# Collaborative Games on Mobile Phones

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**ABSTRACT**

There are many efforts to utilize the mobile phone as a computing platform in developing regions of the world. One effective approach is to build educational games for children in these regions. Existing games in this space are typically single-player affairs, devoid of the possibly beneficial element of collaboration between multiple learners. We seek to explore the feasibility of creating multiplayer mobile phone games based on traditionally multiplayer real-life games played by children in these regions, in such a way as to encourage collaboration between players. We describe a game called Colour Colour that was built for this purpose and the results of initial deployments of this game to children in rural India and ESL students in California.

**ACM Classification Keywords**

H.5.3 [Information interfaces and presentation]: Group and Organization Interfaces---Computer-supported cooperative work

**General Terms**

Design, Experimentation, Human Factors

**Author Keywords**

Cellphones, developing world, digital divide, e-learning, games, language learning, mobile games, mobile learning, serious games, third world, cooperation, competition, children.

**INTRODUCTION**

In developing regions, such as parts of rural India, mobile phones typically far outnumber personal computers. The MILLEE [6] project is an ongoing research initiative that attempts to use mobile phones as a platform for games to educate children in these developing regions.

The games built for MILLEE are usually based on real-world physical games that children play in the communities where these games are deployed. For example, the Tag-like game of "Tree-Tree" has been turned into a mobile phone game (see Figure 1). The benefit of this approach is that children are able to easily understand the game concepts and quickly begin playing since they have familiarity with the real-world version of the game.

**Figure 1. An example of a real-world game that MILLEE games are based on**

The problem with this approach so far is that the inherently multiplayer aspects of the real-world games do not translate easily into their mobile phone counterparts. The games are developed as single-player experiences and children play them with/against virtual players. When there are multiple children present, they have no choice but to gather around one person playing the game or each play their own game separately.

We would like to explore the possibility of introducing multiplayer aspects into MILLEE games. We believe that MILLEE games will become more engaging and effective as educational tools if they encourage interaction between the children. In addition, a large contributor to the fun of the physical games is in the allowance for multiple players to contribute towards a shared goal. It may be possible to recreate this element of collaboration that is a core part of many of the original physical games but is missing from their mobile phone versions.

At the same time, MILLEE researchers are noticing that some of the children in these rural communities (particularly boys) have difficulty sharing the limited numbers of mobile phones and often get frustrated when they cannot play. We hope that the creation of multiplayer games that allow many children to play together at once and a field setup where each child can have his own phone will alleviate this problem. We also expect that interactions between the children will change once they each have their own phone and are interested in how this affects their behavior in gameplay – perhaps encouraging competition or cooperation between the children.


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Therefore, the primary interesting research questions that arise from this effort are:

- Can traditionally physical multiplayer games be converted into digital multiplayer games while retaining their collaborative natures?
- Does allowing each player to have his/her own phone encourage cooperative or competitive behavior in gameplay?

A further question is if implementing multiplayer modes in these games will enhance learning and retention, but we did not address this directly in this phase of the work. We are primarily interested in the possibility for these games to encourage collaboration between the children in our target audience. However, if successful, future games will be developed with this question in mind.

## RELATED WORK

In the past, there has been extensive research on single display groupware (SDG), specially shared technology like whiteboards, handheld devices, and tabletops. Such research generally involves looking at the effects of the introduction of a new technology into an environment. In our case, we are attempting to augment an already introduced technology with collaborative features. We would like to evaluate the user experience as it is affected by the introduction of these features.

CSCW has been a platform for constant discussion on design and study of leisure activities, like tourism [2]. Moreover, multiplayer games and the social organizations that they create has been a centre of discussion for some time now. However, the use and effects of Collaborative Virtual Environments (CVE) and the kind of interactions they generate have also been an issue of interest for the CSCW audience [1].

Use of SDGs in education and their instrumentality in bringing about a change has been a center of experimentation [8]. However, there has been conflicting evidence from various sources [8, 3] about how gender is related to learning. On the one hand, the results from the Multimouse experiment suggest that girls in single-gender groups tend to perform worse than girls in mixed-gender groups do. The Kidpad [3] experiment, on the other hand, tends to suggest exactly opposite results. However, the Multimouse experiment does bring out an interesting point: girls tended to perform better in mixed-gender groups and boys tended to perform better in all-male groups.

The Multimouse study further reveals that boys tended to engage in conflict often when there was only one controllable object for the group (the mouse). In addition, it was noted that they became overly competitive in situations where they were racing each other to the point where their retention of the knowledge suffered. Girls, however, consistently outperformed the boys in multi-user modes and did not engage in conflict. These results suggest several needs for boys:

- Each needs to have his own device to control to avoid situations of conflict.
- For a better learning experience, they need to feel as if the experience is not a direct competition between them.
- They can collaborate if there is no explicitly individual goal/reward (i.e. in any of the multi-user modes except racing).

Hence, one of our goals in this work is be cognizant of such gender-related issues attached with multiplayer gaming and carefully consider the way we present our multiplayer game – if it is too obviously competitive, boys may not collaborate at all during play. This also influences our subject choice – we would like to test our game with boys to ensure that it does not breed the kind of silent, driven competition that was seen in the Multimouse multi-user racing mode.

Other interesting insights come from Singer [10], who notes that when dilemmas arise in the course of productive work, the combination of communication and activity can lead to learning. This is why we hope for communication between the children as they play our game, and structure the design of the game to encourage it.

Insights from a study on deer hunting [8] suggest that some mix of solo and group play is what makes collaborative play fun. Although we did not explicitly include this in our study, there exists a one-player mode that the children are free to explore at any time.

A game called FishPong [11] was also designed to encourage collaborative gameplay; the researchers attained their goal by increasing the prompts for social interaction (e.g. making the table large and attractive for bystanders to want to engage with each other). This game also has both a multiplayer and single-player mode.

## SYSTEM DESIGN

### Choice of Game

In order to answer the two research questions posed above, we need to choose a traditional multiplayer game that can be played in a cooperative manner. To do this, we refer to a list of about 50 traditional Indian games from the book *Play and Play*.

The games found in *Play and Play* can be divided into 2 main categories: turn-based and real-time. Turn-based games are those that have multiple players but require that only one of the players act at any one time. There may be no direct player interaction (i.e. tagging or chasing) in the game. Although these games can be educational and are categorized as multiplayer games in real life, they do not require multiple devices to play. Rather, these games can be implemented on one device that is passed around to a player

when it is his/her turn. We are not targeting games that fall into this category.

The category of real-time games has much more opportunity for player interaction. These games can be further divided into the following 2 categories: games that are based on physical skill and games based on a player's choice of location. Games based on physical skill refer to games where the challenge lies in physical motion (i.e. sensing the person dropped the handkerchief behind you in Caps for Sale or being able to leap on one foot in Hopscotch). Games based on the player's choice of location are games in which players are constantly moving and each player's status depends on the player's past and present positions. For example, in Tag, if a player is standing next to the person marked *it*, he will be the next person marked *it*.

Most of the games that are based on physical skill cannot be implemented in the same way on mobile phones. Games based on the player's choice of location are a better fit. We shortlisted 16 games from *Play and Play* in this category and ranked our choices based on the following criteria:

- Ease of implementation
- Retention of game details of traditional game
- Play time of each player
- Chance for players to interact in the physical world
- Replayability
- Ability to incorporate many levels of English language learning in the future

Out of those 16 games, we chose Colour Colour. In Colour Colour, players are responsible for collecting and/or identifying physical objects of a certain color (e.g. "green") in their surroundings. They must physically move to pick up these objects or touch them, and lose the game if they are unable to find an object of that color. Their score in the game is based on how many objects they find.

In terms of language learning, this game has fairly high replay value since the lessons can easily be made harder when necessary (i.e. we can make the requirements stricter: "red square", "yellow circle" or "blue bear", "green house"). Each player is also always playing, so no player becomes bored for long periods. Finally, the game does not feature perfect information (there is always information about players that is hidden to the others, such as what they have found), and hence motivates the players to talk amongst themselves to determine that missing information.

A sample of our first storyboards for the game can be seen in Figure 2.

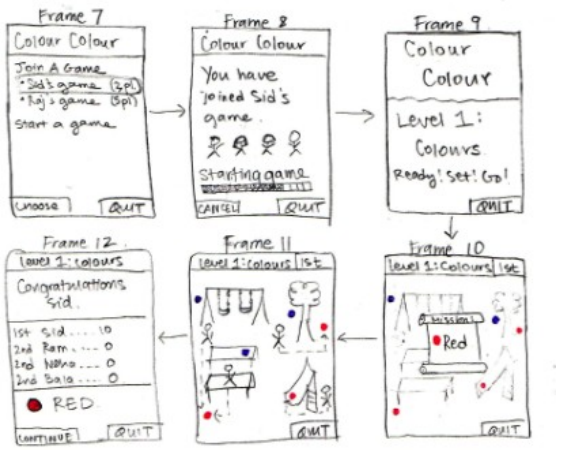


**Figure 2. Early Storyboards**

### Game Specification

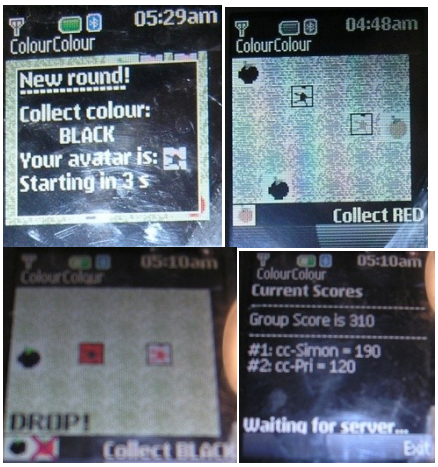


**Figure 3. Game Screenshots**

[See Figure 3.]

The mobile phone version of Colour Colour places objects at various locations on the game screen and asks each player to move to collect objects of a particular color (e.g. "Red"). Unlike the real-world game, each player is responsible for collecting a different color than the other players. We feel that having everyone collect the same color would lead to undesired competitive behavior, as the children would race to grab all the items for themselves.

This means that there are always multiple colors of objects on the field, and players must discern which objects "belong" to them. It makes the game more difficult since players must avoid the objects that are not theirs while they attempt to collect their own. It also allows for a **shared goal** as a game-winning condition – rounds do not end until each player has collected all objects on the field that match their color.

Scoring is based on whether players are able to pick up objects of the correct color, as well as the time it takes them to collect everything on-screen. Players are penalized for picking up objects not matching their color, as this prevents the rightful owner from completing their collection. If a player picks up an object not matching their color, visible signs on the screen tell the player to "DROP" that object with a key press. The players receive bonuses added to their

score for being the first, second, etc. players to collect all of their objects.

Since we would like to promote collaboration and encourage the players to help each other through the game, there is also a "group" score. This score, a sum of each player's individual score, represents the performance of the group as a whole. We built this into the game as an incentive for groups to efficiently work together to complete a round.

The color that each player is assigned changes each round. At the start of each round, each player is shown his or her color for five seconds before gameplay begins. The English name of their color (e.g. "RED") is displayed at all times during the round. At the end of each round, the players' individual scores and the group score are displayed, at which point the "Server" player can start a new round or exit the game.

### Choice of Technology

#### *Wireless Protocol*

We debated whether to use Bluetooth or Wi-Fi technology for our mobile phone game. The advantages and disadvantages of each are listed below.

Bluetooth:

+ Free
+ Available on most phones
+ Available in all areas – no infrastructure required
− Small range
− Relatively slower data transfer speeds
− Supports Client-Server model only
− Long connection times necessary

Wi-Fi:

+ Fast data transfer speeds
+ Supports long-distance connections
+ Available on most phones
+ Supports P2P model
− Requires monthly payment
− Requires infrastructure
− Not available in all rural areas

The most important criteria were availability in rural areas and low cost. Hence, we decided to use the Bluetooth stack for our game.

#### *Programming Platform*

There were several platforms we could build our game on, including J2ME, BREW, Flash Lite, and the .NET compact framework. BREW and Flash Lite do not support Bluetooth, so our main decision was between J2ME and .NET. We chose J2ME for several reasons. J2ME has an official Bluetooth library built in (JSR-82), generally has better documentation, and runs on a wider variety of devices (including low-end phones, which are used in MILLEE).

#### *Networking Design*

Since we chose to use Bluetooth, we were forced to design our multiplayer features using a client-server model. One of the phones would have to be designated as the Server and that phone would have to be responsible for starting the game and each round in the game.

This created the need to incorporate the idea of a "Server" or "Leader" in the game, which inherently had a slightly unfair advantage because all movements were routed through that phone.

## ENVISIONED BEHAVIORS

As we designed the game and the study, we had several predictions of how the children would behave.

One envisioned behavior was that the children would communicate often during the game. We expected them to discuss the strategy for each level among themselves in the time they had between rounds. Since they have a shared goal, we predicted that they would initially come up with a strategy to ensure a high group score. We also expected them to talk during the course of a round. Each player can pick up another player's object without them knowing, and we felt that this lack of information would naturally lead players to ask to find the whereabouts of their missing colored objects. We also expected that the children would help each other to ensure they were all only choosing to pick up their own colored objects and/or dropping incorrect ones as necessary.

In addition, we had imagined that the children would arrange themselves in a manner conducive to collaboration during the game. More specifically, since we thought the children would be talking while playing the game, we expected them to stand facing each other. For example, if there is a group of three players playing, we generally expected them to create a formation like that suggested in Figure 4.

We also predicted that the children would be highly attentive to the group and individual score. We predicted that they would spend some time on the score page at the end of each round, looking at both the group and individual scores and comparing them with each other and to previous rounds.

Finally, we expected that some type of power structure would arise because one of the players becomes the Leader

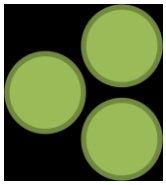

**Figure 4. Envisioned arrangement of children**

**Figure 5. Deployment in Lucknow, India**

in each game. Since this person must trigger the start of each game, we thought he would naturally tend to act as a leader, ensuring each person would be ready before starting each round.

## EXPERIMENT

We first sent a version of the Colour Colour game to associates in Lucknow (a rural village in northern India) to deploy with children there. [See Figure 5.] However, upon review of the field notes and video recordings from that deployment, we decided that a more controlled study was needed to supplement our results – one that more closely adhered to our planned procedure (below). Hence, we also tested our game a second time with ESL students at Menlo-Atherton High School in California.

### Participant Profile

In Lucknow, the game was tested with eight children having the following characteristics:

- All of the children were boys.
- All of the children had a first language that was not English.
- Their ESL levels were lower than the levels of counterparts in urban areas.
- They were from comparatively higher castes, meaning that their families were higher in the power structure in their villages.
- Their grade levels varied from grades 4 through 6.

At Menlo-Atherton High School in California, we had two groups of three students each play our game separately. These six children had the following characteristics:

- There was one girl (in the first group of three) and five boys.
- The children were all native Spanish speakers.
- They were part of an ESL Literature class, of 9$^{th}$-grade age.
- The three children in each group were friends.

### Procedure

Before the children arrived in the study area to play our game, we prepared the phones as follows:

- Ensured that they were all charged enough for at least 15 minutes of play
- Adjusted the Bluetooth settings so only one of the phones could be the Server and turned off Bluetooth in any nearby devices to prevent interference
- Launched the Colour Colour game on all the phones, had the Server start a game and the rest of the phones join that game
- Waited until all the phones were fully connected and ready to play

Next, we brought in the children and proceeded to brief them on the game they were about to play (without relinquishing the phones to them yet). These were the instructions for the briefing as given to our associates doing the deployments in the field:

*"Children need to be told about the cooperative aspect of the game before they start playing. They should understand that each kid will be assigned a different color each round and is responsible for collecting all objects of that color on the screen. At the same time, he should not pick up any objects that are not his color. However, he needs to know that he is working together with his teammates to get the highest group score. The team gets points when each person in the team picks up objects of their color. The team loses points if a person picks up an object that is not their color. When they pick up an object that is not their color, they have to drop it so that the other player can pick it up. The round ends only when everyone picks up his or her own colored objects.*

*When starting a game, one player needs to be designated as the 'Leader' and will start the game. Once he starts the game, all the other players will join the game."*

We considered this to be an overview that sufficiently emphasized the cooperative aspects of the game, such as the

**Figure 6. Menlo-Atherton High, semi-structured interview**

group score and the teamwork needed to ensure that everyone moved on to the next round. Upon further consideration (after the first deployment in Lucknow), we realized that instructions for the game could possibly be given in a way as to encourage competition instead of cooperation. We imagined a set of "competitive instructions" to be something like this:

*"Each of you will be trying to quickly collect all the objects on the field that belong to you. The faster you do this, the more points you get. You each get an individual score that represents how well you are doing, and you get to see everyone else's score as well at the end of each round."*

We aimed to provide the more cooperative version of the instructions to the children in the second deployment at Menlo-Atherton High.

After having provided the instructions to the children, they were each invited to pick up one of the connected (and ready-to-play) phones. We allowed the children to play for 15 minutes or so (or until they bored of the game) and then called for a break to discuss their experiences. [See Figure 6.] We held an informal interview with the group where we asked questions such as:

- What is your score?
- Did you have any difficulties?
- What was your strategy?
- Did you strategy change over time?

We also asked follow up questions to any comments the children made that we felt was worth exploring.

#### Data Collected

From each deployment, we gathered many different types of data that we analyzed later. These included:

- Videos of gameplay sessions between the children
- Notes and daily reports by the administrators in the field
- Logs generated by the game itself – these include information about when the games begin, when players drop goodies (correctly or incorrectly), and when they pick them up

In this phase of the work, we focused more on analysis of the videos and notes from the field.

#### Qualitative Metrics

There were several qualitative observations we wanted to take note of during the study. These observations included:

- The extent of the collaboration between the players: We wanted to see how much the players would talk about the game and how much they would help each other out.
- The power structure within the players: Since one player is designated as the Server and may naturally assume the position of "leader," the other players might react by treating him as the person in charge of strategy as well.
- Strategies developed by the children for before and during the game rounds.
- Conflicts between the children: Possibly caused by someone taking someone else's object, for example.

#### Problems specific to first deployment

Our first deployment was to the rural area of Lucknow in northern India. We gave the game and a set of instructions to two associates of ours in the field, and they gathered eight children from the villages to try our game.

When reviewing the video from this deployment, we noticed that there was one major problem in the administration of the study: Namely, our associates seemed to understand our game only as a competitive one and conveyed that sense to the children before and during their play. Although our instructions implied that the game was built as a collaborative activity (with features that lent themselves towards cooperation between the children), our associates would repeatedly make comments and suggestions to the children that encouraged them to focus on the competitive aspects of the game. In particular, there were many references to the scores and speed to completion.

Comments included phrases such as:

- "Whoever is the fastest"
- "Let's see who wins this stage"
- "Buck up" (to child with a lower score than others)
- "What's your score now?" (often)
- "Whoever hits [a score of] 500 wins"

Another issue we noticed was how little instruction the children were receiving on how to play the game. There was no point at which our associates sat down and demonstrated the game for the children, explaining the features in a controlled manner. They were instead seen explaining features as the children began playing and compensating by making themselves available to answer the many questions the children posed during gameplay.

The result was an abundance of questions from the children and much reiteration of the fundamental game rules during the time the children were playing.

From this, there also seems to have been a miscommunication or misunderstanding about the scoring features of the game. The children did not seem to know the difference between the group (combined) score and their individual scores, often reading their group score as the only indicator of score and claiming it as their own. This led to interesting situations where multiple children would be boasting about their score, under the impression that they

were tied indefinitely because they were all doing equally well.

In general, the situations where the game was being played often seemed to be chaotic. The children seemed to be able to convince our associates to hand over the phones without confirmation that they were connected and ready to play. This caused many children to become frustrated as they waited long periods for the phones to connect via Bluetooth.

Finally, there was a very unbalanced children-to-phones ratio, with many children left without phones to play with. Their presence among the game players may have affected a lot of the behavior we observed from the field.

### Problems with the design of the game

We also discovered a few issues with the design of the game after the initial deployment in Lucknow.

#### *Connecting the Phones*

We had first imagined that our associates in India could hand the phones over to the children, who would then be able to set up games between the phones themselves. However, after reviewing notes from the field, we realized the children would not be able to do this on their own; the connection process was excessively complicated (multiple steps) and took a particularly long time to successfully complete. The amount of patience required was beyond that possessed by the children, so they would often hand the phones back to our associates to connect the phones for them.

#### *Design of "Drop" Mechanism*

We noticed that the children were not immediately able to comprehend the concept of "Drop." They would ask our associates many times what it meant. The concept may not have been conveyed clearly enough by our associates, or it is too foreign to the real-world game to be easily understandable. Further, the action of "dropping" an object has no mirror action in "pick up." Picking up objects does not require pushing a special button, whereas dropping it does – this may also be confusing for the children.

## RESULTS

### Key Observations

#### *How the Children Organized Themselves*

We had hoped that the children would communicate with each other during gameplay and stay close enough to each other for collaborative purposes – however, it seemed that they were naturally content to drift apart.

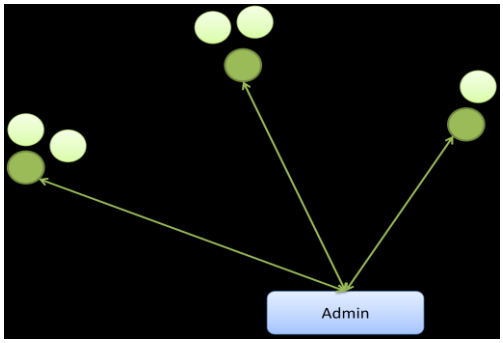


**Figure 7. Actual Arrangement of Children in Lucknow**

In the deployment in Lucknow, we observed the children drifting apart after being given the phones. Other children without phones would linger around those that had them, watching and sometimes providing "help" (see next section). The children with the phones generally would not be facing each other, rather choosing only to communicate with the group of other children around them and the research administrators who made themselves available. [See Figure 7.]

Exceptions to this occurred when players became impatient with the progress of others; sometimes a player would walk over and attempt 'helping' as well, but this was more of a confrontation and tended to represent conflict between players and not cooperation.

This was certainly not our envisioned behavior. This behavior is reminiscent of the silent, highly concentrated competitive behavior that was observed in multi-user multi-mouse racing modes [8]. We believed that this might have been a result of the competitive framing of the game by the administrators, which was part of the motivation to run a stricter study at Menlo-Atherton High School.

At Menlo-Atherton High School, we forcibly arranged the children in our envisioned formation at the start (Figure 4) in an attempt to solicit collaborative behaviors – in retrospect, this may have had adverse affects on their performance as they were perhaps under the impression that they could not move freely in a way that was comfortable to them. These children did talk to each other slightly more than the children in Lucknow did, but they did so often in whispered voices and in their native Spanish language.

#### *The Phases of 'Helping'*

Only in Lucknow, we observed an interesting pattern in the way one child would attempt to 'help' another. If a child 'A' were attempting to help a child 'B', the general process would proceed as follows:

1. Child A tells the Child B what to do verbally
2. Child A points at the screen on the phone to indicate movement or action at a certain location
3. Child A points at the button to press to make his indicated action occur
4. Child A pushes the button with his own hand to get the action done
5. Child A grabs the phone away from Child B and continues pushing buttons
6. If this all fails (Child B takes the phone back), Child A walks away

We witnessed this pattern numerous times when reviewing the videos of the deployment. This progressively more aggressive take on "helping" suggests to us that there were

possibly other motivations at play that encouraged children (who were not even playing!) to "collaborate."

*What the Children Discussed*

In Lucknow, the children who had phones and actually were playing tended not to discuss anything between themselves. Communication mostly happened between those players and the small "huddled" groups around them. When a player finished collecting his objects, he tended to stand and watch the screen as the other players scrambled to complete their collections. The bystanders would sometimes act as proxy communicators, stating the status of the player they were watching and running to other players to see how they were doing.

This extended a lot further with scores; the player might report his score out loud to no one in particular (or the administrator, who often prompted the player while using a video camera) and a bystander might go around and inquire about scores from the other players.

At Menlo-Atherton, communication between the children was quite different. In this second deployment, there were no children without phones in the study area, so the players did not have the opportunity to have these "huddled" groups surrounding them. We arranged the children close to each other, and they did not move much while playing.

During the course of gameplay, communication came in small bursts with relatively long periods of silence in between. When someone did say something, it tended to be an expression of frustration at whoever might be holding his or her colored object. The players did not try to look at each other's screens to figure out who had their objects, but they did ask questions to the other players such as, "Who has my red object?" These questions would often go unanswered and players tended to not question further. Hence, conflict was kept at a minimum. Besides these remarks, other communication was mostly joking around with each other concerning the game; for example, the player finishing first might tell the other players to speed up or mock them for mistakes made in the game as he watched from his screen.

*Other Observations*

In Lucknow, we noticed that the children were quite likely to be competitive about the game. They would express great pride in their score, some even singing it aloud repeatedly. However, it is interesting to note that the children did not spend that much time studying the scores after each round; it seemed that they were more in favor of starting the next round quickly.

The game has a one-player version as well, and this much simpler setup proved to be quite popular with the children. When they play this one-player version, other children huddle around their phone (bystanders) just as they do when they play a multiplayer round.

We did not observe any noticeable power plays by the Leader/Server in either Lucknow or Menlo-Atherton High. Even though he had the power to delay a round for as long as he desired, this was never a problem.

**Qualitative Responses**

When asked about scores, most of the children across the two studies were able to recall their *individual* score at the end of the game. In Lucknow, this was unfortunately often confused with the group score, so it was unclear whether the children were aware of a group score at all. At Menlo-Atherton High, the group score was actually ignored by all the children and no one could recall it. It was stated that they typically just looked at their own score and quickly moved on to the next round.

When asked about difficulties in the game, students at Menlo-Atherton High cited the common occurrence of having someone else pick up an object of your color, preventing you from completing your collection. They mentioned how difficult it was to get a response from the other players as to the whereabouts of their object, but that asking was still necessary.

Their strategy to do well in the game consisted of moving quickly yet carefully to avoid others' objects. This never really changed over time.

## ANALYSIS

**Differing Demographics**

It is important to note that the children differed significantly between the first and second deployments in India and Menlo-Atherton High, respectively. While we tried to keep them similar in terms of their knowledge of English, their age differences probably account for as much of the differences in observation as the considerably more controlled process in the second deployment.

Notably, there was a far more casual attitude towards the game from the children at Menlo-Atherton High as opposed to the younger children in Lucknow. The game seemed to mean a lot more for the Lucknow children and they seemed much more driven to do well. While both groups of children focused on their individual scores, the Lucknow children were far more likely to engage in verbal exchanges over their score and to be compelled to "beat" the other person.

At Menlo-Atherton, the children seemed to be more interested in having fun with the game and with each other. To that end, sometimes one child would purposely hold an object belonging to someone else, just to see their frustrated reaction for fun (while knowing their score suffered as a result). This never occurred in Lucknow, as the children seemed to take the game far more "seriously." This may have much to do with the fact that the children at Menlo-Atherton High were already friends before they played our game.

### Collaboration?

In Lucknow, when the children 'collaborated' in the game through aggressive assistive measures, it often seemed as if it was just a means to an end. Two reasons we believe the children had for 'collaborating' are:

- Showing dominance – one child would like to demonstrate that he knows how to play the game better than another, so he offers his 'assistance' (see section above).
- Getting another turn – the administrators would only let a child have a turn after another child played a certain number of rounds, so there was an incentive to help others finish their rounds more quickly.

While the children *are* helping each other, it is not clear whether this kind of collaboration for ulterior motives would be effective for learning and retention of knowledge. Ideally, we would like to see the children help each other while focusing on their shared goal and receiving shared value by doing so.

At Menlo-Atherton High, there was certainly more communication happening between the children but it is unclear whether they were really helping each other or more interested in having fun. We predict that if the game were more challenging to the point where the children would have to take it more seriously in order to do well, there would be an opportunity for real collaboration needs to be fulfilled.

## IMPLICATIONS FOR DESIGN

There are several implications for the design of future studies as well as for the design of multiplayer mobile games for learning in general.

### Competitive vs. Collaborative Gameplay

In the study in Lucknow, when the research administrators were explaining the game to the children, it was not clear that Colour Colour was designed as a collaborative game. In fact, the competitive aspects of the game (e.g. individual scores) were emphasized and the children were encouraged to finish each round as soon as possible to keep their score high. Because of this, the children were highly competitive while playing the game, only focusing on their individual scores and not realizing there was a group score. Based on this, we predict that the way the game is introduced makes a significant difference in the attitudes of the children. In future studies, research administrators should emphasize collaborative aspects and have the children understand that they are meant to be helping each other.

### Motivators for Collaborative Gameplay

Currently, the only motivator for collaborative gameplay is the group score. Based on the reactions we received from the children, we believe that a group score is not adequate for this purpose. A better incentive, perhaps a congratulatory video or other treat for the players, may motivate children to cooperate towards this shared goal.

### Phone-to-Children Ratio

In Lucknow, it turned out that there were many more children than there were phones. Hence, there were many instances when children without phones (non-players) would huddle around children with phones. This may have subtly prevented the children with phones (players) from collaborating with each other. If so, the non-players did affect the outcome of the study. In future studies, we would recommend having only players in the room to give them a chance to collaborate with each other.

### Presentation of Real-World Aspects in Digital Games

The game Colour Colour was based on a traditional, physical multiplayer game. We used many of the concepts from the game, but did not necessarily retain the full presentation of the real-world version. Using more of those elements in the user interface of the game would help children better associate the digital games with their physical counterparts.

## CONCLUSION

### Contributions

In this project, we have created the beginnings of a platform for collaborative multiplayer games on mobile phones. We have built a game on this platform based on a real-life physical game, given it to children in rural India and ESL students at Menlo-Atherton High, and analyzed the extent of their collaborative behavior during gameplay.

While we were successful in building a mobile phone game based on a real-world physical game, it is not clear that we were able to generate the type of collaboration we hoped would occur between players. We have seen a more competitive nature encouraged by our game, and allowing each player their own phone only allowed them to be isolated while competing. We note that approaches to the game differ between demographics and suggest explanations and implications for design.

### Future Work

We have only begun to explore the possibilities of multiplayer games on mobile phones. There are many more real-world games we could create mobile versions of, and it is likely that each will have varying success in eliciting collaboration between the children who play them.

Although we were not able to see our envisioned behavior in the children with this version of Colour Colour and our study setup, modifications to make the game have better incentives for collaboration and creation of study environments where each child has his own phone may yield better results. We can also improve aspects of the game such as addressing the difficulty in initially connecting the phones and providing better in-game support for terms like "DROP".

We also have yet to fold this work back into the main MILLEE project and create games that do have educational value. Once a game of that sort is built, we can test further for knowledge retention as well as engagement.

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