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Investigating the role of shared screen in a computer-supported classroom in learning

Rafikh Rashid Shaikh[1] · **Nagarjuna G**[1] · **Ayush Gupta**[1]

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Abstract

Networked computers can potentially support classrooms to be more interactive. It can help students share representations amongst themselves and work together on a shared virtual activity space. In research on the role of shared screens or shared virtual workspace in learning settings, there has been less attention paid to contexts where learners are co-located. This paper looks at the impact of the shared screen in a computational game environment on mathematics learning and practices and the construction of learners' emotions and social status in classroom interactions. We designed two versions of a simple arithmetic game: a solo version in which the student played the game alone and a multi-player version in which the screen was shared, and the players could see the arithmetic moves of the other players. We implemented these two versions of the game in a 4th-grade classroom in a suburban school in a large metropolis in India. Classroom sessions were video recorded, computer logs were collected, and field notes were taken. Focus group sessions were held with the students. We coded a portion of the data to get at patterns of classroom interactions. Then we drew on qualitative video analysis tools to analyze specific episodes to understand the fine timescale dynamics of dominant interaction patterns in each setting. Our analysis shows that the shared screen served as a shared memory device, keeping a record of all the students' posts, and was entangled in the moment-to-moment dynamics of self- and peer- assessments of arithmetic. These findings suggest that thoughtful integration of networked digital tools in computer-supported learning environments can increase student–student interactions and support disciplinary learning.

Keywords CSCL · Educational games · Design features · Games with share memory space

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✉ Rafikh Rashid Shaikh
rafikh.sk@gmail.com; rafikh@hbcse.tifr.res.in

Extended author information available on the last page of the article

1 Introduction

Interactions in most Indian schools follow a particular pattern. Most of the time the teacher talks, and students listen and take notes. Occasionally teacher asks questions, and students answer one at a time. It follows a pattern that Mehan (1979) calls IRE (initiation by a teacher, a response by a student, and explanation/elaboration by the teacher) or its variants. A report by UNESCO published in 2021 says that 41% of activities are teacher-centric, whereas 24% of activities could be called student-centric (Sarangapani et al., 2021). Students rarely get an opportunity to speak in the classroom; occasionally, they can ask questions to a teacher, but talking to peers is discouraged. Same UNESCO report says that 60% of classroom time goes to teachers writing on a blackboard, students copying it in notebooks, teachers reading from a textbook, and students repeating what the teacher says. Whereas 30% of the classroom time went into activities like the teacher asking questions, students writing on a blackboard, the teacher using local context and language, and students working in groups (Sarangapani et al., 2021). Students' interactions are viewed as a hindrance to the learning process as learning is believed to be an individual pursuit. Talking to other students also goes against the 'discipline' culture in Indian classrooms. Indian teachers' perception of an ideal student is someone who sits quietly, obediently follows orders, and respects the teacher. The belief is inherited from the Indian tradition of Guru-Shishya (Sarangapani, 2003). The teacher is a central figure in the classroom, the sole authority on knowledge, and the go-to person for any academic or other issues.

On zooming out of India and looking at classrooms from other countries, we can see that providing spaces for free and fruitful peer interactions remains challenging. Social interactions are essential for learning (L. Vygotsky, 1978); therefore, creating spaces and opportunities for students to interact with peers is vital. Multiple ways to improve interactivity in the class have been tried, studied, and reported. These efforts have ranged from pedagogic reforms to the use of digital technologies. Few significant pedagogic efforts include a framework called ambitious science teaching (Windschitl et al., 2020), educational infrastructure to support argumentation and debate in the class (Bell, 2004), support to an instructor to manage the tension in class during group work (Sohr et al., 2018) and supporting teachers in facilitating productive discussion by using 'talk-moves' as tools (O'Connor & Michaels, 2019). At the same time, other efforts involve using digital/electronic technologies, both standalone and networked. In the present study, our focus is on the use of networked computers as they hold the potential to transform the educational landscape (Baumöl & Bockshecker, 2017). The networked computers and the internet make sharing representations in and out of the classroom possible. Our interest is in space that offers simultaneous access to all users, where representations can be created and manipulated. It can be a simultaneously editable document, a wiki or chat environment, a multiplayer game, or a virtual whiteboard. In literature, various terms are used to talk about such space. Terms like shared activity space (Aiken et al., 2005), shared workspace (Scott et al., 2015), or shared memory space (Shaikh et al., 2020) are used. In the present study, we will use the term shared memory space (SMS) as we feel it better captures the idea. In a socio-technical system such as a computer-aided classroom, an application window where all the participants can create, view, and manipulate representations can be viewed as an extension of the memory space of all the agents (Hutchins, 1995).

In this paper, we investigate the role of shared memory space in a collocated setting in making tasks engaging, leading to disciplinary learning and socio-affective changes in the students. We designed an arithmetic game with two versions, one in which students played individually, and another in which the students had access to a shared memory space as they competed against one another for speed and accuracy. We analyzed the video recordings of classroom sessions and computer logs from the computers used by students to compare the level and character of intellectual and social interactions in the two settings.

This manuscript examines the impact of a shared screen (virtual) in a co-located classroom within a computational game environment. We designed two versions of the game: with and without a shared screen. Students in the setting without the shared screen (ChatStudioSelf) were asked to work alone or with the teacher, while those in the shared screen setting (ChatStudioGroup) were encouraged to interact and engage in self-and peer- assessment. We contrast observations from the two settings to illustrate how the shared screen was entangled in the cognitive, social, and affective dynamics of the classroom. Our analysis showed that the shared screen supported students in interacting with peers, though towards more competitive rather than collaborative goals. The configuration of social interaction and technology design in the shared-screen setting supported students' disciplinary learning.

In the next section, Background and Related Work, we present a synthesis of the research on the use of shared activity spaces in educational settings. Next, we present a description of the computational game environment and our settings, data collection methods, and methodological orientations in the Analytical Flow and Methodology section. In the Findings section, we present our analysis and findings. We conclude by discussing the relevance and implications of the findings.

2 Background and related work

In this section we look at few relevent studies on the role of shared memory space (SMS) in learning. We start with role of SMS in shaping learning, then we look at digital games with SMS and finally we look the studies that are similar to present study.

2.1 Shared memory space (virtual)

Learning in computer-supported spaces, where shared memory space is involved, has been studied by many researchers—starting with Roschelle and Teasley's (1995) study of a dyad collaboratively solving a challenge involving velocity and acceleration vectors. Their study demonstrated the effectiveness of qualitative study involving conversation analysis in understanding the role of computer support in providing context for social interactions among students and leading to the construction of shared knowledge. Their study also demonstrated how shared conceptual space is created through the use of shared language, common situations, and joint action. Computer-mediated sharing helps in learning (Junco et al., 2011; Shaikh et al., 2013) by increasing social engagement (Wise et al., 2011). Shared representations act as mediators in facilitating productive conversation among learners (Suthers, 2006). In group activities, a shared workspace increases the visual awareness of the problem context and helps members better understand the problem (Müller et al., 2017). In contrast, the absence of a shared workspace in a group activity decreases shared visual attention and activity awareness (Chung et al., 2013). That is why in collaborative activities, learners who work in independent workspaces (not in the shared workspace) also tend to work more individually and less collaboratively (Scott et al., 2015). Lin et al. (2016) used the 'shared virtual space' term to indicate the digital space that supported collaboration. Their study found that those who perceived higher collaboration also performed higher in problem-solving tasks. They also found that the collaboration improved over time. However, they also reported that those who did multi-tasking outperformed those who focused on a single task. Another study by Baturay and Toker (2019) looked at the development of trust among students. They compared the development of trust in two different settings; trust as a result of face-to-face communication and trust as a result of computer-mediated communication. They found that even though building trust took time in the CMC setting, it surpassed the face-to-face setting in the long run.

2.2 Games and shared memory space

Games, in general, are considered a powerful medium for learning (Clark et al., 2013). Multiplayer digital games involving participants' sharing and manipulation of representation can be considered games with shared memory space (SMS). The present study focuses on these types of games and their affordances.

A critical affordance of the educational games with SMS is motivating students to engage in disciplinary practices in STEM (Bransford et al., 1990; Kirriemuir & McFarlane, 2004). Such motivational effect is seen regardless of gender (Klein & Freitag, 1991a, 1991b; Papastergiou, 2009). Educational games also provide context for learning by doing and make learning a fun activity (Kirriemuir & McFarlane, 2004).

In their meta-analysis, Ho et al. (2022) mention that the most helpful theory to understand the affordances mentioned above is Deci and Ryan's Self-determination Theory and Need Satisfaction Theory. These theories suggest that every human needs to feel connected, competent, and in control. During games, students experience a sense of connection with others. Peer interactions are induced by the game and mediated by the shared memory space. Social recognition as a result of performance in the game satisfies the need to feel competent. Furthermore, the informal nature of games and freedom to choose various aspects gives a sense of autonomy.

Social games can be collaborative, competitive, or a combination of both. Games involving peer competition and collaboration have been widely researched (Johnson et al., 1981; Pareto et al., 2012; Plass et al., 2013; Shaikh et al., 2013). Studies show that both types of learning activities (collaborative and competitive) harbor a powerful motivational effect (motivation to engage in disciplinary practice) (Pareto et al., 2012).

Competition is considered more effective in stimulating students' learning progress (Cagiltay et al., 2015). It is because, in competitive mode, students are more probable to adopt performance-orientated goals (Lam et al., 2004). However, Craig et al. (2019) reported the opposite results. They designed two versions of a digital game that helped young students learn English vocabulary. One version had collaborative game-play, and the other had competitive. The games were to be played in co-located settings. They found that the collaborative version was better than the competitive version for learning. However, both were not as good as the traditional method of learning vocabulary using learning cards. Whereas, having both competition and collaboration elements in a game makes it better than only a competitive game in achieving learning outcomes (Clark et al., 2016).

Ho et al. (2022), in their meta-analysis, also use the sociocultural theory to explain the affordances mentioned above of games with SMS. The theory considers social interactions essential for learning. Here, 'play' is considered one of the essential childhood activities that play a role in a child's development (cognitive, social, and emotional) (Verenikina et al., 2003; L. S. Vygotsky, 1977). Vygotsky's idea of the Zone of Proximal Development explains why peer interactions are essential for learning.

2.3 Virtual Math Teams as an example of SMS

The Computer-Supported Collaborative Learning (CSCL) community extensively studied the role of networked computers in collaborative knowledge building. Specifically, Gerry Stahl (2009) and colleagues have systematically studied what we call SMS and its role in learning in virtual spaces they termed "Virtual Math Teams (VMT)". In VMT, a group of students work on an interface where they can create and manipulate representations simultaneously. The interface has a chat window, a whiteboard for drawing, and a wiki for recording and sharing group work. Users can create objects in the activity window and discuss them in chat. They can also point to objects in the activity window in chat posts.

In their decade-long investigations, Stahl and colleagues found that virtual groups can learn subjects like mathematics through interactions. They used ethnomethodological conversation analysis to unpack the moment-to-moment details of interactions in VMT. Their analysis of student interactions showed that the joined problem space was co-constructed at the group level and not an individual level. It happened through temporal and sequential orientation to join meaning-making. They also observed that sequential co-creation of representations on the whiteboard and deictic referencing to those representations in chat posts and content from the past interactions played an instrumental role in achieving shared understanding among the group of students engaged in VTM. Question–answer pairs played an essential role in constructing peer relationships and regulating participation. These interactions positioned individual members in the group as more/less competent. Resolving differences that arose during the discussion contributed to learning. Refer to the book by Stahl (2009) to get a comprehensive understanding of their work with VMT.

In the VMT project, participants were not in physical proximity. Their interactions were solely through networked computers. However, SMS can also be used in co-located (face-to-face) settings. Stahl studied knowledge construction in co-located settings but not as extensively as in virtual settings. In one study (Stahl, 2002) he used micro discourse analysis to unpack the complexity of collaborative learning of a group of students trying to design a digital model of a rocket. The analysis showed how conversation broke down due to a problem in understanding, leading to confusion, and how the group repaired it and came to a resolution.

Gerry Stahl and team's work primarily focuses on socio-cognitive dimensions of learning. However, other studies have pointed out that researchers should not study math learning by only examining concepts, instructions, and procedures (Ramirez et al., 2012). Learning is also affected by students' anxieties and emotions (Pekrun et al., 2002; Zan et al., 2006). For example, multiple studies found that students' emotions (math anxiety) affect their math achievement, specifically those with high working memory levels (Beilock & Carr, 2005; Ramirez et al., 2012). Similarly, students' perceived math competence positively impacts math performance both in boys and girls (Erturan & Jansen, 2015; Meece et al., 1990). Students' perceived competence, attitude, and emotions are constructed in and outside the classroom. Many classroom activities such as performance in tests, games, and group work can affect students' perceived competency. Interactions with peers and teachers may play a role in constructing students' attitudes and emotions. To design better teaching–learning applications, it is essential that, along with the cognitive aspect, we should also study how various design features of applications play a role in the construction of emotion and beliefs.

3 Methods

3.1 Pilot study

Our exploration of computer-mediated sharing started with a request from a primary school teacher who had an ongoing One Laptop Per Child (OLPC) project in his school. He was looking for an application to teach arithmetic skills, and since we had collaborated with the school previously, he asked us to help. We had observed students of his school using "Chat Activity," an instant messaging environment to play simple word games. We thought of using the same application to play number games. We devised a few simple rules that we thought might make the game joyful to play and learn. In the game 'stepping number' is the number that is added

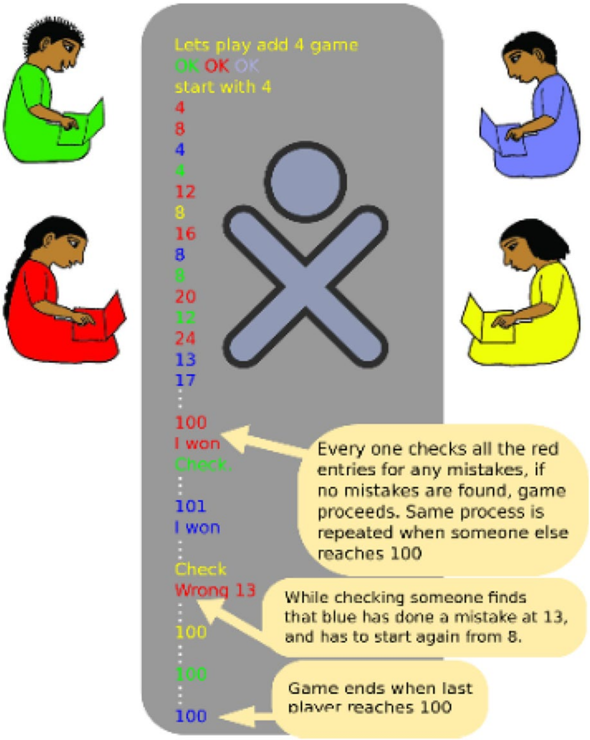


Fig. 1 An illustration of the number game from pilot study (Shaikh et al., 2013)

repeatedly and 'starting number' is the number you start with. Figure 1 is an example of the game, in which four students decide that they want to play game with 4 as stepping number ("Let's play add 4 game") and 4 as starting number ("start with 4"). As soon as the number pair is decided the game starts, each student adds stepping number to the starting number (4 + 4), then posts the result of addition i.e., 8 on the screen and again adds stepping number (4) to 8 and post the result i.e., 12 on the screen. This goes on till either student reaches three-digit number in the series, or some other student declares that s/he won.

Some of the critical observations from the pilot study are:

- Students and the teacher enjoyed playing the game. The game was so popular among the students that they even played it outside school. In fact, more sessions of the game were played outside the school.
- A comparison of students' arithmetic skills before and after the intervention showed that their arithmetic skills improved (Shaikh et al., 2013).
- Students devised or discovered new strategies to perform arithmetic operations. For example, students discovered that in addition game multiplication tables could be used if the starting and stepping number is the same. Newly discovered/devised strategies spread in the class.
- Students interacted to assess each other's work and help each other.

- We also saw a few socio-affective changes. For example a female student considered below average by the teacher and peers showed gradual improvement in her arithmetic skills in the game context. The teacher and students' perception of her academic abilities also changed.

While reflecting on the observations from the pilot study, we asked ourselves why the number game worked and what features of the game were central to it? We imagined if such as game could be played with laptops, or using a paper and pencil or blackboard and chalks or verbally. If the game is played verbally, we anticipated that there might be multiple speakers at the same time, and harder for students to perform calculations and monitor others' numbers simultaneously. Monitoring others' numbers for assessment was an essential part of the game. If the game was played on paper or blackboard, students could monitor others' numbers, but only 2–3 students could have played at any given time. We felt that having a larger group play simultaneously was important. The shared screen served as a Shared Memory Space (SMS) providing instant access to one another's posts. This supported cross talk amongst the students, where they could assess their own and others' work, supporting and/or contesting their work. In this way, we felt that the shared screen, as a SMS, supported students' individual and collective learning. Thus, in our view, the shared screen was one of the game's central features and played a role in generating the patterns of learning and interactions that we were observing.

Based on this pilot effort, we refined our research questions for the main study which we describe in this paper:

(1) How does a shared memory space (SMS) in a networked computational game environment influence students' engagement? (2) How does a shared memory space (SMS) in a networked computational game environment affect disciplinary learning and practices? (3) How does a shared memory space (SMS) in a networked computational game environment influence the construction of social status in the classroom and the public display of emotions by students? We see the constructs of engagement, learning, practices, construction of social status, and public interactional displays as all coupled in the production of the students' whole experience.

3.2 Research Design

3.2.1 The basic game

The basic game is similar to the game from the pilot study described earlier. We added a few extra elements to it. We changed the rule that required a student to start again from one step before the step where she made mistake. In the present game, student did not have to start again. We created three difficulty levels (easy, medium, and high). We also added an option to generate a pair of 1–3 digit random numbers as the starting and stepping numbers. The random number generator was tuned for the chosen difficulty level. In the pilot study, the game session ended when every participant had crossed the last number; then, students moved to a new session. For this study, we added a backend algorithm that generated a scorecard that ranked the students by accuracy and speed (the average time taken by student between steps). Accuracy was the first parameter for ranking. If two students had the same accuracy score, they were ranked based on speed. The one with the lower average time per step ranked higher. The generation of the scorecard became the event that marked the ending of a session.

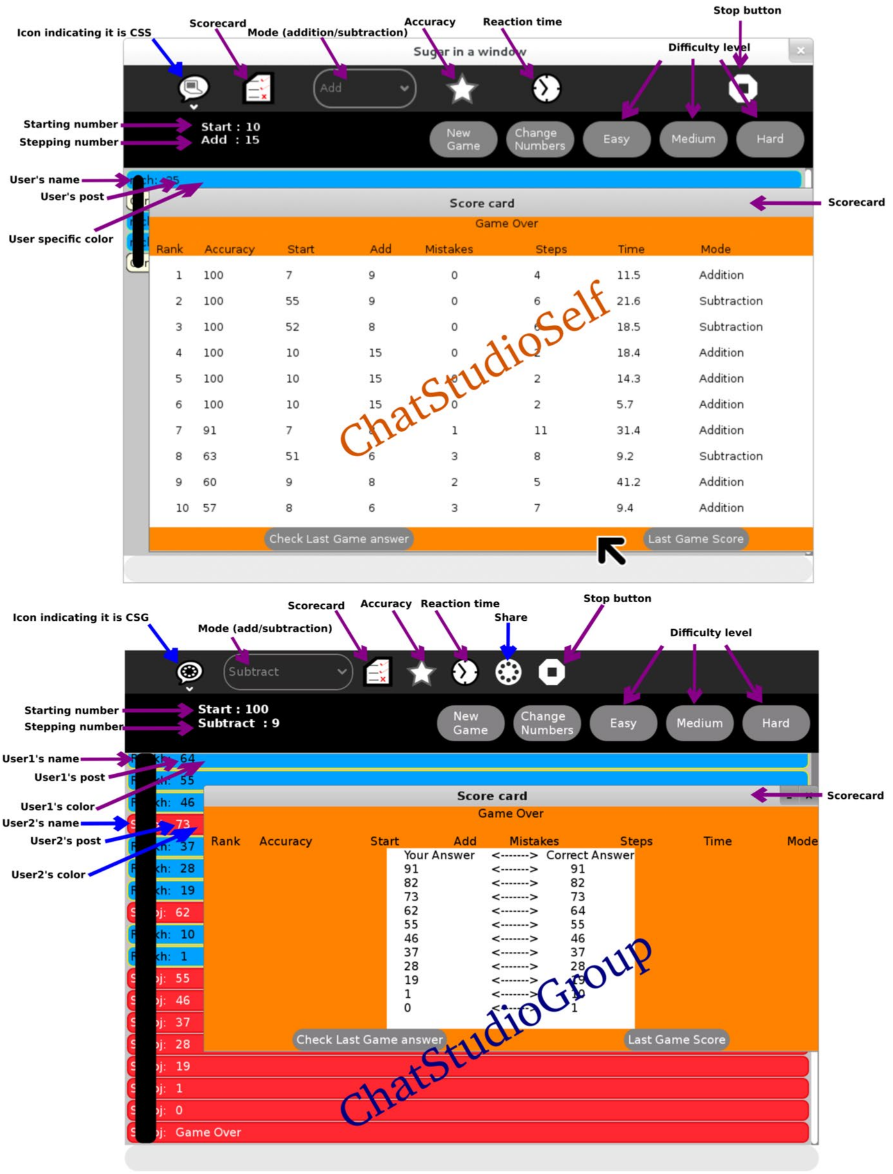
While modifying the ’Chat Activity’ into the ’ChatStudio,’ we had two simple criteria. First, keeping the fun element in the game intact, and second, making learning visible. For this study, we needed a few features to be added to the original activity and also make two versions of the game, with and without the Shared Memory Space. While adding any feature, we asked ourselves whether adding this feature affect the fun element in the game? For example, during testing, we noticed that not all students crossed the last number simultaneously. The students who finished before others were showing signs of boredom when waiting for the everyone to finish. So, we added another rule in the game: Any student who finishes could go through others’ posts and find mistakes made by any student who is playing the game. A scoreboard on the blackboard kept a record of this by adding a “ + 1” to anyone who reported an error accurately.

3.2.2 Infrastructure

The school used laptops called XO, popularly known as OLPC, developed by the OLPC Foundation (https://laptop.org/). The XO supports peer-to-peer networking of all the devices through wireless (WiFi) without any additional configuration. All the applications have two modes of usage, single or collaboration, that can be switched on or off. The design of the applications and the machine uses Papert (1980) constructionist philosophy of education (Kane et al., 2012; Urrea & Bender, 2012). Activities performed by the children in each session are recorded automatically in a journal. The students can generate portfolios periodically to check their performance. The Sugar Learning Platform desktop is an activity-centered desktop specially crafted for primary school children. Since the Sugar Learning Platform is a free and open-source platform, the source code of the applications was available to us, which granted a license to modify. This feature helped us modify Chat Activity, an activity present in the system, into two versions of the arithmetic game used for the study.

3.2.3 Design of “Self” and “Group” versions of the game

We designed two versions of the game. One was a standalone game without a shared memory space (ChatStudioSelf); the other was a multi-player game with the screen serving as the shared memory space (ChatStudioGroup). The game interface looked similar and had similar features in both versions, with few exceptions. Figure 2 has screenshots of both versions of the game. To show all the features in a single image, we have taken screenshots of the view that a student sees at the end of the game.



Rank	Accuracy	Start	Add	Mistakes	Steps	Time	Mode
1	100	7	9	0	4	11.5	Addition
2	100	55	9	0	6	21.6	Subtraction
3	100	52	8	0	6	18.5	Subtraction
4	100	10	15	0	2	18.4	Addition
5	100	10	15	0	2	14.3	Addition
6	100	10	15	0	2	5.7	Addition
7	91	7	[illegible]	1	11	31.4	Addition
8	63	51	6	3	8	9.2	Subtraction
9	60	9	8	2	5	41.2	Addition
10	57	8	6	3	7	9.4	Addition

Your Answer	<------->	Correct Answer
91	<------->	91
82	<------->	82
73	<------->	73
62	<------->	64
55	<------->	55
46	<------->	46
37	<------->	37
28	<------->	28
19	<------->	19
1	<------->	10
0	<------->	1

Fig. 2 Two versions of the ChatStudio game and their features (**a**) ChatStudioSelf version and (**b**) ChatStudioGroup version

The Scorecard window appears when a student clicks on the ’Scorecard’ button. To show two modes (add and subtract), we chose to show the “add” mode in the ChatStudioSelf and the ’subtract’ mode in the ChatStudioGroup. However, both versions had "add” and “subtract” modes.

Both the versions of the game were tested. They were tested for the following criteria:

1. If the game is recording the accuracy and reaction time correctly
2. If all the features such as mode, difficulty level, scoreboard, etc. are working as intended
3. Further testing was done during implementation in the school. We did not have any instances where students were confused about what to do, or about using the interface, or interpreting the interface as intended. The teacher and students usually checked the answers via direct counting. However, we did not encounter any instances where the game did not perform the arithmetic accurately.

Table 1 Comparison of digital environment

ChatStudioSelf	ChatStudioGroup
Solo	Multiplayer: Students have the option of inviting others to play with them
Students can only see their own posts	Students can see the posts by all the students in the class, in chronological order of posting, coded by user-specified color
Both have “Add” and “Subtract” Modes	
Both have the option of choosing “Easy", "Medium" and "Hard" difficulty levels	
Both allow selecting a custom number pair	
Both have custom color coding option	
Scorecard ranks students’ own game performances	Scorecard ranks students for that particular gameplay by accuracy and speed
Both show accuracy graph	
Both show speed graph	
A badge appears as a “popup” if a student correctly finishes a game	There is no badge for accurate gameplay

Table 2 Comparison of instructional environment and gameplay

ChatStudioSelf	ChatStudioGroup
At any given time, different students could be playing different game configurations	At a given time, the whole class is playing the same game configuration
Since students were playing different configurations, peer assistance was harder	Since students were playing the same configuration peer assisstance was easier
Students assessed their game on their own, using the scorecard, or by talking to the teacher	In addition to self, scorecard, and teacher, peer-assessment was incentivized
Students were rewarded with a Digital badge for accurate game-play	Students were rewarded with ranking on the digital scorecard, as well as the scores on the blackboard for peer-assessments
After finishing, a student can reset the game for a new gameplay	After finishing, students need to wait till everyone finishes, and a new configuration is decided upon by the class

The Table 1 lists all the features of both versions of the game had .

Along with the digital features, the rules of the games were also very similar. Except for a few rules. The Table 2 list all the steps in both versions of the game .

To give a coherent view of both the games, we describe how each version of the game was played:

1) *ChatStudioSelf*- In this game version, a student played against the computer. After opening the application, the student selects the mode (Addition or Subtraction) and then chooses the difficulty level (Easy, Medium, and Hard). Finally, the random or custom option is chosen to get the number pair. The number pair has two numbers, starting number and the stepping number. In the random option, the number pair is randomly generated; in the custom option, a student can insert the numbers of his choice. Once the number pair is selected, a student starts with the starting number and adds/subtracts the stepping number to/from it. For example, if the starting number is ’4’ and stepping number is 5, and the mode is ’addition,’ the game will be as follows:

   9 → 14 → 19 → 24 → 29 → 34 → 39 → 44 → 49 → 54 → 59 → 64 → 69 → 74 → 79 → 84 → 89 → 94 → 99 → 104

   The student posts the number for each step on the screen and gets immediate feedback from the computer, as the correct number for that step appears below the student’s number but in different colors. The game ends when a student reaches above 50 (easy level) or 100 (medium and hard level). In the end, students get rewards based on their accuracy and speed. The computer’s response acts as feedback at each step. The final number is two- or three-digit (above 50 for easy level and above 100 for medium and hard level).
2) *ChatStudioGroup*- The gameplay is very similar to the ChatStudio-Self, except here, students discuss and decide the number pair, or the teacher gives the number pair. Once the mode, level, and number pair are chosen, the game starts, and all the students who are playing the game post their responses on the computer screen. All the students can see each other’s answers; as the computer’s response in the ChatStudioSelf, other students’ responses act as feedback. Other rules are similar; students must cross either 50 (easy level) or 100 (medium and hard level) to win. The game continues till all the students cross the winning line. Students get rewards based on accuracy and speed and get additional marks for pointing out other students’ mistakes by looking at the postings on the screens. Once all the students finish, the students/teacher decides the number pairs for the second session, and the game continues.

3.2.4 Context of the partnering school

The study was done in a semi-government school in suburban Mumbai, India. Marathi was the medium of instruction. Students who participated in the study were from the same classroom, taught by a female teacher who taught all the subjects. The students belonged to the families of migrants who had come to Mumbai from different parts of Maharashtra for employment. Parents of these students either had little or no formal schooling. Most of them knew how to read and write in Marathi. Most of the male members worked as porters or laborers in various markets such as fish markets or vegetable markets. Others worked as drivers or cleaners (helpers) on transport trucks. Most female members stayed at home and looked after the household chores; few went out to work and worked as domestic workers. The first author played the role of a teacher during the intervention. He is from the same state as the students and came to Mumbai for doctoral studies. He did his education in schools in small villages and towns where the medium of instruction was Marathi. Students called him ’dada,’ which means ’older brother’ in Marathi, due to his age.

3.2.5 Intervention activities and data collection:

A total of 45 students from grade four participated in the study. Their age ranged from 9 to 11 years old. Out of 45 students, 29 were boys, and 16 were girls. The school teacher randomly divided them into two groups, keeping the gender ratio the same. Each group was assigned to one of two settings: ChatStudioSelf versus ChatStudioGroup. ChatStudioSelf (CSS) had 22 students and ChatStudioGroup (CSG) had 23 students. Figure 3 shows research design and data collection tools.

The initial three days were used to build rapport with the students and the class teacher. The first author visited the school and played games with students for 45 min each day. Once the students were comfortable and were freely interacting, laptops were taken to the school. Each day we used to charge the laptops, put them in a bag and take it to school. We could not keep the laptops in the school as there was no place to store and charge them. School administration had allowed us a 45 min session towards the end of the school day. During that session, one group would stay in the class, and the class teacher would teach them as before, whereas the other group moved to another room where they got laptops, and the first author was the teacher. As a result of this arrangement, each group came to the computer session on alternate days. This arrangement also helped us as we only had 30 laptops. Each laptop was given a name, students knew their laptop’s name, and they would get the same laptop every time. On the day the CSS group was scheduled to use laptops,

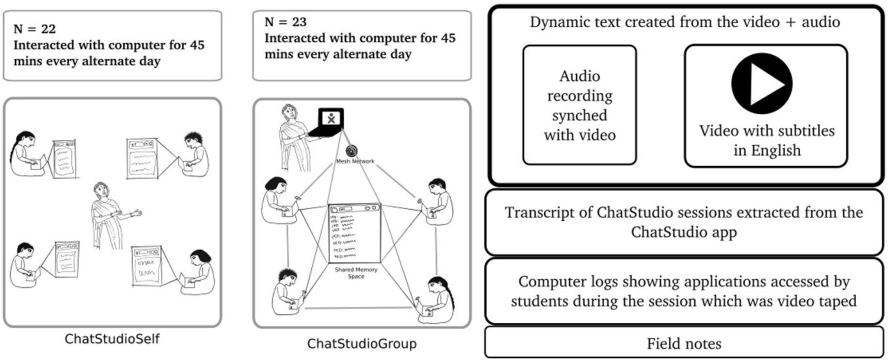


Fig. 3 Research design and data collection tools

we used to disable the network and hide the ChatStudioGroup application. The next day, when the CSG group was scheduled, we used to enable the network and hide the ChatStudioSelf application. The teacher also used one OLPC laptop, and it also had a specific name. Laptops were named after elements from the periodic table. The school was small and had a space crunch, so the computer session was conducted in any room available. OLPC laptops are light, designed for rough handling, and could easily be carried by the students. No wifi or wired network was required; laptops could create a local mesh network using radio technology anywhere in seconds. The initial three sessions with laptops were focused on letting students learn the essential functions. Functions like switching the laptop on and off, opening and closing an application, handling the cursor using the trackpad or mouse, using various buttons to take pictures or play games, connecting with a mesh network, joining a shared activity, and typing in Marathi. For these three sessions, both groups interacted with the laptop on the same days, in turns. For the rest of the days, each group came on alternate days. In these first few sessions, we noticed that the students had difficulty handling the cursor with the trackpad. We decided to use the mice instead; that solved the problem, and students could navigate the screen easily. Once the students were familiar with the laptop, they were introduced to the ChatStudio application. Learning to play the ChatStudio game and learning to type fluently happened simultaneously. Students started using the ChatStudio applications from the fourth day onwards. Each group used laptops for 33–34 days and played ChatStudio games for 30 days. The first 8–10 min and the last 5 min would go into distributing/collecting machines and mice. So effectively, we used to get 30 min each day for actual game-play.

During the intervention, the teacher (first author) used to carry a notebook to take notes and a voice recorder to record the audio. Logs from the computers were collected each day and saved on another computer. Logs contained meta-data and transcripts from the game and data about other applications available on the laptops. We could not video record all the sessions but got permission to record one session of each group. A fellow researcher came to school to record the video for two consecutive days. The camera was set up in one corner to record the entire class. The voice recorder was kept in the first pocket of the teacher (first author). The Voice recorder helped record the conversation between student and teacher that the video camera may have missed.

We also checked students' arithmetic proficiency. For it, we used an existing test developed by the Mathematics Group at Homi Bhabha Centre for Science Education, Mumbai, India. One example of questions from the test is show below:

> In the numbers given below, which is 'two thousand and sixty-nine'? (Mark the correct answer)
> a) 200,609, b) 2069, c) 200,069, d)200,609

The first test was done after dividing the students into two groups. Two groups were equivalent and there was no significant difference ($p = 0.436$) in their test scores before intervention. After the test, the intervention started. The second test was done at the end of the intervention.

After the post-test, focus group discussions (FGD) were conducted with the students. For FGDs, each group was further divided into two sub-groups, resulting in 4 focus group discussion sessions. We thought that the conversation would be better facilitated in smaller groups. The students sat around a long table, and three researchers (including the first author) sat at three different positions on the table. All the three researchers who participated in the FGD knew Marathi and had met the students earlier. Two separate audio recorders were placed at two ends of the table. In the FGD, students were asked about their experience using laptops, playing ChatStudio games, using other applications on the laptop, and connecting between the regular and computer classes. Audio records of the focus group discussion sessions were transcribed for analysis.

3.3 Analytical flow and methodology

To answer the first research question of whether there was a difference in students' engagement in the two settings, we drew on the app's log data and audio–video data. For the level of engagement, the log data was used to compare the number of students playing the ChatStudio app at least once each session. And the number of students checking in on other apps on the laptop at least once each session. Here, we are using "engagement" to mean simply if students were using the app, and not any sense of deeper disciplinary engagement. The video recordings were synced with the audio and computer logs using timestamps. To understand patterns in the nature of students' engagement, we coded 15 min of video in each setting. The videos were recorded one week before the end of the intervention. We coded each interaction by (i) who were the participants in the interaction (student–student (S2S), student–teacher (S2T), student-machine (S2M), and teacher-machine (T2M)) and (ii) the nature of the interaction, such as play, discussion, exploration, seeking feedback, troubleshooting, etc. To infer the nature of the interaction, we used dynamic text that had a textual description of verbal, temporal, spatial, and kinesthetic information from the video (Flewitt & Rosie, 2006). For any time segment, we coded all the students visible in the video. So, each time segment could have multiple codes resulting from co-occuring interactions. Additionally, in a particular interaction, a student, teacher, and the machine could be interactionally coupled. So, in any given time segment, the same interaction could contribute to more than one of the S2S, S2T, S2M, and T2M codes.

Based on the findings from this analysis, we created analytic memos of important events across the whole videotaped 45-min session in each setting. Appendix-1 is an example of such a memo. It has a line number, date-time-stamp, the participant's name in the game with a specific color, a description of the activity, and verbal utterances. We specifically looked to document events that were typical of a pattern in the participants' interactions or surprised us by violating some tacit or explicit assumption of ours. Most of the events we recorded were about self- or peer-assessment, requests for help, public recognition of success or failure, or contestation amongst participants.

To get at the second research question of disciplinary learning, we drew on the log data, focus group interview transcripts, audio–video data from the sessions, and analytic memos of significant episodes described above. Log data was used to compare arithmetic strategies students used to solve the game and win in each setting. We triangulated this with the focus group discussion from each setting, where participants shared what strategies they were using.

Close analysis of video of segments of significant events in each setting using tools from interaction analysis (Jordan & Henderson, 1995) also provided insights into what strategies students were using and how they interacted with their peers. We attended to their body postures during these interactions, their gaze, gestures, facial expressions, loud celebrations and contestations, and tone of their speech (for intonation markers and hedge words that indicate confidence, deferment, or confusion). To build explanatory stories for specific students' interactions, we also drew on the general history of their interactions during the sessions through a coarse-grained pass through the audio–video data. These stories gave us insights into differences in how students engaged in assessments of their (and, in the Group case, others') arithmetic, as well as towards the third research question pertaining to the construction of status and public displays.

In conjunction with the analysis, the specific form of the research question iteratively evolved (Bhattacharya, 2017; Maxwell, 2012). The final refined research questions were:

1. How was students' general engagement different between the CSS and the CSG settings? And why?
2. How was arithmetic use different between the CSS vs CSG settings? And why?
3. What were patterns of differences in how status was constructed by students in the CSS vs CSG settings?

We operationalised general engagement as time spent on the arithmetic game, whether students were generally interested in playing the game, and what kinds of activities were they involved in during the intervention sessions. For arithmetic use, we looked at the types of addition problems students were solving, the strategies they were using, and how they assessed their and others' performance. For status construction, we again looked at episodes of self- and peer- assessment, conflicts and contestations, public celebrations of success, and other significant S2S interactions to see how students were recognized as successful by the teacher or peers, and how they were positioned as mathematically competent or not in interactions. In many cases, it is difficult to pin point causal mechanisms to answer the "why" question. We are also not orienting to the presence or absence of SMS as the only difference between the settings. Instead, as described above, there are a number of digital, instructional, and social (interactional) differences between the two settings. Many of these differences are prompted by the presence/absence of SMS. The explanations we build in this paper show how the different configurations of digital, instructional, and social-interactions together produce the differences in observed patterns. The presence or absence of SMS is part of our explanation, but so are the affordances and constraints of the arithmetic game, of the instructional environment. Thus our findings aim to shed light on the influence of SMS, ecologically situated within a classroom environment, in the context of an arithmetic game, on the students' social, affective, and disciplinary engagement with arithmetic.

We want to emphasize that we divided the classroom into two groups so that our analysis could determine the differences in the interactional aspects of the two settings. Crucially, most of our quantitative measures are also not about measuring "outcomes" but instead getting a sense of differences in the patterns of interactions between the two settings. Then we pivot to qualitative methodologies to analyze chat-data and video-data from the two settings to illustrate how the interactions played out differently. Here we present a detailed analysis of specific episodes that help elaborate on how the classroom norms and specific technology features entangled with students' interactions to produce different coherences in the two settings. In this sense, each of the two "conditions" in our study constitutes a "case," and our analysis illustrates how these two cases lead to different configurations of contextual features and interaction patterns. Specifically, the "Self" setting provided a point of reference that brings into relief interaction patterns, norms, and technology features that we observed in the "Group" setting. Research designs similar to ours have also been used previously (McCoy & Lynam, 2021; Nguyen, 2022; and Pargman, 2003).

4 Findings

Before diving into the process data, we checked students' performance on the arithmetic proficiency test. As mentioned earlier, the tests before the intervention showed no significant difference in the two groups ($p = 0.436$). The post-test showed that each group performed better than their performance in the pre-test, and the p-value for the CSS group was $p = 0.00002956$, and for the CSG group, it was $p = 0.00008645$. However, there was no significant difference in the two groups' performance on post-test ($p = 0.8263$).

4.1 Comparison of engagement across the two settings

To check the student's level of engagement (research question 1) with the ChatStudio, we analyzed the computer logs from both settings. We checked how many students were playing the ChatStudio game each day, and how many students accessed other apps on the Laptop during each session in each setting. This was used as a coarse-grain measure of the level of students' engagement of the students. A difference was observed in the engagement level in the two settings. In Fig. 4a, we can see that at the beginning of the intervention, students from both settings engaged with

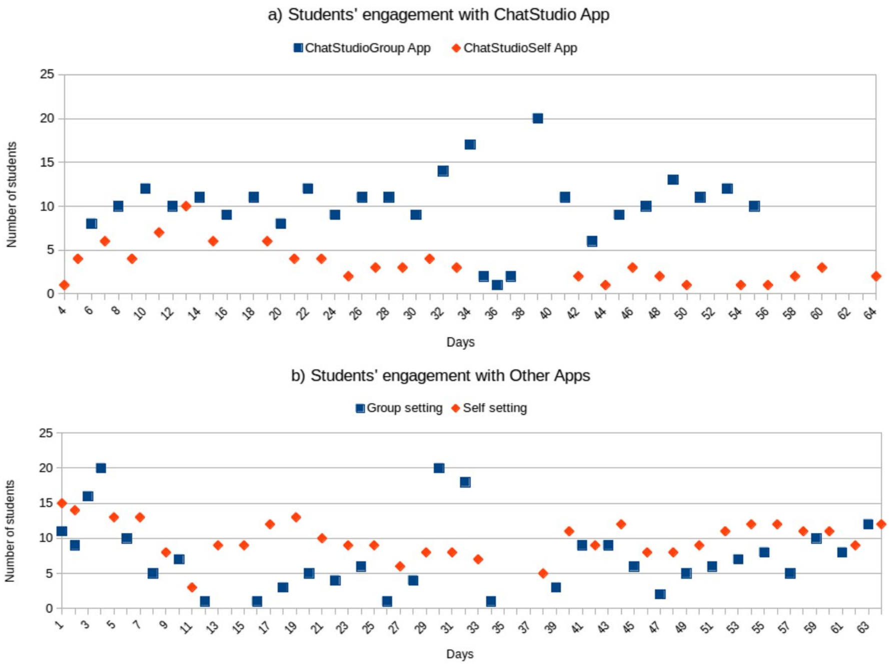


Fig. 4 Comparison of students' engagement with ChatStudio in Self (N = 22) and Group (N = 23) settings; and (**b**) comparison of students' engagement with other application during the entire intervention

the game. However, as time passed, the engagement level in the CSG setting more or less remained constant, whereas, in the CSS setting, it came down. We also checked how the ChatStudio game fared against other applications (Maze game, painting app, word processor, Music composer, Turtle LOGO programming app, etc.) on the laptop. Students were free to choose any application they liked. Figure 4b shows a difference in students' engagement with other applications in both settings. The students from the CSS setting used the other apps more than the CSG setting students. A comparison of both graphs shows that in the CSG setting, the ChatStudioGroup app was more engaging than the other apps. In the CSS setting, the other apps were more engaging than the ChatStudioSelf app.

Next, we checked the interaction pattern in both settings. As we note in the methods, we coded the nature of interactions between students, teacher, and machine in each setting for 15 min of video. Recall that the "teacher" during these interventions was the first author. Out of those 15 min, first 5 min in both the settings were spent on distributing the machines and class management. So effectively Fig. 5 represents interactions that happened in later 10 min of the selected video segments.

Figure 5 shows the number of student–student, student-machine, student–teacher, and teacher-machine interaction events in each setting. The pattern of interactions in the two settings was different. In the CSS setting, the majority of events were student–teacher interactions. There were a few student-machine and teacher-machine interactions, and fewer student–student interactions. In the CSG setting, by contrast, the number of interaction events were distributed more equally amongst students, teacher, and machines. This observation was also triangulated with the data from the focus group discussions and the field notes. In the focus group setting, students from the CSS setting mentioned that they approached the teacher for every issue. However, students from the CSG settings mentioned that they approached peers as well. The total number of interactions in the CSS setting was also much higher than that in the CSG setting (89 versus 54) while the length of interactions were typically longer in the CSG setting.

Inspecting the video to look at the content of the interaction in these events, we notice that the contexts of interactions were also different in the two settings. In the CSS setting, the contexts for these interactions were students seeking evaluation and appreciation from the teacher for the work done, taking the teacher's help in troubleshooting a technical issue, or seeking help with arithmetic. The pattern is similar to the interaction pattern in the traditional class mentioned in the introduction, where teacher is the main source of information and assessment. In contrast, in the CSG setting, the interaction contexts were students' assessing each others' work, celebrating success, having a group discussion around the game (for e.g., to decide on the starting and stepping numbers), reporting others' mistakes to the teacher, and litigating their cases with the teacher. Here, sources of knowledge and information included the other students and the shared screen which kept a record of everyone's game-play. Later we present a few vignettes of such interactions.

Interactions of students and teachers with the machine were analyzed in both settings. From Fig. 5 we can see that, in the CSS setting, there were relatively more teacher-machine interactions as compared to student-machine interactions. The

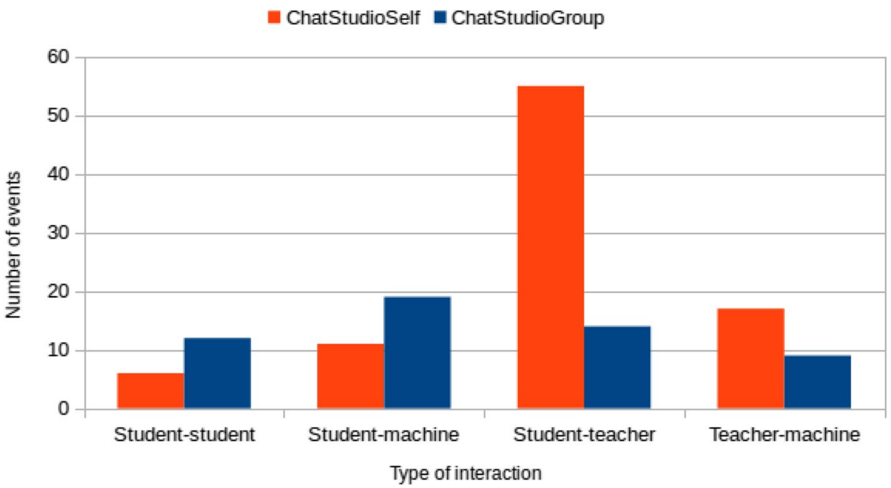


Fig. 5 Graph showing number of different interaction events during a 10-min segment from each setting

pattern was reversed in the CSG setting. In the CSS setting many of the teacher-machine interactions were during evaluations of students' work, which we have noted was a dominant form of interaction in that setting and outnumbered such interactions in the CSG setting. In the CSG setting, there were many more student–student interactions. Student–student interactions in the CSG setting often also involved student-machine interaction events such as looking at the computer screen, interacting with the computer screen (e.g., scrolling), pointing to some number on the screen, or referring to it in talk. In these interactions, the screen was entangled with students' arithmetic (self- and peer- assessment) and argumentation practices. Fine timescale analysis of some of these interactions, presented later, helped us flesh out detailed stories of this entanglement.

4.2 Comparison of gameplay strategies across the two settings

In terms of the learning of arithmetic (research question 2), we looked at what kinds of number pairs students were choosing during game-play, and what kinds of strategies they were using to advance through the game.

The ChatStudio game (both settings) had three difficulty levels and one custom number pair option. We see a difference in the difficulty level chosen and the selection of number pairs in both groups. The computer logs show that the CSG group tried 42 different number pairs, whereas the CSS group tried only 14. For example, from the screen video recording, we document how a couple of students in the ChatStudioSelf setting opt for a customized number pair with one as starting and one as a stepping number. It is the most basic possible number pair in the game. Looking at the computer logs of students in the CSS setting, we found that many students in the ChatStudioSelf setting frequently opted for customized number pairs and chose simple number pairs, such as (10 and 10) or (20 and 20). Many students in the CSS setting repeatedly selected the same 'number pairs,' to our surprise. Table 3 shows examples of two students and the selection of various number pairs in successive sessions. In comparison, the students in the CSG setting opted for variety of number pairs. In the CSG setting, there were 21 pairs that were selected just once, 16 pairs that were selected twice, 4 pairs thrice, 1 pair four time, and 1 pair seven times (5&5).With the exception of the number pair (5, 5), they did not select simple pairs such as '1 and 1' or '10 and 1' or '20 and 20,' which were used repeatedly in the CSS setting.

There was also a difference in the strategies that students used for gameplay. Students used strategies like counting up or down with help of fingers, count up or down by speaking aloud, sequentially add or subtract the stepping number mentally, decompose to nearest simple number and regroup later, and use of mutliplication tables to do additions. Students from the CSS settings predominantly used counting up or down with the help of fingers and counting aloud strategy. The use of more complex strategies was less common. The students from the CSG group used all the strategies mentioned above, however we observed progression from simple strategies to complex ones over the course of the intervention.

Table 3 Part of computer log showing selection of number pairs by two students in successive sessions

Student name	Date	Time	Accuracy in %	RT in sec	start Number	Second number	mode	steps	mistakes	avg_response_time	difficulty_level
Sanjana	03/02	05:17	100	38.188	10	10	Addition	4	0	9.547	Changed_Numbers
Sanjana	03/02	05:24	100	26.45	20	20	Addition	1	0	26.45	Changed_Numbers
Sanjana	03/02	05:29	87	89.178	3	3	Addition	15	2	5.945	Easy
Sanjana	05/03	05:01	100	33.222	10	10	Addition	4	0	8.306	Changed_Numbers
Sanjana	10/02	04:55	100	151.012	5	5	Addition	9	0	16.779	Changed_Numbers +
Sanjana	10/02	04:56	100	26.693	10	10	Addition	4	0	6.673	Changed_Numbers
Sanjana	10/02	04:58	100	50.753	20	20	Addition	1	0	50.753	Changed_Numbers
Sanjana	10/02	05:01	100	41.639	10	10	Addition	4	0	10.41	Changed_Numbers
Sanjana	10/02	05:02	100	40.676	20	20	Addition	1	0	40.676	Changed_Numbers
Sanjana	10/02	05:05	100	156.299	10	10	Addition	4	0	39.075	Changed_Numbers
Sanjana	10/02	05:12	100	32.427	20	20	Addition	1	0	32.427	Changed_Numbers
Sanjana	12/02	05:26	100	33.523	10	10	Addition	4	0	8.381	Changed_Numbers
Sanjana	12/02	05:27	100	26.164	20	20	Addition	1	0	26.164	Changed_Numbers
Sanjana	12/02	05:28	75	34.816	10	10	Addition	4	1	8.704	Changed_Numbers
Sanjana	16/02	05:00	100	37.771	10	10	Addition	4	0	9.443	Changed_Numbers
Sanjana	16/02	05:01	100	22.403	20	20	Addition	1	0	22.403	Changed_Numbers
Sanjana	16/02	05:01	100	15.228	20	20	Addition	1	0	15.228	Changed_Numbers
Sanjana	16/02	05:01	100	22.26	20	20	Addition	1	0	22.26	Changed_Numbers
Sanjana	16/02	05:02	100	59.689	20	20	Addition	1	0	59.689	Changed_Numbers
Sanjana	16/02	05:05	100	23.031	20	20	Addition	1	0	23.031	Changed_Numbers
Sanjana	16/03	05:23	100	92.979	10	10	Addition	4	0	23.245	Changed_Numbers
Sanjana	16/03	05:24	100	21.288	20	20	Addition	1	0	21.288	Changed_Numbers
Sanjana	16/03	05:26	100	19.186	20	20	Addition	1	0	19.186	Changed_Numbers
Sanjana	16/03	05:29	100	27.601	10	10	Addition	4	0	6.9	Changed_Numbers

Table 3 (continued)

Student name	Date	Time	Accuracy in %	RT in sec	start Number	Second number	mode	steps	mistakes	avg_response_time	difficulty_level
Sanjana	16/03	05:30	100	35.369	10	10	Addition	4	0	8.842	Changed_Numbers
Meena	19/12	05:02	100	53.308	10	10	Addition	4	0	13.327	Changed_Numbers
Meena	19/12	05:08	100	251.396	1	1	Addition	49	0	5.131	Changed_Numbers
Meena	19/12	05:09	100	31.013	10	10	Addition	4	0	7.753	Changed_Numbers
Meena	19/12	05:10	100	49.659	10	10	Addition	4	0	12.415	Changed_Numbers
Meena	19/12	05:11	100	43.369	20	20	Addition	1	0	43.369	Changed_Numbers

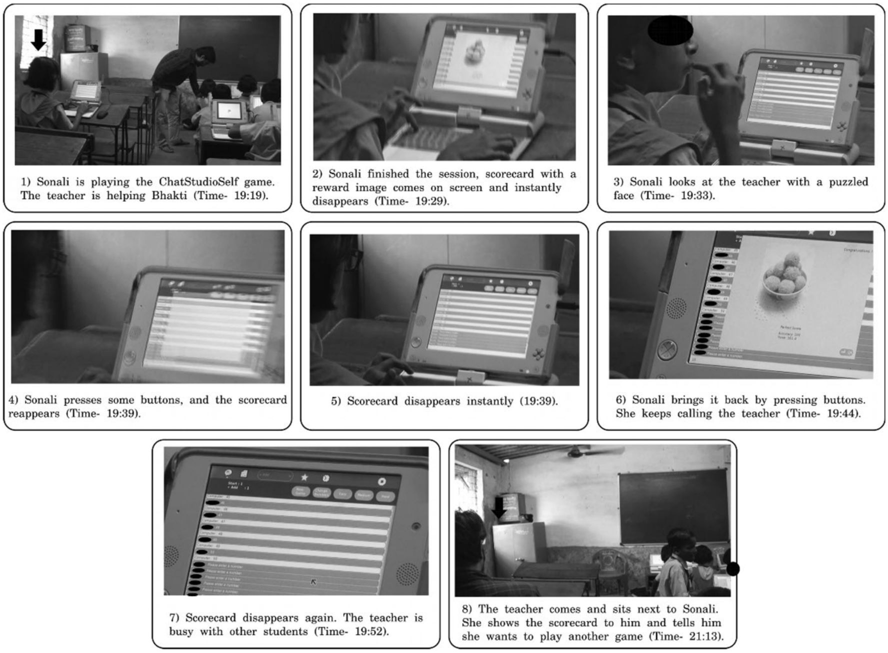
One of the strategies that drew our attention was the use of multiplication tables for deciding number pairs as well as the stepping. Students in both settings discovered that multiplication tables could be used for working through the game in certain situations. The strategy was more widespread in the CSG setting, with 13 students using that at some point during the sessions, as compared to only 3 students in the CSS setting. The elementary school mathematics curriculum in India requires students to learn multiplication tables, and many students learn them by rote. We cannot tell which students first started using the multiplication strategy but the strategy soon spread. In focus group settings, students in the CSG group explicitly noted that they "used multiplication tables to solve addition problems." They also demonstrated a functional understanding of the strategy, In focus group interviews, students from the CSG setting confidently insisted that they could only use the multiplication tables when the starting and stepping numbers were the same, and not in other situations. In comparison, during focus group interviews with students in the CSS setting, they were unsure about using the multiplication tables. For example, in one interview, a student noted that the multiplication strategy can be used for all number pairs, and then, quickly switched to saying that the tables cannot be used for any number pairs.

We cannot draw out a full causal mechanism for these differences. However, field notes of intervention sessions, and video data point to a configuration of factors in each setting that could have contributed. In either setting, there was a need for speed: however, in the CSS setting, students were competing with their own prior completion times; while in the CSG setting, students were competing against one another in the same game-play. One could imagine why it might be attractive for someone to try the same number pair again in the CSS setting to see if they can beat their own prior timing. Another difference was that the students in the CSS setting chose their number pairs individually while those in the CSG setting chose a common number pair for the whole class to compete. This group discussion in the CSG setting led students to choose a more varied set of number pairs and not repeat the same combinations. This raised the arithmetical difficulty of doing fast additions in the CSG setting as compared to the CSS setting. In spite of the increased difficulty, most students in the CSG setting also finished the games with a reasonable accuracy level. Field notes and focus group interviews suggest that the shared memory space (SMS) supported students in completing these calculations. Many students reported looking at the screen for what other students were typing when they were struggling. However, as we show in the subsequent sections, students drew on academic status and friendship to judge which of the numbers from the screen to take up in continuing their own game, suggesting that they were not mindlessly copying. Our field notes and video analysis suggests that the assessment and reward structure differences in the two settings also contributed to the choice of the number pairs. The assessment in the CSS setting was mainly an interaction between an individual student and the teacher, who evaluated the game and gave the student a reward badge for successful completion. The teacher was having to support multiple students at any given time, and was unable to attend to the level of difficulty students were attempting or comment on repetitive choice of number pairs. In the CSG setting by wcontrast, the assessment itself was distributed since students could see each others' gameplay and celebrate or contest outcomes collectively. In the next sections we describe these interactional differences between the two settings.

4.3 Assessment, status, and relationality in interactions

One of the things that jumped out at us during analysis was that many of the student–student and student–teacher interactions were structured as assessments of arithmetic. In these moments, arithmetic assessment, academic status, and social relationalities were co-constituted. But the CSS and CSG settings differed in how these moments were configured in each.

In the CSS setting, the dominant mode of assessment was students reaching out to the teacher. Analysis of selected episodes showed that many student–teacher interactions had a typical pattern in the CSS setting. A student playing the ChatStudioSelf game calls the teacher; the teacher goes and inspects her work. The teacher either gives her feedback or cheers her up by encouraging her. Here we highlight an episode to illustrate how getting the teacher's approval was important to the students in the CSS setting before moving on. In this episode, a female student, Sonali, did not proceed to the next session of the game after finishing a game successfully. She calls the teacher to show her the badge that had appeared on her screen when she finished that session of the game (Fig. 6). However, while waiting for the teacher to come to her desk, the badge disappeared. She pressed some buttons until the badge reappears. The badge



1) Sonali is playing the ChatStudioSelf game. The teacher is helping Bhakti (Time- 19:19).

2) Sonali finished the session, scorecard with a reward image comes on screen and instantly disappears (Time- 19:29).

3) Sonali looks at the teacher with a puzzled face (Time- 19:33).

4) Sonali presses some buttons, and the scorecard reappears (Time- 19:39).

5) Scorecard disappears instantly (19:39).

6) Sonali brings it back by pressing buttons. She keeps calling the teacher (Time- 19:44).

7) Scorecard disappears again. The teacher is busy with other students (Time- 19:52).

8) The teacher comes and sits next to Sonali. She shows the scorecard to him and tells him she wants to play another game (Time- 21:13).

Fig. 6 Chronologically arranged snapshots of the classroom scene and Sonali's computer screen to illustrate assessment interactions between a student, Sonali, and the teacher disappeared again, twice, and Sonali brought it back twice and waited for the teacher. She moved to the next activity only after showing it to the teacher and getting her approval. This suggests that to Sonali, in the context of this activity in that classroom, knowing that she had correctly solved that game and getting the digital badge from the system was not sufficient; the teacher's approval was also necessary for moving on to the next game. Field notes by the first author who was also the teacher support that this way of ending the game with the teacher's approval was common in the CSS setting.

There were also instances of self-assessment in the CSS setting. For example, in another episode, Sonali typed a number but paused before posting it. She erased the number, and typed another number and posted that. It is not easy to say what went into her mind. However, it is plausible that the visible log of the previously typed numbers supported her in error correction.

In contrast, in the CSG setting, there were lots of student–student interactions in conjunction with student–teacher interactions. The involvement of the teacher in the assessment events was also different. In addition to checking individual work, or technical troubleshooting, the teacher was also involved in the peer-assessments that were taking place during and at the end of the game. There were also many more instances of self-assessment in the CSG setting. Partly, we think that the higher number of these self- and peer- assessment events was due to the incentive structure in this setting, where students had an incentive to report on errors by self and others. Our purpose in presenting some episodes of this is to illustrate the dynamics of interactions between students, teacher, and machine in the CSG setting.

The illustrative segments come from a game in which the starting number was 17, the stepping number to be added was 7, and 100 was the threshold to cross. The correct sequence of numbers in this game would be 17, 24, 31, 38, 45, 52, 59, 66, 73, 80, 87, 94, 101.

Within a few seconds of the game starting, a male student, Sadanand, posts 23. For this step, $17+7=24$ is the correct answer. And within 3 s of Sadanand's posting, a female student, Samita, calls out to the teacher announcing that Sadanand has made a mistake. In Table 4, we show the time-coordinated computer log and video-observations leading up to Samita calling out Sadanand's error. We note that Sadanand's post of 23 was sandwiched by other students posting 24. Also note that instead of addressing Sadanand, Samita points out the error to the teacher. Computer log shows that within 10 s of this, Sadanand posts 24.

What this suggests is that at least some students were monitoring the screen for the numbers posted and errors even before finishing their own game. This monitoring of the screen for numbers was also evident in events of self-assessment. Unlike the CSS setting, however, in the CSG setting students often announced their own mistakes to the teacher. This was perhaps prompted by the incentive structure for reporting errors. In about 3 min of gameplay for this particular game, two students reported their own errors to the teacher. In one case, a male student, Nikhil, posts 522, stops, and calls to the teacher:

Nikhil: Dada…wrote 522 instead of 52
T: hmm who?

Table 4 Part of time log showing series of events leading up to Samita calling out Sadanand's mistake

Line	Timestamp	User	Post	Non-verbal	Verbal
13	17:25:56.931586	Mayur	24	Samita uses her fingers as a support while calculating	
14	17:25:57.177407	Amol	24		
15	17:25:57.970794	Sadanand	23		
16	17:25:58.315132	Nikhil	24	Samita types a number, Just before clicking "enter," she looks at screen, her face shows shock	
17	17:26:00.243188	Samita	24	She posts her number and immediately stands and speaks loudly	Samita : Dada, Sadanand made a mistake
18	17:26:00.704793	Krishna	24		Samita: he wrote 23 instead of 24
19	17:26:01.419337	Amol	31		T: ok
20	17:26:01.897525	Mayur	31		

Nikhil: Me
T: hmm ok
T: start posting from 52 onwards

Nikhil posts 52 and continues. Within seconds, another male student, Krishna, announced to the teacher that he made a mistake:

Krishna: Dada there is a mistake.
T: who did?
Krishna: I did, I wrote 69 and then 66.
T: ok go ahead complete the rest of the steps.

Field notes of the first author who was also the teacher support that, in the CSG setting, it was common for students to publicly report on the errors made by themselves or by others, even before they have finished the game. However, at the end of the game, once some students have crossed the finishing number, there were more of such error reporting events. As more students cross the finishing number, more of them joined in finding and reporting errors. During these events, students would often scroll the screen to see the computer log of color-coded numbers posted by the students.

We next present detailed analysis of interactions at the end of this particular game to illustrate some of the dynamics amongst students, teacher, and machine. The episode starts when Amol stands up at his place in celebration, declares that he crossed the last number, and says it is ’106’. However, as soon as Amol declares it to class, Samita counters, saying he is wrong as he wrote ’1006’ instead of ’106’. Soon Mayur also claims that he crossed the last number, ’106’, and starts clapping with a happy face. He also points out that Amol made a typo and wrote ’1006’ instead of ’106’. Then Amol says Samita made a mistake; she wrote ’101’ instead of ’106’. That means Samita has crossed the last number, but unlike Amol and Mayur, she did not celebrate publicly. Computer logs confirm that she did cross the last number, and as per her calculations, it is ’101’. Amol tries to explain to the class and teacher why Samita is wrong, and the answer is ’106’, not ’101’.

Meanwhile, another student, Sadanand, declares that he crossed the last number, and it is ’103’. Soon few more students reach the last number, and confusion in the class increases. For Shushma, it is ’100’; for Mahesh and Amol, it is ’102’. It seems nobody is sure what the last number is. Few students look towards the teacher, but he is also unsure as the computer randomly generates the number pairs, so he will have to calculate and find out. He tries asking another person in the class who is recording the video but realizing that she might not be able to help, he goes near the blackboard and writes numbers on it after calculating. After confirming, he tells the class that Samita is correct and the last number is ’101’. While the teacher was doing calculations, Amol was standing near him and pressing that it was he who was correct; it was ’106’. Even after the teacher says that Samita is correct and the last number is ’101’, a few students seem to contest that. Mayur and Amol still feel that it is ’106’. Amol says their last number (106) is correct as he did every addition by counting with fingers. After the teacher’s confirmation, Samita is confident and points out that Shushma and Sadanand made mistakes; Nikhil also accepts the teacher’s last number and points out that Sadanand made a mistake.

Meanwhile, everyone crosses the last number, and the system automatically generates a scorecard. Students can see that the teacher correctly said Samita’s calculation was proper. The combined authority of the teacher and computer algorithm finally settles the confusion in the class.

Some of this dynamic perhaps was also influenced by the positionality of the first author. The first author was also the teacher, even though he was not a regular teacher, and interacted with each group for a limited time on alternate days. He still enjoyed the position of power due to the school administration presenting him as a temporary teacher, his age, and his association with a research institute. However, he also differed from other teachers in the school in some aspects. Students did not call him teacher or sir. They called him ’Dada,’ a Marathi word for brother. Maybe due to his non-formal position in the school and his age. Its effects could be seen in how students interacted with him. Contrasting the observations from regular classes show that students talked freely in ChatStudio class; there is also more noise. The difference could be seen in an episode in the video, where the regular teacher of the students comes to the ChatStudio room to talk to a few students regarding some work; as soon as the teacher enters the class, suddenly, everyone goes quiet. However, the first author was the teacher in both the settings but, only in the CSG setting do we see students confidently arguing their case.

4.4 Student's attitude

We take you back to the episode presented in the above section. In this section, we are focusing on a female student named Samita (See the Fig. 7). We want to point out how different students behaved differently when finishing the game. For example, when a male student Amol announces that he won, he leaves his seat and comes out shouting. However, when Samita crosses the last number, she does not announce or celebrate like Amol or other male students. Samita was a shy student. The teacher also took some time to build rapport with her. In contrast, Amol was not shy and showed emotions openly. The difference between Amol and Samita could also be due to the culture. We noticed a difference in how male and female students conducted themselves in the class. Male and female students sat separately, even in the ChatStudio class, where the first author was the teacher and did not force gender-based seating arrangements. Female students were much more soft-spoken than males; male students could be seen arguing and fighting in class. Male students showed much aggression and celebrated loudly, whereas female students quietly celebrated by smiling or high-five-ing with neighbors. Even though students in grade 4th and around 9 to 11 years old, they could be seen behaving as per social gender roles. These roles are part of Indian culture, specifically the local culture of a Maharashtrian family with a low socio-economic background (Bhattacharjee, 2021).

The next critical moment in the episode was when students were auguring about the correct final number. As nobody is sure, students approach the teacher. He calculates and tells the class that Samita is correct; the final number is '101'. At this moment, we see Samita deviating from her observed behavior so far. Even though she does not celebrate, she soon points out the mistakes made by others. At one point, like male students, in excitement, she even tries to leave her seat and come out in the open, but as she is sitting in the middle struggles to come out. So far, her interactions were with the teacher or female students seated next to her. However, at this moment, she, for the first time, directly engages with two students from the opposite gender. She points her finger at a male student, tells him about his incorrect calculation, and explains why she is right.

In this episode, Samita did her calculations, came up with an answer, and stuck to it when others confidently touted their numbers as correct. She did not change her number to match what others were saying. After much back and forth between students and teachers, when the teacher declared that she was correct, we saw her self-confidence boosted by her expressions.

4.5 Status, trust, and friendship

In our final vignette, we show how pre-existing relations amongst the students influenced who they looked to for help. The episode (Fig. 8) starts with Nikhil

1) Game starts, Samita is busy in calculating (line 13-15)

2) Samita points mistake made by Sadanand to teacher (line 20)

3) Amol says he is correct and Samita is wrong, Samita watching exchange (line111)

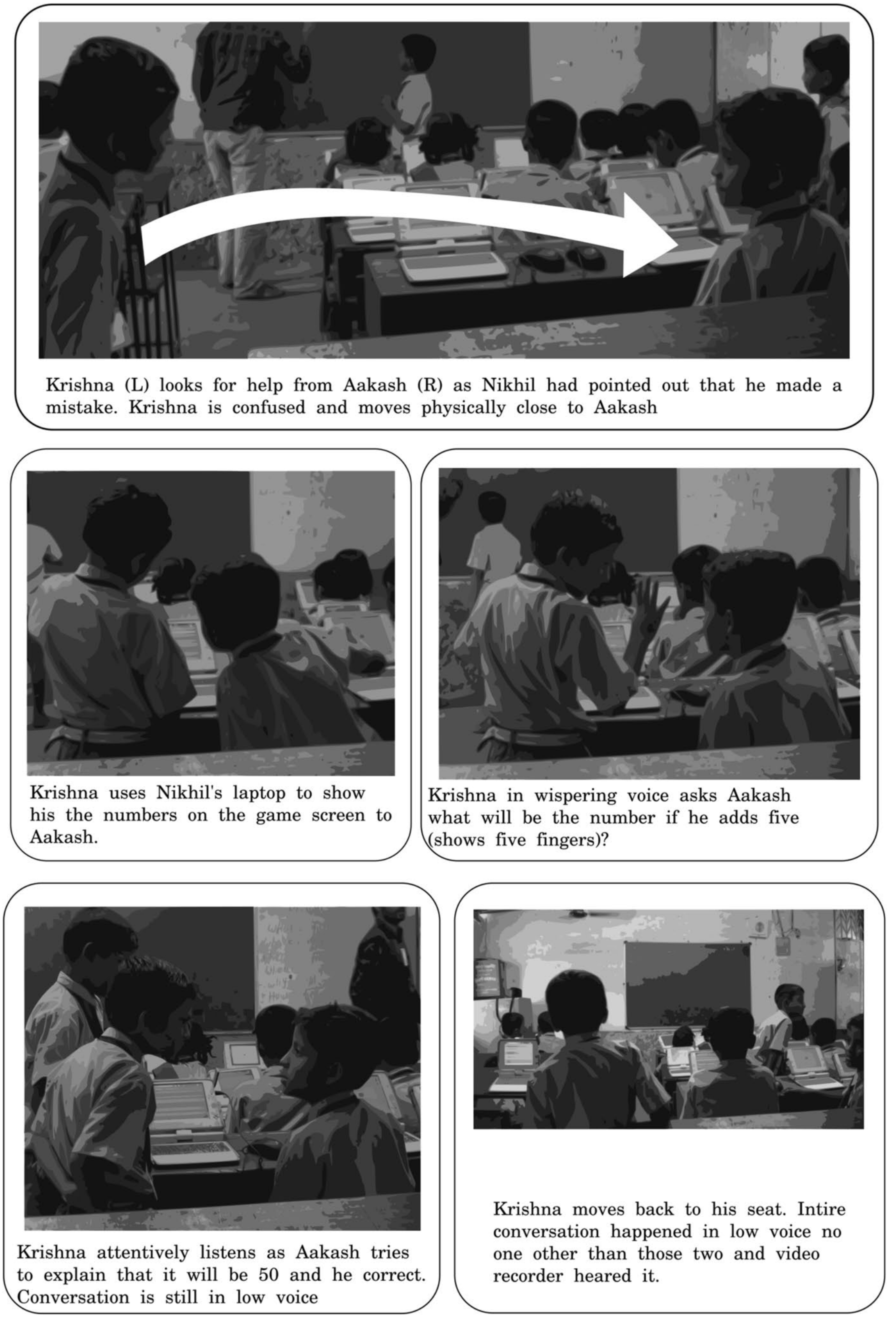
4) Teacher tells Samita that she was correct as Amol leaves for his desk (line 120)

5) Samita tries to come out of her desk in open (line 121)

6) Samita is arguing with Sadanand saying he made a mistake (line 122)

7) Samita smiling at the end of the game, she was on top of the leaderboard. (line 131)

Fig. 7 Chronologically arranged snapshots of the classroom scene showing the sequence of events that lead to boost in Samita's confidence



Krishna (L) looks for help from Aakash (R) as Nikhil had pointed out that he made a mistake. Krishna is confused and moves physically close to Aakash

Krishna uses Nikhil's laptop to show his the numbers on the game screen to Aakash.

Krishna in wispering voice asks Aakash what will be the number if he adds five (shows five fingers)?

Krishna attentively listens as Aakash tries to explain that it will be 50 and he correct. Conversation is still in low voice

Krishna moves back to his seat. Intire conversation happened in low voice no one other than those two and video recorder heared it.

Fig. 8 Chronologically arranged snapshots of the classroom scene showing the interactions between Krishna, Akash and Nikhil pointing out that Krishna made a mistake. Krishna looks unsure about Nikhil's claim, but he does not respond to him even though he is sitting on an adjacent desk. Instead, Krishna goes to Aakash, even though Aakash is not playing the game in this session 1 (See the Fig. 8). He uses Nikhil's laptop (as Nikhil is away from his desk) to show him the game screen numbers and ask his opinion. They discuss, and Aakash tells Krishna that he is correct and the answer should be '50'. The whole conversation between Aakash and Krishna was in very low voice, as if, private. We suspect that Krishna feels safe with Aakash because they have a history of pleasant and friendly interactions. Even though Aakash is not playing the game in this session, he has been a regular player, and on that day, he joins the game in later sessions. Both are equally good at the game (in later sessions, both score 100% accuracy); they have helped each other in the past. They have built a friendship through regular interactions in the game context. Krishna does not have such a relationship with Nikhil.

5 Discussion and implications

The study was conducted to examine the role of SMS in learning. Our study confirmed what others (Lomas et al., 2017) had reported: simple rule-based games can be engaging and motivating. In parallel to other studies in the literature (Plass et al., 2013), we also saw a higher level of engagement when the digital interface and classroom norms encouraged peer interactions and peer assessment.

We also found that the pattern and context of interactions in both settings were different. The interaction pattern in the CSS setting was similar to that in the traditional Indian classroom (Sarangapani, 2003). However, the pattern from the CSG setting with SMS differed from the traditional and CSS classrooms. The students not only interacted with the teacher but with other students, both face to face and via machine.

Learning happened in both settings; however, our analysis showed that having SMS in the class changed the learning process. Offloading representations and instantly sharing them enabled certain interactions. We saw that students from the CSG setting monitored others' posts on the ChatStudio screen and used it for several purposes: to check the accuracy of their calculation, get a hint, assess others' work, and litigate their case with other students and the teacher. Interactions where students assessed their own or peers' work were instrumental in the learning process, and the shared screen was entangled in the moment-to-moment dynamics of these assessment events.

Our findings were similar to Hoang et al.'s (2022) finding that students have a positive attitude towards peer assessment and quality is also better when they know that their peer-assessment activities were considered in the final score. The assessment activity also helped students travel from the periphery (novice) to the center (expert). It happened as students became independent in developing skills needed to complete the task in the ChatStudio game (Rada, 1994) as one could play the game by following and copying someone's numbers. However, one needs to think and reason to assess others' work.

The students in both settings could choose any activity on the laptops. Nevertheless, they chose the ChatStudio application and interacted with it. What is the motivation to use the ChatStudio application? We think both versions of the ChatStudio satisfy two basic needs of students, as (Deci & Ryan, 2012) suggested. Students were free to choose (autonomy), and students could opt for the difficulty level and number pair of their choice and complete the task (competence), as seen in Sonali's case. However, we saw the difference in engagement level in both settings, and we think the third need, i.e., the need to feel connected with others, was missing in the CSS setting. That could be part of the explanation for why students from the CSS setting were not as motivated as students from the CSG setting. The shared screen played a role in creating a feeling of connectedness in the CSG setting. Representations on the screen initiated and mediated most of the interactions.

The episode involving Krishna, Nikhil and Akash suggests that along with the knowledge level of the peer/adult, the relationship with the learner also matters. Epistemic interactions can be more powerful for learning when the participants are friends (Takeuchi, 2016). Relationships of this kind can develop when students can freely interact for a long time, and there is a context for interaction. They also can lead to development of trust (Baturay & Toker, 2019). Support through such relationships may explain the observed difference in the level of engagement in the two settings. Having shared representation is a mediator and facilitates productive conversation among learners (Suthers, 2006). Conversations can contribute to construction of relationships.

5.1 Implications for instruction using digital games for mathematical learning

This study suggests that classroom norms are important for creating space for social interactions. Therefore, teachers/educators should design classroom norms that can support more peer-to-peer interactions. And such interactions can support students in learning via instructional games. Competition in an instructional game can help students engage with the task; and so, competition can be included as an instructional strategy at times. However, there should be careful instructional deliberation on how to balance competition and collaboration. The work also suggests that having friends in mathematics class can help students learn from mistakes, and friendships can provide safe interactional contexts. Therefore, game design should include opportunities to build friendships.

5.2 Implications for the design of instructional games

This study also suggests that, within particular classroom contexts, games that support peer interactions might be better at helping children learn than ones that only support student-machine interactions. A space that allows externalization and instant sharing of representations among participants has certain advantages. Therefore, designers of instructional games should include features that allow the externalization of representation.

This study echoes the suggestions by other researchers that instructional games should be as simple as possible (Lomas et al., 2017), especially when designed for young students. Games should not consume considerable time in learning the rules. While designing the games, designers should ensure that learners are interacting readily and have the option of interacting with any member privately when necessary. Games should have features/rules that support building supportive relationships, for example, rules allowing students to help each other.

The game design in the present study encourages competition more than collaboration. It is visible in the frequency of interactions; most S2S interactions are about peer assessment. In comparison, the instances of students helping each other are fewer. Also, helping in this context is not the same as collaborating. It shows how technology design affects social interactions. Therefore, technology design should be attentive to what kind of interactions we want to encourage in the classroom and towards what goals (such as disciplinary learning, identity work, and community building).

5.3 Implications for learning scientists and education researchers

Our observations support that learning is simultaneously cognitive, affective, and social. There is a need for further research to *how* these aspects are entangled in the context of instructional games.

Having a shared memory space in the classroom can open an extra channel for students' interactions. Verbal interactions have limitations; many students can not speak simultaneously, and verbal utterances may not always be accessed later. Our study and others (Stahl, 2006) have shown that having classroom interactions accessible is beneficial; students use them for referencing while discussing. For example, a diagram drawn on a blackboard is at least visually available for everyone in the class. Students can point to diagram elements while asking questions or arguing. A blackboard is also a shared memory space with limited access and memory. Not all students can create representations simultaneously, and there is a limit to how many representations can be created without rubbing previous ones. Digital shared memory space can help address this problem, provide simultaneous access to many students, and support students in having greater control on creating representations. However, our findings also show that classroom norms interweave with the design of the instructional game in how learning and interactions emerge in the classroom. This suggests the need for more ecologically situated research on instructional games rather than clinical studies that may not engender such entanglements by design.

Appendix

Sr no	Computer log time	Participant	Post	Non-verbal	Verbal
1	17:25:19.520086	Teacher	17	Game starts	T: Write 10.. hmm sorry write 17.. write 17
2	17:25:21.072295	Aakash	17		
3	17:25:21.573305	Sadanand	17		
4	17:25:22.031942	Krishna	17		
5	17:25:22.458177	Sushma	17		
6	17:25:23.729547	Samita	17		
7	17:25:26.530124	Nikhil	17		T: Hey what happened? Start it again.. start it again
8	17:25:26.925064	Mayur	17		
9	17:25:27.165138	Amol	B-)१ ७		
10	17:25:27.819794	Mahesh	17		Nikhil: How many? T: 17 write 17
11	17:25:30.491995	Amol	१ ७		Mahesh: ok 17. T: Write 17 Samita: adding

12	17:25:38.821203	Amol	17		number? T: wait... wait I'll say T: Did every wrote 17? T: yesssss T: Amol... hmm yes he wrote.. he wrote T: Amol.. hmmm ye he wrote T: Now... now.. add to it 7 T: start adding 7 to it S: 7? T: You have to go beyond 100
13	17:25:56.931586	Mayur	24	Samita uses her fingers as a support while calculating	
14	17:25:57.177407	Amol	24		
15	17:25:57.970794	Sadanand	23		
16	17:25:58.315132	Nikhil	24	Samita types a number, Just before clicking “enter,” she looks at screen, her face shows shock	
17	17:26:00.243188	Samita	24	She posts her number and immediately stands and speaks loudly	Samita: Dada Sadanand made a mistake
18	17:26:00.704793	Krishna	24		

19	17:26:01.419337	Amol	31		Samita: he wrote 23 instead of 24
20	17:26:01.897525	Mayur	31		T: ok
21	17:26:04.598399	Nikhil	31	Sadanand hear Samita’s claim and checks his screen	Bharti : (inaudible probably counting numbers around)
22	17:26:05.790866	Krishna	31	Sadanand keeps staring at his screen	
23	17:26:06.270818	Amol	38		
24	17:26:07.224829	Aakash	24		
25	17:26:08.762517	Sushma	14		
26	17:26:09.240590	Mayur	38		
27	17:26:10.447414	Nikhil	38		
28	17:26:10.940127	Mahesh	24		
29	17:26:11.625822	Sadanand	24	Sadanand corrects his mistake by posting 24 and starts calculating number for next step	
30	17:26:11.825775	Amol	45		
31	17:26:12.168497	Krishna	38		
32	17:26:13.568947	Samita	31		
33	17:26:14.063774	Mayur	45		
34	17:26:14.581125	Sushma	21		
35	17:26:16.953010	Nikhil	45		
36	17:26:17.142569	Amol	52		
37	17:26:17.340245	Aakash	31		
38	17:26:17.718668	Sadanand	30		

39	17:26:18.607730	Mayur	52	
40	17:26:19.480917	Samita	38	
41	17:26:19.954046	Nikhil	522	
42	17:26:20.504615	Krishna	45	
43	17:26:21.077578	Mahesh	31	
44	17:26:21.854650	Amol	59	Nikhil: Dada.. wrote 522 instead of 52 T: hmm who? Nikhil: Me T: hmm ok
45	17:26:22.754322	Sushma	35	
46	17:26:23.590967	Aakash	38	
47	17:26:24.263848	Mayur	49	
48	17:26:24.501681	Sadanand	37	
49	17:26:26.440134	Amol	66	
50	17:26:27.799037	Mahesh	38	T: start posting from 52 onwards
51	17:26:28.288223	Samita	45	
52	17:26:31.056689	Sushma	42	
53	17:26:31.534413	Krishna	52	
54	17:26:32.022635	Mayur	59	Bharti : Dada I got 51
55	17:26:32.517409	Sadanand	44	
56	17:26:33.170507	Amol	73	T: done? Bharti :hmm T: high five
57	17:26:34.462345	Samita	52	
58	17:26:34.948593	Nikhil	56	

59	17:26:36.079216	Mahesh	54		
60	17:26:37.035138	Mayur	64		
61	17:26:38.518833	Amol	80		Surjeet : look dada how is this coming
62	17:26:40.323892	Sadanand	50		
63	17:26:40.819389	Aakash	45		
64	17:26:41.339766	Krishna	69	Krishna makes a mistake, writes 69 instead of 59. But is he not visible in video as he has kept his laptop on his side instead of on desk and he is bent so desk covers him.	
65	17:26:42.483918	Samita	59		
66	17:26:42.985050	Amol	85		
67	17:26:43.620774	Mahesh	52		
68	17:26:44.185151	Nikhil	67		T: hey no hitting no hitting
69	17:26:46.048240	Krishna	66		
70	17:26:46.767448	Sushma	48		
71	17:26:47.490341	Samita	66		
72	17:26:48.443593	Amol	92		Bharti : dada he is pushing keys T: who is pushing
73	17:26:49.030723	Sadanand	57		
74	17:26:49.837754	Aakash	52		Archana: Dada I didn't
75	17:26:52.171973	Mahesh	59	Difficult to say what	Krishna: Dada there

				was Krishna doing when he realised his mistake. Through the gaps in the desk can see that just before pointing it to teacher he touches his head may be the sign that he realised his mistake.	is a mistake, T: who did? Krishna: I did, I wrote 69 and then 66. T: ok go ahead complete the rest of the steps.
76	17:26:52.938597	Mayur	71	Krishna realises his mistake (wrote 69 instead of 59) and points it out to the teacher and class	
77	17:26:54.226733	Samita	73		
78	17:26:54.702200	Amol	99		Krishna: Dada there is a mistake, T: who did? Krishna: I did, I wrote 69 and then 66. T: ok go ahead complete the rest of the steps.
79	17:26:57.922802	Sadanand	64		
80	17:26:58.566526	Mayur	78		Aakash: Dada its 52 (refering to last number)
81	17:26:59.447371	Sushma	55		
82	17:27:01.496568	Mahesh	62		T: you have to go beyond 50.. sorry beyond 100.. do it.. do it
83	17:27:02.871118	Samita	80		
84	17:27:03.365891	Amol	1006	Amol crosses the last number, as per	

				his calculation it is 106 but he makes a typo and writes 1006	
85	17:27:04.586469	Mayur	85		T: go beyond 100
86	17:27:09.240337	Sadanand	71		
87	17:27:11.245175	Sushma	62		Amol: data 106 Samita: I said it (referering to the mistake Amol made) T: did he made mistake?
88	17:27:14.635533	Aakash	59		Geeta: Dada... dada
89	17:27:15.698314	Mayur	92		T: Hey Amol she says you made a mistake, did you?
90	17:27:17.122370	Sadanand	77		T: She says you wrote 1006 instead of 106
91	17:27:20.168309	Sushma	69		
92	17:27:20.359519	Samita	87		
93	17:27:21.097275	Mayur	99		
94	17:27:21.610379	Aakash	66		
95	17:27:24.705737	Krishna	73		Geeta: How to remove this square? T: Remove or create?
96	17:27:25.796271	Sadanand	83		Geeta + Surjeet : Remove T: hmmm click here
97	17:27:27.944054	Mayur	106	Mayur crosses the last number, according to his calculations it is	Mayur P: Dada... 106... dada 106 Amol: yes 106

				106. He stands up and jubilently declares to the class	
98	17:27:29.337260	Mahesh	70		
99	17:27:29.791515	Amol	106	Amol corrects his typo and posts 106.	
100	17:27:35.109098	Samita	94		Mayur P: Amol you wrote 1006
101	17:27:35.602344	Mahesh	77		Amol: I also wrote 106
102	17:27:36.620903	Sadanand	89		Mayur P: chal (a marathi word used disapprove)
103	17:27:37.927388	Krishna	80		
104	17:27:38.648281	Sushma	72		Nikhil: he wrote 106 T: hmm then click here.. here here Nikhil: wrote 106 Amol: Ask dada.. I correctly wrote 106.
105	17:27:47.062811	Samita	101		Amol: I wrote 106 ask dada
106	17:27:48.631996	Sadanand	96		
107	17:27:50.739026	Mahesh	84		T: Look for mistakes .. look for mistakes
108	17:27:50.983770	Sushma	79		Bharti : (Calling teacher) inaudible Amol: Dada Samita made a mistake, final number can't

				be101 Amol: You get 100.. then 101 102 103 104 105 and 106 seven times
109	17:28:00.555160	Sadanand	103	
110	17:28:01.941739	Aakash	72	Amol: But she wrote 101 Sadanand : 103 it is 103
111	17:28:06.107114	Sushma	86	Amol: it can't be 101 T: Hey if we start from 10 and keep adding 7 what will be the first three-digit number
112	17:28:11.848578	Mahesh	91	
113	17:28:15.493995	Sushma	93	
114	17:28:19.411777	Aakash	79	Amol: Tai it is 106, right? Bharti : Dada dada
115	17:28:23.385510	Sushma	100	
116	17:28:33.882093	Sushma	107	T: hmmm 7 T: 24 T: 31 T: 38 T: Go sit at your places Bharti : Sush wrote 81 T: ok ok T: 45
117	17:28:48.286681	Aakash	68	T: 52

118	17:28:54.024866	Mahesh	98	T: 59 T: 66 S (can't be seen, male voice): it is 101 it is 101 T: 73 T: 80 T: 87 S: 89 no no 99 T: 94
119	17:29:08.387423	Aakash	95	T: 101 101 is correct
120	17:29:13.808866	Mahesh	95	T: you are right Samita: Sushmawrote 107 T: hmm yes Sushma wrote 107 Mayur P: Dada we are correct we did it by counting T: what number is correct? Mayur P: we got 106
121	17:29:36.769770	Mahesh	102	Samita: Dada Sadanand made a mistake, he wrote 103 Bharti : that colourful thing... thank you thank you Samita: Dada dada

				Sadanand 's 103 is wrong it should be 101 Nikhil: Dada he wrote 103 instead of 106 S: huuuuuuuuu S: Dada Mahesh wrote 102 instead of 101 S: Dada he wrote 81 S: Dada Amol's 106 is wrong and I pointed it out
122	17:30:15.056698	□□□□□□	□□□□□□left the chat	S: Aakash wrote 102 instead of 106 S: he wrote
123	17:30:16.237568	Aakash	102	
124	17:30:16.292232	Nikhil	Nikhil left the chat	
125	17:30:16.347802	□□□□□□□	□□□□□□□left the chat	
126	17:30:16.478400	□□□□□□□	□□□□□□□joined the chat	
127				S: 106 instead of 101 sorry 107
128				T: Ok lets go did everyone done?
129				Ss: Yes
130				S: Dada dada inaudible
131				T: Only Samita did all did all correct

132	T: Yes correct S: And me me Nikhil
133	T: Samita, Amol S: Yessss
134	T: Krishna S: Yeyyy
135	T: Aakash
136	T: Mayur Patil S: Shelar?
137	T: Mahesh S: Yess
138	T: Sahi Shelar
139	T: Sadanand S: (inaudible)
140	T: Akshada
141	S: How did you do it?

Data availability Terms of consent allow us to provide anonymized excerpts from the data but not the raw data. Anonymized data excerpts will be provided on request.

Declarations

Conflict of Interest NonE.

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Authors and Affiliations

Rafikh Rashid Shaikh[1] · **Nagarjuna G**[1] · **Ayush Gupta**[1]

Nagarjuna G
nagarjuna@hbcse.tifr.res.in

Ayush Gupta
ayush@hbcse.tifr.res.in; ayush.hbcse@gmail.com

[1] Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mumbai, India