4. Nontask: Statements that do not have anything to do with the decision task. They include off-topic jokes and tangents
5. Simple agreement
6. Simple disagreement

Table 3 Sample of data coded with first level DFCS codes

Participant: utterance	DFCS first level code
furcolo1: hi there	4
furcolo4: hi!	4
furcolo2: hi	4
furcolo5: So?	2
furcolo1: has anyone thought of any ideas?	2
furcolo5: what are you guys thinking of for this classroom idea?	2
furcolo1: i am looking through the icons that they gave us now	2
furcolo3: the first things that jump out at me are the blocks	3b
furcolo1: some of them would definitely work	3c
furcolo1: yes, the blocks are a good idea	5
furcolo5: I think we should include a sandbox…	3b
furcolo1: object 10 correct?	2
furcolo3: for that whole constructive play	3c
furcolo2: yes, i love the blocks	5
furcolo4: I like the large puzzle pieces	3b

Table 4 Decision-making phases and DFCS phasic indicators Poole and Holmes' (1995)

Symbol	Definition	DFCS phasic indicators
PA	Problem analysis	1a, 1b+
PC	Problem critique	1b−
OO	Orientation	2a, 2b
CD	Criteria development	3a
SD	Solution development	3b, 3c
SA	Solution approval	3d+, 3d, 3e+, 3e
SC	Solution critique	3d−, 6
IN	Integration	4

may be indicated by more than one individual interaction code. For example, the solution development phase may be indicated by solution suggestion and/or solution elaboration interaction codes. The solution development phase category is a broader category that subsumes these individual interaction codes, yet, still accurately reflects group activity during that particular time period.

According to Poole and Holmes (1995), phasic-codes may be combined to create composite phases that identify meaningful sequences. We were interested in identifying sequences that evidenced substantive discussion of the problem. For example, an individual may make a comment that contributes to criteria development which spurs others to provide solution development comments. This is a meaningful sequence. Furthermore, we realized that the composite phases actually identified segments of the discussion that were most substantive in that they revealed the tensions in the development of the solution through criteria development, solution critique and finally solution approval. For the purposes of our analysis, we identified the following composite phases: criteria development/solution development, solution critique/solution development and solution development/solution approval. A sample of our data coded for phase is presented in Table 5.

Table 5 Sample of data coded with DFCS second level phase indicators

Participant: utterance	Code	Phasic indicator	Phase
umassfurcolo3: it could be good for them to paint a picture together…to show how each of them have something to contribute	3b	SD	
umassfurcolo7: yes so they can build their motor skills	3d+	SA	
umassfurcolo4: yea like a huge mural	5 3c	SD	SDSA
umassfurcolo6: and learn to work together	3c	SD	
umassfurcolo3: yeah and how to share the materials	5 3c	SD	
umassfurcolo6: and how to get messy	3c	SD	SD
umassfurcolo5: different stations for coloring reading etc.	3b	SD	
umassfurcolo4: some recess anyone? got to let out some energy,	3b	SD	
umassfurcolo3: yeah. Legos would be good too 3b	SD	SD	
umassfurcolo6: yeah and some organized games outside like red rover or kickball	3c	SD	
umassfurcolo3: jump rope,	3c	SD	
umassfurcolo4: 3 is really young i think though for school,	3a	CD	CDSD

The DFCS allows the decision paths of the online groups to be analyzed and compared for similarities and differences. Each utterance in the session logs was coded and phasic indicators identified. The DFCS coding method required careful and intensive review of each session log. Training and coding proceeded concurrently in the following manner: after a careful review of the DFCS coding materials, two members of the research team individually coded the same session log. When coding discrepancies were identified, they were resolved through consensus building discussion among the coders and in consultation with the second author. Inter-rater reliability was calculated based on Krippendorf's alpha. The first jointly coded session log yielded an alpha of .31, the second an alpha of .66 and the third an alpha of .72. In scoring the fourth session log, coders demonstrated an inter-rater reliability of 1.00 (indicating complete coding agreement) and therefore the remaining eight session logs were coded individually.

Once content analysis was performed on all of the chats, we further analyzed the logs to identify the chat within each condition that demonstrated the highest level of substantive dialogue, as evidenced by the frequency of composite phase indicators. These representative chats were then comparatively analyzed to further explain problem solving trajectories (how the group went about solving the problem) and the nature of the substantive discourse. This comparative analysis consisted of research team member's individually comparing the dialogue in each representative chat, followed by a research group meeting that focused on discussing the results of individual analyses. Consensus on problem solving trajectories and differences in substantive discourse was achieved through group discussion.

Post survey analysis

The post survey analysis focused on student experience during the study and the rubric provided an independent evaluation of individual student learning outcomes, which allowed us to further interpret the results.

Results

Chat content analysis

Our content analysis of collaborative problem solving indicated differences across conditions in the average frequency of problem-solving phase. For example, the average frequency of solution development phases for participants in the TEXT condition was four times as great as either the SR + T or MUVE condition and the average frequency of solution critique/solution development composite phases for the TEXT condition was almost twice that of either the SR + T or MUVE condition. The SR + T condition produced criteria development/solution development and solution development/solution approval composite phases at more than twice the average frequency than either the TEXT or the MUVE condition. And participants in the MUVE condition produced orienting phases and non-task phases at twice the average frequency of either the TEXT or SR + T condition. Table 6 provides the raw counts of problem-solving phases per condition, including the total number of phases in each condition. Figure 5 displays the average frequency of phases by conditions as a percentage of all phases within a given condition.

To further understand these differences, we analyzed the utterances of individuals across conditions using DFCS first level codes. MANOVA analysis indicated that

Table 6 Numerical count of problem solving phase by condition

	CD	CDSD	IN	NP	OO	SA	SC	SCSD	SD	SDSA	SDSC	Total
TEXT	3	20	40	8	20	3	1	24	144	31	0	294
SR + T	3	40	76	8	14	7	0	12	28	45	1	234
MUVE	0	3	77	13	23	1	1	6	11	12	0	147

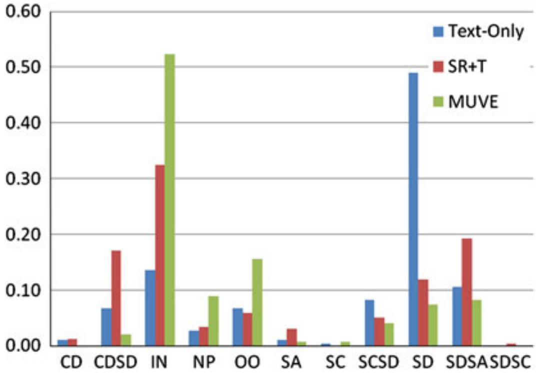

Fig. 5 Average frequency of phase by condition

Table 7 Types of individual problem solving contributions by condition

	TEXT	SR + T	MUVE	*F*(2, 53)	*P*	Partial η^2
Orientation of group	$.09_a$	$.11_b$	$.25_{a,b}$	17.91	.000	.40
Solution analysis solution	$.03_b$	$.06_a$	$.01_{a,b}$	8.16	.001	.24
Suggestions solution	$.16_b$	.11	$.09_b$	4.07	.023	.13
Elaboration solution	$.24_{a,b}$	$.15_b$	$.09_a$	11.06	.000	.29
Evaluation solution	$.03_a$	$.16_{a,b}$	$.05_b$	15.01	.000	.36
Confirmation	.00	.00	.01	1.73	.186	.06
Non-task	.24	.18	.31	.97	.380	.04
Agreement	.18	.22	.15	1.14	.327	.04
Disagreement	.01	.01	.00	0.27	.767	.01

Note: Means represent the percent of total utterances made by an individual participant. Shared subscripts indicate significant differences between means at $p < .05$

individual problem solving contributions vary by condition (Wilks' (.15), $F(18, 90) = 7.49$, $.2 = .61$, $p < .001$). Post hoc mean comparison test (Bonferroni) results (df 2, 53) indicated that significant differences were observed among the three conditions in the comments related to orientation, solution analysis, solution suggestion, solution elaboration, and solution evaluation. Table 7 provides the results of the Bonferroni tests. The MUVE participants engaged in more orientation comments than those in both the TEXT and SR + T conditions and less solution analysis than either the TEXT or SR + T groups. Participants in the TEXT condition made more solution elaboration comments than those in the SR + T and MUVE conditions and more solution suggestion comments than the MUVE condition. SR + T participants engaged in more solution evaluation comments than those in the MUVE and TEXT conditions.

Table 8 Substantive Collaborative problem solving talk as a proportion of total talk for all groups

Group	Substantive talk ratio
TEXT Group 1	.20
TEXT Group 2	.22
TEXT Group 3	.26
TEXT Group 4	.40
SR + T Group 1	.11
SR + T Group 2	.70
SR + T Group 3	.71
SR + T Group 4	.61
MUVE Group 1	.05
MUVE Group 2	.29
MUVE Group 3	.32
MUVE Group 4	.23

Composite phase analysis

To develop a deeper understanding of the observed differences in collaborative problem solving interactions, we selected the one chat from each of the conditions that evidenced the most substantive collaborative problem solving dialogue. As previously mentioned, we judged the composite phases to be strong indicators of such dialogue inasmuch as these sequences evidence the developmental nature of the discussion. Therefore, we selected the chat from each condition that had the proportionally highest number of composite phases recorded. Table 8 indicates the proportion of talk within each chat that focused on substantive collaborative problem solving dialogue.

As can be seen from Table 8, the SR + T groups on the whole, engaged in more substantive collaborative problem solving than either of the other two conditions. Our analysis provides examples of and describes the general pattern of discussion observed in the representative chat from each design condition.

TEXT

The TEXT group's chat began by brainstorming specific ideas and providing reasons for why these ideas might be appropriate, they also reflected, at times, on their own or a relative's personal preschool experience, the ideas were then adopted, revised or rejected by the group. This basic process was repeated throughout the problem solving session. Below is a segment of talk taken from this chat, which demonstrates this basic pattern (please note, all transcripts are reported verbatim with no corrections to typos or grammatical errors):

umassfurcolo1	-in this class room i think the students need to have blocks
umassfurcolo5	-ok well there should prob be desks
umassfurcolo6	-i agree
umassfurcolo1	-for their building skills
umassfurcolo3	-yea
umassfurcolo1	-yes desks would be good, but not desks, tables
umassfurcolo5	-ya

umassfurcolo1	-this gives more interaction
umassfurcolo3	-and crayons!
umassfurcolo6	-group tables would be preferable
umassfurcolo5	-so they can work in groups
umassfurcolo1	-crayons for creativity
umassfurcolo6	-so thgey can interact with eachother while learning
umassfurcolo2	-draw
umassfurcolo3	-so they can be artisitic
umassfurcolo1	-i think the desks should be in the middle of the class room
umassfurcolo5	-well in my preschool we had stuff to play house
umassfurcolo2	-nice me too
umassfurcolo1	-this puts students in the middle of the room, "center of attention"
umassfurcolo1	-i didn't go to preschool
umassfurcolo6	-i would like to see one of the rugs that has the picture of the play city on it, I have a younger brother, 3 yo, who constanly plays with one of those

The TEXT group gave reasons for why a certain toy might be used (e.g. -"this gives more interaction," "so they can work in groups," and "crayons for creativity,") but they did not specifically relate these reasons to child development theory. Rather, they mentioned personal experiences as a means of reflecting on the design. This group did not arrive at a final conclusion as to how the room should be set-up. They continued discussing the design of the classroom until the end of the experimental period.

SR + T

The SR + T group's talk was centered on discussion of the images of toys and equipment made available to them on a web page. Participants would introduce an item to be considered by referring to its object number (as listed on the web page) and they would generally provide a rationale for why this item would be useful. Other participants would then remark on this item as the group discussed the developmental aspects of the item. At some point, a new item would be introduced for consideration. The below excerpt exemplifies this pattern:

furcolo1:	objects 4 5 6 would be perfect for a music part of the day fostering creativity
furcolo4:	I like the objects that create interactions between the children
furcolo1:	children love to explore with things that make noise
furcolo1:	yes
furcolo3:	definitely, and motor skills for kids, learning coordination and such with them
furcolo1:	and children, each having a different instrument, can learn participation and working together
furcolo1:	and also recognition of what sounds sound like..which is more based on physical development
furcolo4:	not to mention learning and exploring with sounds
furcolo2:	they may get interested in playing music instruments
furcolo1:	a lot of these objects support all types of emotional and physical development
furcolo1:	yes absolutely
furcolo1:	which is offered to them later in elementary school, at least it was for me
furcolo3:	what do you guys think about the costumes
furcolo3:	object 7?
furcolo1:	i played two instruments throughout school and it helps you meet people too

furcolo2: when they play the musical instruments, they can sing at the same time..
furcolo3: yeah, for some people it turns into a life long skill
furcolo1: because we discussed the importance of social aspects in school today and how even though class should still be curriculum based..socialization is becoming much more important as well
furcolo1: the costumes are a good idea
furcolo2: they can practice their team work to play the instruments or sing together..

Similar to the TEXT group, the SR + T group provided reasons for why a certain object may be useful in the classroom (e.g., "fostering creativity" or "create interactions"). But, in addition to this, the SR + T group also discussed the design of the classroom in terms of child development. For example, in the above excerpt, they considered the development of motor skills, emotional development, physical development and socialization. These concepts are ones that were introduced in the students' child development course. In fact, one student makes explicit reference to a concept that was discussed in the class that day: socialization. This qualitative finding of the SR + T groups use of class concepts in discussing the task is supported by the results of the independent evaluation conducted with the instructional rubric (reported below). Finally, similar to the TEXT group, this group did not arrive at a final solution to the design task, but continued discussing the design until the end of the experimental period.

MUVE

The MUVE group's problem solving trajectory began with participants experimenting with moving the available toys and equipment on and off of the rug that was provided in a corner of the room. Most of the students engaged in this activity. This experimentation was accompanied by discussion of what the group was actually supposed to be doing.

Educate 12: so are we placing what we want on the rug?
Educate 8: i guess… i don't really get it haha
Educate 12: me neither
Educate 1: I don't think we're supposed to put everything on the rug at once
Educate 1: :)
Educate 12: yeahh i dont think the big blocks should be on it
Educate 13: I cant drop the slide
Educate 8: oh i think we're supposed to do the task
Educate 8: and put things on the rug for 3–5 year olds
Educate 12: okkk
Educate 12: why did we take away the easle board?
Educate 13: this is so lame
Educate 12: the sand box is good for little kids
Educate 8: i don't know, i think we should just put everything on the carpet
Educate 13: ya was realy the oonly hint we got
Educate 12: we should place them though nicely
Educate 8: so we have costumes, blocks, a truck, a sand box
Educate 12: are those the most important things?
Educate 9: what are we suppose to do after we move the items
Educate 8: i have no idea

As the majority of the group was experimenting with moving things on and off the rug and discussing the task, another student was experimenting with the MUVE itself. Since we did not restrict building permissions in the environment, one participant discovered that the walls of the room could be moved. This participant brought this to the attention of the group and they decided to change the dimensions of the classroom.

Educate 13: we can move the wall
Educate 13: should we make the room smaller this is like a wearhouse
Educate 12: yeah make it a little smaller
Educate 12: the easle board can be in front of the rug
Educate 12: good for teaching
Educate 8: yeah maybe the slide should be away from the rug, so the kids don't get distracted if the rug is where the kids will be during class or something
Educate 12: how small ar we making the room'?
Educate 13: we dont want any kids to get lost
Educate 12: well we hould make the room first before setting everything up so we can see the size of the room

The group moved one wall of the structure to make the room smaller. After this they revisited their initial arrangement of objects and revised the placement of items by assigning thematic items to corners of the room. At this juncture, a participant mentioned that the group should be providing rationales for their design decisions. The group takes up this suggestion.

Educate 8: it says in the task description that we have to provide reasons to why we are putting things in certain places
Educate 13: on our paper?
Educate 8: do you think we have to do that in order to finish?
Educate 8: ya the one we just got upstairs
Educate 12: ok well we put things in the corner so each corner has a specific task
Educate 1: no idea
Educate 12: dress up area, play area, etc
Educate 12: i think we should just discuss it here
Educate 9: music area
Educate 13: its all play stuff pretty self explainatory
Educate 1: yeah, but they are kinda in catagories
Educate 1: right?
Educate 12: the easle board is in the front of the rug for the kids to sit and the teacher to learn and use the board to write things out
Educate 8: yeah and putting the play stuff and school stuff in seperate areas can help the kids concentrate
Educate 12: yeah that's a good point
Educate 12: nothing is too close to one another
Educate 1: yeah
Educate 12: things are spread out
Educate 8: maybe if we even put the easle board on another side where the kids won't be facing the slide and the play toys when the teacher is trying to teach
Educate 12: yeah that can be arranged
Educate 1: good idea
Educate 13: the capret would be good for learning and having meetings

Educate 12: it's a small enough area but enough room to not be too close
Educate 13: the block section is coming along
Educate 13: ya to keep an eye on everyone
Educate 13: the way the walls are it wont get to loud to

The MUVE participants provided design rationales that focused primarily on attentional and classroom management (teacher supervision) aspects. For example, they were concerned about preschoolers being able to concentrate, the room not being too loud and the teacher being able to keep an eye on everyone. In addition, the MUVE group decided on a final design for the classroom. Once they had achieved consensus on the design, the group began chatting about other things, unrelated to the task until the end of the experimental period.

Post-survey results

To explore student perceptions of the differences in the discussion tools we asked participants to complete a post-survey in which they rated on a 4-point scale the quality of their experience during the discussion and their perceptions about the usefulness of the tool for discussion. Given that the data were ranked and non-normally distributed we used non-parametric statistics methods (Kruskal–Wallis). As can be seen in Table 9, participants across all conditions tended to view the usefulness of the task similarly and shared positive perceptions in terms of their comfort in using the specific chat tools. While there were no differences in participants' perceptions about the quality of the discussion or their engagement with peers across conditions, participants in the SR + T group rated the experience overall as less enjoyable than those in the TEXT and MUVE conditions.

Instructional rubric

To understand the learning outcomes characterizing the different discussion tools we evaluated student performance with an instructional rubric. The results of the chat evaluations based on the instructional rubric serve to triangulate the results obtained with the

Table 9 Post survey results

	MUVE ($n = 18$)	SR + T ($n = 22$)	TEXT ($n = 18$)	Total ($n = 58$)
Usefulness for future coursework	3.06	2.82	3.00	2.96
Usefulness for understanding child development	2.78	2.59	2.94	2.75
Enjoyment of experience	3.39	2.93[a]	3.33	3.19[bc]
Immersion in discussion	3.22	3.27	3.50	3.32
Engagement with peers	3.50	3.36	3.56	3.28
Quality of discussion	3.38	3.14	3.39	3.26
Comfort with tool	3.39	3.55	3.78	3.56
Contribution of tool to success	3.39	3.23	3.11	3.21
Contribution of tool to collaboration	3.33	3.23	3.39	3.31

[a] The n for this cell is 23

[b] The n for this cell is 59

[c] Kruskal–Wallis (2, $N = 59$) $= 5.86$, $p = .05$

Table 10 Mean scores for participant performance using the instructional rubric

	MUVE ($n = 18$)	SR + T ($n = 18$)	TEXT ($n = 20$)	Overall ($n = 56$)
Observable understanding of course materials	2.00	2.28	1.65	2.05[a]
Engages peers	2.33	2.61	1.90	2.37[b]
Organization of discussion	2.44	2.28	1.95	2.32
Response to questions	1.89	2.17	2.10	2.10
Relates to life experiences	1.67	2.22	2.20	2.10
Respects peers	2.39	2.39	2.35	2.41
Active engagement	2.33	2.50	2.30	2.47

[a] Kendall–Wallis H (2, $N = 56$) = 5.27, $p = .072$

[b] Kendall–Wallis H (2, $N = 56$) = 8.51, $p = .014$

content analysis. As shown in Table 10 participants in the SR + T condition demonstrated the highest level of integration of the course content at a marginally significant level (Kendall–Wallis $H = 5.27$ (2, 56), $p = .07$) and were more likely to engage their peers in the discussion (Kendall–Wallis $H = 8.51$ (2, 56), $p = .01$).

Discussion

This study examined the impact of representational design on participants' collaborative problem solving interactions in three online synchronous environments: TEXT, SR + T (shared representations and text) and a MUVE (shared representations, 3D-movable objects, and texts). In answer to our primary research question, our results indicate that representational design does play a role in collaborative problem solving interactions. Content analysis of participants' discussions revealed differences in the focus of the collaborative problem solving talk across the three conditions. Those in the MUVE condition were twice as likely to make comments related to orienting themselves to the task then were participants in the other two conditions. The SR + T group made significantly more solution evaluation comments than either the TEXT or the MUVE groups and they made significantly more solution analysis comments than did the MUVE group. Finally, the TEXT group made significantly more solution elaboration comments than either the SR + T or MUVE conditions and significantly more solution suggestion and solution analysis comments than the MUVE group.

Further analysis of the collaborative problem solving interactions found that participants in the SR + T condition demonstrated the most substantive dialogue as a proportion of total talk in three of the four groups as measured by composite phases. Additionally, the independent evaluation of the chat using the instructional rubric found that the participants in the SR + T condition demonstrated a higher-level integration of the class material and engaged their peers more in the discussion. Finally, when the representative chats from each condition were comparatively analyzed, we found that the TEXT and the SR + T conditions took relatively similar routes to solving the problem, but the SR + T group provided more theoretical grounding of their choices than did the TEXT group. Also, neither of these groups arrived at a solid conclusion to the task. The participants in the MUVE condition, on the other hand, followed a different route to problem solution, they focused primarily on the arrangement of objects in the virtual space and the MUVE group reached a final conclusion to the task. However, their solutions were not theoretically-based.

As we reflect on the results of the content analysis and the instructional rubric analysis it appears that the SR + T condition, while not reaching a firm conclusion, was the condition that facilitated stronger learning outcomes in terms of the substantiveness of the discussion and integration of course concepts among the participants. Participants in this condition spent more time evaluating each other's solutions and analyzing the problem itself. Proportionally, they spent more turns involved in substantive dialogue than participants in the other two conditions, and their discussions included the explicit reference to the concepts they were learning in class. While these discussions do not represent *new* learning for the students, the substantive discussion of the design and theoretical grounding for specific design choices, potentially allowed the students to ground and expand their knowledge through applying it in this task. In essence, the task allowed students an opportunity to integrate and synthesize their knowledge: acts that will eventually lead to greater learning in the domain.

In considering why this group evidenced more substantive discussions, we turn to the notion of representational guidance. As noted earlier in the paper, representational guidance refers to inscriptions in an online environment that make salient certain epistemic aspects of the domain under discussion, and in so doing, becomes the focus of the dialogue (Toth et al. 2002). It is possible that the shared representations acted as a means of providing participants with representational guidance in considering the problem. The images of the toys, materials and equipment that one may use in designing a preschool classroom made salient the relevant child development ideas the participants had learned in their class and, therefore, helped to focus the discussion.

Following this argument, one may well ask why the shared representations in the MUVE environment did not serve the same purpose. In other words, why would shared representations serve as representational guidance in one visual setting, but not in another? We believe the answer to this question lies, in part, in Frohlich's (1993) description of interaction metaphors that underlie interface design. According to Frohlich, an interface may be designed according to a conversational metaphor (emphasizing linguistic interaction) or a model-world metaphor (emphasizing direct manipulation of the environment through clickable icons and virtual world navigation). These metaphors allow for varying levels of distance and engagement in interface interactions that can make such an interaction easier, or more difficult, depending on the goal of the interaction.

Distance in terms of an interface metaphor refers to the "mismatch" between how a user normally accomplishes a task in a domain and the way that the computer allows one to accomplish the same task. The closer the computer method is to one's own method, the lesser the distance. For example, clicking the icon of a folder on a computer screen to retrieve a file creates less distance than typing in a DOS command to accomplish the same goal. Therefore, clicking the icon is considered an easier task. Engagement refers specifically to the model-world metaphor. In Frohlich's (1993) view, the simulative nature of the environment and the capacity for direct manipulation of objects creates more user engagement.

In large part, the three conditions in our study map to these metaphors. The TEXT chat follows a conversation metaphor, emphasizing linguistic interaction, and the MUVE condition follows a model-world metaphor, emphasizing virtual navigation of the environment. The SR + T condition represents something of a mix between the two, as this group had access to both linguistic and graphical forms of representation, but neither metaphor dominated. The task itself required both spatial and theoretical thinking.

In terms of distance, the TEXT group had perhaps the greatest mismatch between how they may have approached the task and the computer representation of the problem. Since they had no visual representations to reflect on, this group had to work the hardest to develop a solution to the problem. In order to create a solution, they had to first brainstorm the items that should be considered. When an item was offered for consideration, other participants would elaborate on the use of that item. Since participants had only their own imaginations and memories to rely on for introducing ideas, more time was spent elaborating offered ideas then introducing and arguing for new possibilities.

The MUVE condition, on the other hand, seemed to have the least distance between the objective of the task and the computer representations. And, the participants in this condition did arrive at final design solutions to the task. However, they engaged in very little substantive dialogue, when compared to the SR + T condition participants, and they spent a lot of time orienting themselves to the task. There are most likely two explanations for this. First, participants in this condition reported little previous experience with the MUVE. Therefore, participants had to spend more time becoming oriented to the environment, whereas, participants in the other two conditions reported more experience with their respective environments. Second, the immersive nature of the model-world emphasized the navigable space. Participants in this condition approached the problem primarily as a spatial arrangement problem. As determined from the comparative analysis, the MUVE participants' collaborative problem solving approach centered on the placement of objects around the rug in the virtual classroom. Discussion of the theoretical reasons for selecting and placing objects in certain areas was given only secondary consideration. The characteristics of the model-world, in combination with the spatial nature of the task, served to overshadow consideration of the theoretical aspects of the task. Suthers' (1999) notion of representational bias and Kirschner et al.'s (2004) concept of educational affordances are very useful here in understanding the MUVE groups' activities. The provision of movable objects within the MUVE was an educational affordance that made possible the completion of the group design activity, but the representation itself biased student discussion towards spatial arrangement and attention/supervisory aspects of the classroom, as opposed to theoretical discussion of the childhood development topics that would guide such spatial arrangements.

The SR + T group represents a mixed approach in which neither the conversation metaphor nor the model-world metaphor were emphasized. Rather, the metaphors were balanced. The chat utility allowed for linguistic interaction, and the shared representation of images allowed for model-world interaction in that the real world was represented by the images. Participants were able to move back and forth between the two worlds without being overly influenced or distracted by either. As aforementioned, the graphical display served as a form of representational guidance that focused the discussion on the salient features of a preschool classroom. The participants neither had to brainstorm the items, as the TEXT group did, nor were they concerned with moving items in a navigable virtual space as the MUVE group was. As a result, the participants in the SR + T group were able to engage in substantive discussion of the theoretical underpinnings of design choices, and to spend more time evaluating and analyzing proposed solutions.

In terms of engagement, in Frohlich's (1993) formulation, the MUVE should be the most engaging of the three environments due to its 3-dimensional representational style. The results of our study bolster this claim, as participants in the MUVE reported the highest level of enjoyment with the experience. The SR + T group should be the group with the second highest level of engagement. This was not the case in our study, as the TEXT group reported higher levels of enjoyment than the SR + T group. One reason the SR + T group may not have enjoyed the experience as much as other groups is that their discussions, substantive as they were, may have felt more like school work and the evaluation of the images may have felt like a test situation for the participants.

A second possible explanation for these results is drawn from the work of Garrison et al. (2000) on developing communities of inquiry in computer mediated discussions. Garrison et al. argue that online learning experiences encompass three core elements: cognitive presence, social presence and teaching presence. The two elements of this model that are most directly applicable to our results are cognitive presence and social presence. According to Garrison et al., cognitive presence refers to "the extent to which the participants in any particular configuration of a community of inquiry are able to construct meaning through sustained communication" (p. 89). Social presence refers to individuals' ability "to project their personal characteristics into the community, thereby presenting themselves to the other participants as 'real people'" (p. 89). It is possible that students in the TEXT condition and the MUVE condition were better able to establish social presence in their respective environments than the SR + T group. The TEXT group engaged in much brainstorming and elaboration that was drawn from their own experience. Speaking from their own experience may have allowed students in the TEXT group to better "project" themselves as "real people" into the discussion. The MUVE group, represented by avatars within a navigable space may also have felt a greater sense of social presence just by virtue of such instantiations.

The SR + T groups' discussions were guided by the shared representations and focused on discussion of these images, such activity may have lessened the groups' ability to "project" themselves as "real people" in the discussion. Therefore, this lower level of social presence potentially experienced by this group may have resulted in the groups' reported feeling of less enjoyment in the exercise, despite the higher level discussions that took place.

There are potential limitations to the study findings given that our sample, being predominantly female and based on enrollment in three sections of a specific course, is not representative of a more general population of college students or even potential users of these online synchronous environments. However, these limitations when cast into the broader realm of the literature, which has often focused on technology applications to the natural sciences, does contribute to our understanding of how representational design may provide different affordances within the social and behavioral sciences. A second limitation is the brevity of the intervention. However, the task itself was similar to an assignment that students in previous semesters completed in asynchronous discussions. And, the goal was not for students to learn *new* knowledge, but to apply and synthesize the knowledge they had already gained in the class. So, while the intervention was short (30 minutes long) it was consistent with typical assignments in the Child Development course.

Conclusion

In conclusion, our research indicates that representational design appears to have an impact on student collaborative problem solving in chat environments. Specifically, designs that provide representational guidance that make salient epistemological aspects of the domain of interest and that balance the interface metaphors of conversation and model world analogies appear to lead to more substantive discourse of the problem being considered. Additionally, our research indicates that participants experienced high levels of enjoyment in the MUVE condition. Future research should consider the design of MUVEs that integrate representational guidance through a conversational metaphor. Combining the design elements that appear to lead to higher levels of discussion with those that students find most enjoyable will allow us to further investigate the potential role of such environments in student learning across a variety of domains.

Appendix

See Table 11.

Table 11 Instructional rubric

	1	2	3
(1) The student demonstrates an observable understanding of the class material	Postings do not reference material discussed in class or in readings	Postings generally reference material discussed in class or in readings	Postings clearly/explicitly reference (e.g., using the name of a theorist or researcher, appropriate terminology) material discussed in class or in readings
(2) The student demonstrates the ability to engage peers in a discussion *relevant* to the discussion topic	Student posts comments unrelated to peer comments *and/or* material posted is unrelated to discussion topic	Student posts comments generally related to material raised by peers	Student posts engaging questions, elicits responses from peers, and clearly references discussion points raised by peers
(3) The student demonstrates the ability to effectively organize the discussion	Student posts comments which are unrelated to the discussion topic *and/or* leads the group into discussions unrelated to the discussion topic	Student posts comments which may expand peer comments but do not organize discussion	Student organizes strategies for how problems may be solved or relevant issues addressed and/or supports the group in remaining on topic
(4) The student demonstrates the ability to respond to questions on the discussion topic effectively	The student does not respond to questions related to discussion topic posed by peers	The student posts comments generally related to questions or issues about the discussion topic raised by peers	Postings clearly reference questions or issues raised by peers about the discussion topic
(5) The student demonstrates the ability to relate the concepts discussed in the course material to personal or professional experiences	The student does not related course material to personal or professional experiences	Examples of experiences with children, families, teachers or example's from the student's own life are included but not as examples to illustrate points	Examples of experiences with children, families, teachers or examples from the student's own life are used as concrete examples to illustrate points
(6) The student demonstrates respect for peers' contributions and differing viewpoints	The student posts comments which are disrespectful of peers' contributions and differing viewpoints	Postings seem to ignore peers' contributions	Postings are respectful and supportive
(7) The student demonstrates active engagement in the discussion process (related to the discussion topic)	The student has little engagement in the discussion process (related to the discussion topic)	The student is somewhat engaged in the discussion process (related to the discussion topic)	The student takes an active role in the discussion (related to the discussion topic)

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