Playground Games: A design strategy for supporting and understanding coordinated activity

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ABSTRACT
From a design point of view, coordination is radically under-theorized and under-explored. Arguably, playground games are the universal, cross-cultural venue in which people learn about and explore coordination between one another, and between the worlds of articulated rules and the worlds of experience and action. They can therefore (1) teach us about the processes inherent in human coordination, (2) provide a model of desirable coordinative possibilities, and (3) act as a design framework from which to explore the relationship between game and game play---or, to put it in terms of an inherent tension in human-computer interaction, between plans and situated actions. When brought together with a computer language for coordination that helps us pare down coordinative complexity to essential components, we can create systems that have highly distributed control structures. In this paper, we present the design of four such student-created collaborative, distributed, interactive systems for face-to-face use. These take their inspiration from playground games with respect to who can play (plurality), how (appropriability) and to what ends (acompetitiveness). As it happens, our sample systems are themselves games; however, taking *playground* games as our model helps us create systems that support game play featuring not enforcement of plans but emergence of rules, roles, and turn taking.

Categories and Subject Descriptors
H5.3. [**Information interfaces and presentation**]: Group and Organization Interfaces – *Collaborative computing, Computer-supported cooperative work.*

General Terms
Design. Tuple Spaces. Pervasive Computing. Multi-platform.

Keywords
Interpretation, ubiquitous computing, pervasive computing, coordination, interaction, democracy.

1. INTRODUCTION
Sociality is one of the most fundamental aspects of being human. Key to sociality is coordination, that is, the bringing of people "into a common action, movement or condition" [30]. Coordination is, at base, how social creatures get social things done in the world. We may approach the study of coordination from many perspectives. For example, Malone and Crowston [29] define coordination as "the process of managing dependencies between activities." This reflects their organizational and informational perspective, a perspective shared by several other thinkers concerned with influencing workplace process [4, 10, 12, 24, 33, 47].[1] Anderson [1] also takes an informational perspective to coordination; however, his work emphasizes not the equivalence between or interchangeability of human and machine but the identification of differences, especially in accountability. That is, Anderson is concerned with modeling how the automatic navigation systems on large ships can take over operational details, while the underlying responsibility remain with the human.

Another perspective emphasizes the relationship between coordinative elements and larger systems of action or meaning. For example, the OED says that to coordinate is "to place or arrange (things) in proper position relatively to each other and to the system of which they form parts; to bring into proper combined order as parts of a whole" [32].

This is a systems approach. It is consistent with the call to stay open to interpretation [39] and is the perspective that we bring to the study of coordination. We start with a concern with understanding and influencing the microstructure of coordination. This perspective points out the considerable influence of microstructure on how and what gets done. This is the traditional foci of conversation and interaction analysis [15, 23, 36, 38]. It is also concerned with values, not only the efficient attainment of goals, but values embodied in the process of interacting such as human control, engagement, participation and inclusion. We then use design as a strategy for exploration [13].

In the context of a class, we explore coordination through creating collaborative systems for face-to-face use that are modeled on playground games. They are not playground games, but they have elements that are taken from playground games. The games are technologies with elements to be manipulated and passed around by people who are face-to-face. Like playground games, they involve radically distributed control, little pre-specified hierarchy, and an indeterminist approach to most aspects of activity and activity enactment. We use these

[1] Fitzpatrick and Welsh [4] build on the microstructure of interaction but use it as background rather than as a topic for exploration or design.

systems as a mechanism for exploring coordination, both in the machine space and in the social space.

In addition to contributing the concept of playground games as a design strategy for exploring and understanding coordinated pervasive computing systems, this paper draws attention to the promise of Tuple-space based systems for the flexible design of coordination, and points out several examples of thoughts that emerge from this direction and from staying open to interpretation during design.

1.1 Mock Games

Playground-like games are quite similar to "mock games", which have been proposed as a new genre of pervasive play [6]. Brynskov and Ludvigsen position mock games as blending or combining what is missing from theories of *social games* [37] and pervasive games [46]. Compared to other computer games, "mock games" have different kinds of outcomes; like the outcomes of playground-like games, the outcomes of mock games may be negotiable and less quantified. Like games that draw on playground games, mock games entail, for example, a "constant invitation to *transgress boundaries*" ([6], p. 174). Mock games are an important idea for the computer game industry because they broaden its thinking.

We agree with Brynskov and Ludvigsen that games with negotiable and non-quantifiable outcomes represent a crucial genre for technological exploration; however, the reasons are not limited to enlarging game theory or pervasive play.

Insofar as mock computer games are like playground-like computer games, they are neither "mock" not just games. They are not mock in that they arguably represent not a peripheral, but a central notion of games, or at least of game play. Furthermore, they are not just games because to explain any sociotechnical system that involves coordination between people in the presence of technology, e.g. any collaborative pervasive computing system, requires understanding the relationship between design features that support coordination and representational features. Coordination is important in any system in which peoples are acting around artifacts together with negotiable goals and unfolding processes. Therefore, their importance goes beyond the immediately pragmatic games or easily identifiable rules. They have resonance with an essential human tension between plans held in common with others and situated action with others that allow us to explain and explore behavior in relationship to technology. For example, playground games have rules, but are not defined by rules. By changing design elements, we can investigate the tension brought to the forefront of human-computer interaction and computer-supported collaborative work by Suchman [40], who famously argued that plans can never fully determine human behavior. They allow us to ask what the boundaries are on behavior and the influence of technology on behavior.

2. PLAYGROUND GAMES AS A YARDSTICK

Arguably, playground games are the universal, cross-cultural venue in which people learn about and explore coordination between one another, and between the worlds of articulated rules and the worlds of experience and action.

Playground games are those familiar, persistent, cross-cultural, universally occurring childhood activities exemplified by catch, jump rope, clapping games, jacks, and tag [17, 18, 20, 31]. They are played around the world. Variations occur in different countries. (For example, in some parts of the UK, the chaser in Tag is called "He" while in other parts and the USA, the chaser is called "It." [31]); however, variations also occur on the same playground and even within the same game. Playground games are most typically passed on from child to child with little or no adult intervention; however, children's games in one culture may occur as adult activities in another. For example, string figures are typically undertaken by young girls in the United States but are (or were) the provenance of male elders in Malaysia in the context of story-telling [21]. Nonetheless, at least until the predominance of television, automobiles and nuclear families caused children to engage in less outdoor play, playground games were played in mixed age groups. Playing in mixed age groups means accommodating the ways in which the same game must be and are made different by the players for actors of different ages and abilities. The illusion that playing is solely about winning, which may be maintained in groups of peers, is consistently challenged.

Playground games are an important class of activity for the study of coordination for a number of reasons. First, both game and game-play are important. Second, both game and game play are seen by the players as worth discussion. They bring together coordinated action and reflection about that action. In their comprehensive cross-cultural study, Opie and Opie [31] point out that the negotiations over the start of a playground game may be as important as the game itself, and indeed identify a class of games that are about starting other games, including "Scissors, Paper, Rock" and "One potato, Two potato." Although games are generally treated as non-serious, Goodwin [16, 19] describes two girls arguing over the status of a move in hopscotch with intensity and vehemence. While their activity and argument may be dismissed from an etic perspective as non-serious, it gives every evidence of emic importance.

2.1 Some Essential Qualities of Playground Games

Three qualities follow from the nature of playground games.

2.1.1 Plurality

The first is *plurality*, that game participants may differ in who they are, their number, their skill and their organization from moment-to-moment and from one instance of the game to another. We may, for example, extend a clapping game that usually involves two participants into a circle of three or allow two jumpers at a time to skip rope. For some, continuing to play may be of paramount importance. For others, the notions of procedural justice and injustice may prevail. For yet other, inclusion and exclusion may be primary. Negotiations may themselves be seen as central or peripheral to play and, however seen, may constitute a major component of time spent on game play. Another aspect of plurality is that playground games remind us that all players are not necessarily peers.

2.1.2 Appropriability

The second is that playground games (as a class) can be *appropriated.* They can be modified for use, taken up as the players' own, and made to fit circumstances. The concept of a starting line is important in a foot race, but when a 7-year old and a 4-year old run a race, one may have a different starting line from the other. Everything can be negotiated: how many people participate; the kinds of roles they assume; the rules for who goes next, when, and under what circumstances; the rules for game completion or progression; and the nature of any artifacts with which the games are played. What matters is that people want to and continue to want to play. Concessions may be made to a losing player to prolong game play. One person may, under the right circumstances, take a turn for another. Even the constitutional rules can be changed, as when Tag is played with two people designated as "It" (or "He").

2.1.3 Acompetitiveness

The third is that playground games are acompetitive. Even when the rules specify who wins and by what means, the importance given to winning varies. As mentioned above, Opie and Opie [31] observe that the beginning of a game is often more important than the end, and that indeed games often peter out or change into something else rather than having a definitive end point. Additionally, metrics may pertain as much to an individual's satisfaction with his or her own performance and skill or to appreciation of the skill of another as to comparison. Last, not everyone who engages in, for example, a spitting contest actually wants to win it. Issues of identity may be involved.

When a thoughtful 12-year old runs a race with a 4-year old, it may be very important not only to ensure that the small child wins but to regulate the right amount of tension about the outcome (by breathing down their necks, catching up and falling back, tickling them or other such strategies). This is not to deny that winning can be of the utmost importance, merely to point out that winning and a comparative metric are not the only or most important stances towards the game. Satisfactory performance is key. Note that these qualities are true in many other games as well. Someone who loves tennis may choose to have a friendly game with an inadequate partner for the pleasure of playing or teaching.

In conclusion, playground games are social, but involve a great deal more than merely being friendly. They are an important venue in which the nature of coordination and underpinnings of sociality are explored in relationship to action. We focus here on three aspects of playground games, plurality, appropriability and acompetition.

Plurality, appropriability, and acompetitiveness are properties that illucidate aspects of playground games as a yardstick for collaborative, distributed face-to-face activities. They can (1) teach us about the processes inherent in human coordination, (2) provide a model of desirable coordinative possibilities, and (3) act as a design framework from which to explore the relationship between game and game play.

Plurality, appropriability and acompetitiveness are important aspects of coordination and the design of coordinated systems. These are not necessarily qualities that spring to mind as crucial in serving corporate ends such as the efficient attainment of goals or sales, nor are they likely to entail the intermittent, positive reinforcement that is so prevalent in gaming. Instead, they have to do with values and responsibility related to human control over interaction, engagement with others in the presence of technology, and issues of participation and inclusion.

3. A LANGUAGE FOR EXPLORING COORDINATION: TUPLE SPACES

Many advances in computing are made by finding powerful representations that express the issues cleanly. Tuple Spaces is a simple, powerful language developed to describe the problems and possibilities in the design of distributed, coordinated systems. Tuple Spaces was designed to allow programmers to easily implement different methods of allocating tasks to processors [7] and has been used in middleware [26, 48] and to connect different devices in promoting a user experience of interoperability [22]. Programmers have used Tuple Spaces to experiment with different strategies for allocation of work. They have also used them because they are robust to machine disconnection and reconnection and other aspects of dynamic environments, including the rapid or automatic integration of new devices.

We employ Tuple Spaces because of these important elements of flexibility, because they free programmers from socket-level programming to focus on coordination, and because of several coordination-specific system components.

3.1 The Tuple Space System

Tuple Space is a simple system with three important components: the Space, the Tuples, and operations on the Tuples.

The Tuple Space mediates the coordination. Tuples may be written to the space, taken from the space or read but not taken. Note that the space does not determine the coordination. The use that a particular program makes of the space is determined by the instance of that program which interacts with the space. Thus, two or more programs can operate independently for their own purposes on the same space. These programs could be running on the same machine, and be associated with the same user, or be operating on different machines and associated with different users. The design of Tuples and the circumstances under which they are read, written or taken define the machine component of the coordination.

3.2 Properties of Tuple Space Systems

The system has three important properties.

3.2.1 Representation

First, Tuple Space allows the programmer to represent the resources to be coordinated explicitly. Designing the system means designing the units of coordination and the limits on resources. This is radically different from the underlying metaphor of the web, which is essentially document based, or from the unit of connectivity in IMing, which is not tied to any resource utilization apart from communication itself. (Also we are using the Tuple Space primarily to augment the use of technology when people are also face-to-face.) A tuple is a thing that can be kept privately or made available. A central issue in the design of coordination is deciding what Tuples should be made available in what quantities, and what qualities are called out as searchable, that is, represented as first class objects. At a conceptual level, in the case of jump rope, we might make two slots available for turning the rope at any given time, but an infinite number may wait to jump.

Template Matching

Representing the resources explicitly is complemented by a second important property of the system: associative or template matching. This is a simple general-purpose mechanism. It allows programmers to search for matches on many combinations of kinds of criteria and/or specific criteria. This means that repurposing, using the basic terms of coordination is very easy. Thus, again by analogy, we might want to ask whether Johnny, a 7-year old, has been playing, whether all the 7-year olds have been playing, how often the seven year olds have been participating in a particular role or, alternatively, across all roles.

3.2.2 Loose Coupling

This leads to a third property, loose coupling between the content provider and the content user. There are three aspects to this. At the computational level, resource providers and consumers need know very little about one another. Anyone can become a provider by creating Tuples of a certain kind and anyone may become a user by using an appropriate Template. This is decided by the particular program or feature being used. This promotes the bringing of separated, individual perspectives to the understanding of the resource.

These are qualities of the architecture of a program rather than of the appearance of the program to users. However, there is a relationship. One reason that programmers choose languages and architectures is because they make certain issues easy to think about. Although it is perfectly possible to express any interface idea in a large number of ways, programming ideas that are more clearly expressed invites development along the expressed dimensions. While it is perfectly possible to implement hierarchical, centrally controlled systems that employ rigid structures using the Tuple Space, explicit representation of resources, template matching and loose coupling make it particularly easy to permit and promote the dissemination and distribution of control at many levels. The easy dissemination and distribution of control is a necessary but not sufficient condition to support a plurality of perspectives, design for appropriability, and an acompetitive stance towards outcomes.

4. PLAYGROUND-LIKE GAMES

In the context of two classes and two independent studies given in the Department of Computer Science at Virginia Tech in the Fall 2005 and 2006, students developed and made initial usage trials of playground-like games and learning activities using Tuple-Space based architecture. Students were upper level undergraduates or graduate students. All were experienced programmers, but few had ever implemented a user interface, much less a multi-user interface. Some had experience with network programming at a technical level.

Fourteen games were implemented in Java, with user interfaces implemented in SWT, so that they could run on mixed combinations of laptops, desktops, tablets, and handheld machines. The lack of native support for drag-and-drop in J2ME as well as the limited time in the semester and the small form factor of the handheld meant that the user interface designs that included handhelds (our first and third examples) were severely compromised.

4.1 Simple Design Goals

The original intention was to create distributed coordinated systems that explicitly supported learning. This intention built on the first author's prior success with building similar activities to support math and science learning in the classroom [34, 43, 44, 45]. The playground game yardstick was initially an expedient to explain the qualities we were looking for in learning activities, both for pedagogical and classroom management reasons. The teaching challenges with respect to computer science student cognition and beliefs about human behavior and coordination have been reported elsewhere [27, 42]. However, these teaching challenges at the undergraduate and graduate levels pointed out how radical this simple, human oriented vision of interaction appeared within the context of modern computing.

4.2 Four Distributed, Collaborative Systems

The four systems presented here are examples of games that have been implemented in a way that brings out their playground-like potential (plurality, appropriability and acompetition) and allow us to examine the implications of such an implementation. Each then illustrates an aspect of design for coordination that emerged from this approach and an important surprising question that arises from that design. Team Sudoku initially raised the issue of designing to support not encode rules. This issue led to an important question about the relationship between coordination and representation. Together, Collaborative Crossword and Team Sudoku illustrate different effects of representations on the pathways to coordination. They raise questions about the relationship between representation and collaborative processes. Coordinated Password™ is designed to support not encode roles. It raises questions about new, nuanced types of engagement. Last, Shared Apples-to-Apples™ implements a flexible turn-taking scheme, raising questions about the relationship between human and machine turn-taking regimes.

4.2.1 *Team Sudoku: Supporting, not encoding, rules*

The team Sudoku game is a multi-user parallel-distributed form of well-known Sudoku game. The game pieces include a board consisting of a 9x9 grid and copies of digits from 1 to 9 with which to fill the grid. The board is conceptually divided into cells constituting nine rows, nine columns and nine distinct 3x3 blocks.

The goal of the game is to fill in the grid so that each column, each row, and each block contains exactly one instance of the digits from 1 to 9. Games are differentiated by which digits are initially provided. Initially provided digits are a different color (black) from those that are "in play", and cannot be written over

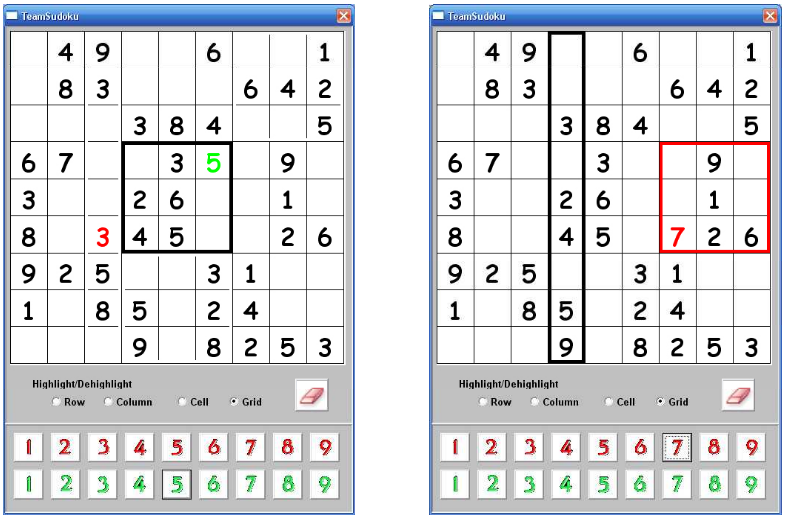

Figure 1: Team Sudoku at Different Times

or changed except by starting a new game.

Team Sudoku (Figure 1) is collaborative in a very simple way. Each player has a copy of the entire board on his/her screen and sees the numbers as they filled in by themselves or others. Anyone can pick a number, by tapping with a stylus or clicking with a mouse and then clicking on a cell. If the cell is in play (as opposed to pre-provided), the new number will appear.

Yet this simple collaborative set-up involves a number of significant decisions. Cells are the limited resource around which coordination occurs; only one player can have a cell at a time. There are two possible ways to allow interaction with this resource: (1) allowing players to pick a cell first and then fill it in or (2) allowing them to pick a number first and put it in the cell. This choice creates subtle differences in collaboration because in the first case, the cell may be taken for quite a long time while the person decides what number to fill in or possibly returns it without filling it in. In the second case, the cell will normally be unavailable to others only for the time it take to click on it and return the number to the Tuple Space.

Digits can reasonably be implemented either as unlimited resources, allowing people to make mistakes by overusing them, as in the paper version of the game, or as limited to the total number needed for the puzzle, meaning that overuse can lead to running out. As implemented, the digits are an unlimited resource, like an infinitely extending sticky pad. This is because the effects of running out of a digit would often be experienced at such a considerable temporal remove from the mistake that led to it as to undermine satisfaction with the game. Thus, a player could decide to paper over the board with 9's, although under most circumstances this would be thought of as uncooperative behavior.

4.2.1.1 "Zensign"

Plurality, appropriability, and acompetition are supported by "zensign", creating opportunities by leaving out features that would add constraints [42]. This is where the playground yardstick has maximum impact. Anyone who joins the activity can play. Any number can play. A person can join the activity and watch but not play (lurk). The number of turns a player takes and the order of play is unspecified by the system, but remains in the social realm. The system is thus pluralistic. Furthermore, the system is acompetitive. It does not identify mistakes or decide when the game is finished. It does not identify who has contributed more or less, better or worse, or specify whether attention is drawn to a contribution or not. All of these are negotiated tacitly or explicitly in the social space. We will discuss appropriability of game play in the next section in comparison with Collaborative Crossword, but there is no doubt that order of play is negotiable. So too are the purposes. If a player decides to paper over the board with 9's, the players as a whole must work out what that behavior means, who continues to play, and whether that turns in to some new kind of game, in the same way that crying "slow race!" at the end of a footrace may or may not be acceptable to the other players, may be serious or a joke.

4.2.1.2 Kinds of Representations

To support game play, we implement a representation, and we support coordination of those representations by making them multi-user. We also support the rules of the game, but not by encoding those rules directly. We support the rules by supporting the social space in which the rules may be constituted.

Two features support the social space in which the rules are constituted. Most importantly, by tapping or clicking, users can highlight a column, a row, any one of nine 3x3 blocks or a cell at a time for themselves and others. Each user's highlighting is in a different color. Highlighting can be used for deictic purposes in close conversation, or to indicate an important place for individual or joint focus. (That is, it may stand in for the intention to work quietly in an area, or a proposal that the group work quietly in that area.)

Additionally, users can choose to fill in digits in green versus red to indicate confident versus tentative candidates. This difference is supposed to allow reminders to both self and others and may provoke an evaluative response from other players.

The decision to implement highlighting via indicators of pre-defined objects of interest (cells, rows, columns, and blocks) as compared to a general-purpose indicator such as an arrow or telepointer should be seen as controversial. By this decision, we are raising the idea that the specific representational properties of this game should be acknowledged in the coordination realm, rather than maintaining representation and coordination as separate levels. The utility of this decision remains to be evaluated; however, it suggests that the details of effective, easy coordination may run counter to more usual computer science assumptions about system isolation.

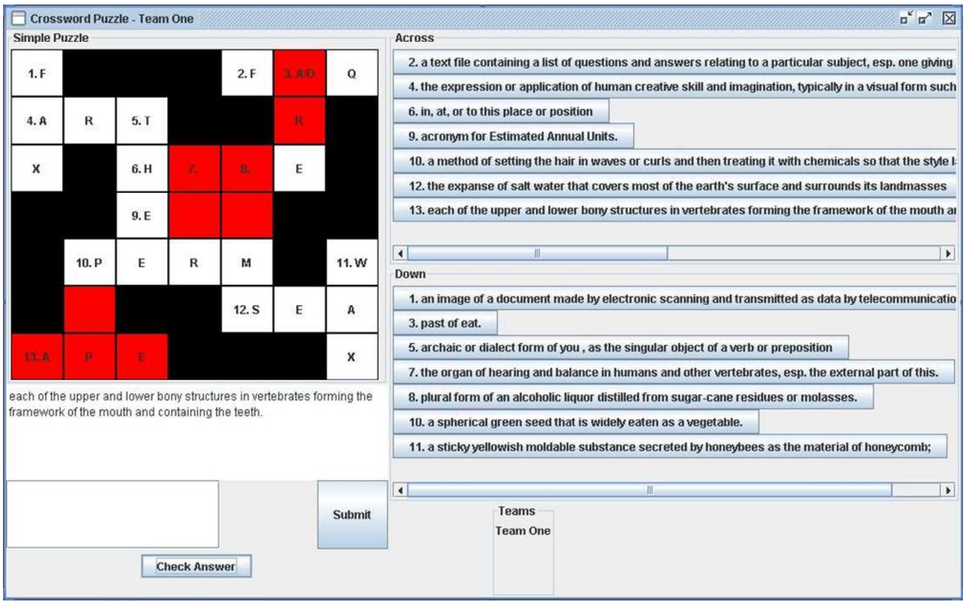

Figure 2: A Simple Collaborative Crossword

4.2.2 Collaborative Crossword: Pathways in coordination

Collaborative Crossword (Figure 2) is another simple collaborative game, also implemented in the sprit of playground games. Similarly to Sudoku, crossword puzzles are, of course, a game that involve filling in answers in a grid. Some squares in the grid are already filled in with black. Others are filled in by virtue of providing letters that go into cells. The letters that occupy cells spell words or phrases that answer clues associated with horizontal or vertical sequences of cells. A given clue is associated with a given set of cells constituting a portion of the grid and indexed by a number indicating the first cell in the sequence. However, each cell may also be associated with another clue, another set of cells and another index number. Numbers are assigned to cells that start sequences in ascending order from the upper left corner of the grid and to the bottom right.

Collaborative Crossword differs from Team Sudoku in a number of respects. The primary unit of interest in the crossword puzzle is the clue and associated portion of the grid rather than the cell. This is a limited resource. Use of it must be coordinated. This means that a clue and associated grid portion is "taken" to enter cell elements (letters) into that grid portion. However, the cell is also important if it belongs to two different clue/grid portions. In our version of Collaborative Crossword, one user may take "1 down" while another has "1 across", allowing both to enter letters into the cell marked "1". In case of conflict, a cell may have and display two answers. Resolution is entirely in the social space.

As with Team Sudoku, the number of players and their roles is unspecified. Players decide through action and/or discussion who goes next and how much each contributes. Similarly, the computer's ability to prevent wrong answers or explicitly to gauge performance is unutilized.

Despite many similarities, the radical underuse of the power of the computer to determine action has led to the identification of an important collaborative difference between Team Sudoku and Collaborative Crossword. In Team Sudoku, if a game is easy enough, players may proceed in isolation. However, in the more usual case in which the board is challenging, one player's actions impact the others' options within a very few moves. The nature of the game means that each move is in relationship to most of the board. Furthermore, mistakes compound. Since it is difficult to remember all the dependencies between moves, the cost of a persistent mistake is high. (Undoing is, by the way, less useful than it might seem, as it is difficult to identify the original mistake.)

In initial trials within our class and with three groups of outside student users, some groups were seen to work closely together from the beginning. However, even those who did not collaborate initially learned in the first game that they had to talk with each other in order to have fun and succeed.

Collaborative Crossword is different from Team Sudoku. There are many ways for people to coordinate in the successful and fun execution of the puzzle. Players might divide up the board, work closely together, or leave the relationship between one person's work and another to chance. Dependencies are primarily local and relatively easily undone. One player might quietly fix another's answer or a mistake might become the subject of discussion. However, in Collaborative Crossword as opposed to Team Sudoku, there is no systematic interaction between the collaborative game and the nature of the coordination between participants.

The coordinative properties of the game themselves constitute a framework in which attempts to influence behavior should be understood.

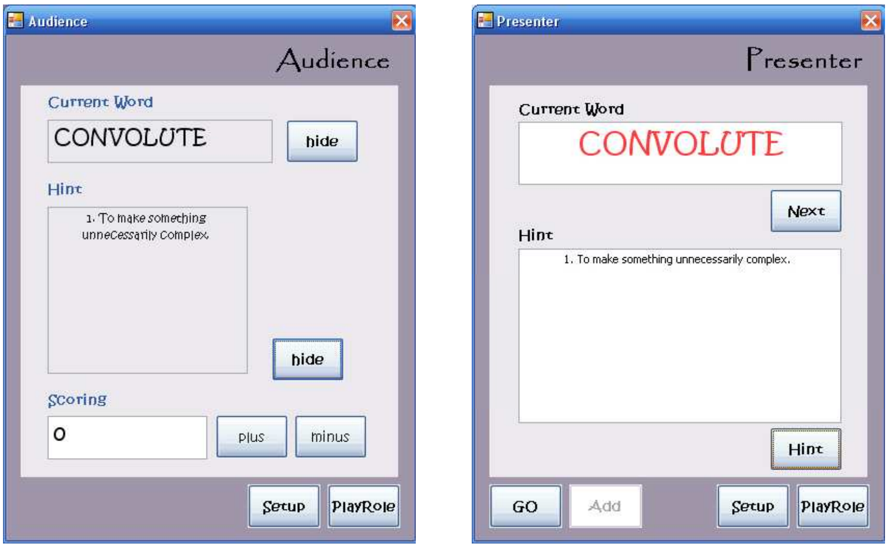

Figure 3: Presenter and Audience Screens from Coordinated Password™

4.2.3 Coordinated Password™: Supporting, not encoding, roles

Neither Team Sudoku nor Collaborative Crossword demand explicit roles. If roles emerge, they are entirely in the social space and have to do with the nature of game play. The Password game allows us to design support for explicit roles and role transitions.

Password™ was originally a television game show in which a presenter was given a target word or phrase and asked to use words that would get the guesser to say the target. For example, a presenter can say "it's raining cats and …?" to make the guesser to say "dogs." Guessers were allowed to ask questions to presenters and actively engage in the game. If the guesser cannot guess the word, the presenter may "pass" or move on to the next word. Thus, the original game involves two roles, that of the presenter, who knows the word or phrase, and that of the guesser, who does not. These roles were filled by exactly one person at a time. There is also a third role, that of audience, filled by many people. The audience was told the target word or phrase and was therefore presumably more allied with the presenters' than the guessers' experiences. Although the audience role is tacit in the game description, this role is quite important. The original T.V. game was arguably designed as much or more for the audience as for the players.

The two main resources in this game are (1) the target word or phrase and (2) the hints and associations primarily produced by the presenter. In Coordinated Password™ (Figure 3), the presenter sees and controls the target, the guesser does not, and individual members of the audience may, by clicking on "show". Users switch roles by clicking on a role, which they may do at any time. The technology therefore allows any number of presenters, guessers and audience, and the audience may play along as either a guesser or a presenter.

Hints and associations are produced in social space. However, we augment the coordination by providing hints. We have tried both hints to the guesser and hints to the presenter with interestingly different effects. Hints to the guesser have consisted of purely formal information (e.g. how many letters in the target). They have also been non-coordinative, in that they have required the guesser to divert attention from the presenter to puzzling over the hint. They have also been received with little enthusiasm in initial use. Hints to the presenter have thus far consisted of dictionary definitions of words. Both denotative content and guides to pronunciation have been received with relief.

Initial use has consisted of (1) in class trials, (2) trials with groups of prospective female students in the College of Engineering, (3) trials with fifth grade science students and (4) a number of trials with English Language Learners in the context of voluntary, short term classes. Each group involved the development of a tailored dictionary of words and definitions.

In initial use, we have frequently seen the audience join in spontaneously, always on the side of the guesser. It is our belief that the more difficult role is actually that of the presenter and that therefore it would be more fun if the audience was able to help the presenter out. Therefore, we are currently implementing a version in which the audience can type in and submit hints for the presenter to use. These hints can either be submitted privately, thus strengthening the identity of the presenter as being in charge of the information, or they can be called out, leading to multiple presenters. The question is "to what extent can we, as designers, influence the definition of roles and rules, not by enforcement, but by supporting underlying coordination?"

4.2.4 Shared Apples-to-Apples™: Turn taking?

A fourth system, a collaborative version of Apples-to-Apples™, illustrates the ability to play with order of turns. Apples-to-Apples™ is a paper-based collaborative game with two kinds of resources. "Green apples" are cards with nouns or noun-phrases on them. "Red apples" are cards with adjectives or adjectival phrases. Each player has a hand with a certain number of Red Apples. A stack of Green Apples is a shared resource. On each round, one person, the judge, turns over a green apple card, revealing it to everyone. Each of the other players must choose a Red Apple from his or her hand, and put it on the table face down. When everyone is done, the cards are turned over and the judge decides which Red Apple card is most similar to the Green Apple. The person who played that Red Apple wins the round.

Apples-to-Apples™ is an enjoyable game in part because there is no absolute right or wrong. Each player must decide from his or her limited hand what card the judge is most likely to find similar to the Green Apple. If the judge is five years old, one might make a different choice when presented with a card that says "Shirley Temple" than if the judge is 80. Therefore, the predictability and fun of the game depend on having exactly one judge at a time.

In our Shared Apples-to-Apples™, the limited resources are the cards in play. The Green Apple is controlled by the current judge, and each player controls the Red Apples in their own hands. Dealing the cards into hands is handled by the computer. In paper Apples-to-Apples™, the cards put down are shuffled to hide who has contributed what. However, this step may be skipped or there may be a playing practice of claiming cards or an alert judge might quietly monitor a particular card during shuffling rearrangement and remembers to whom it belongs. (Although the idea of such routinized "cheating" or accommodation might shock some adult players, it is an important part of human interaction as noted in Harvey Sacks' aptly named article "Everyone has to lie" [35].) In our version of Apples-to-Apples™, we did not provide any technological way of indicating who chose which cards, thus leaving this problem for the social space. We did, however, implement different regimes for turn taking at the game level, one of which automated the movement of the judge position to the winner of the previous round, and one of which asked the players to decide on each round who would go next. We also implemented a feature by which new cards could be authored by players and submitted into the general pool.

5. DISCUSSION

We have focused here on exploring coordination using three of the essential aspects of playground games---plurality, appropriability, and acompetition---as a yardstick for collaborative, distributed face-to-face activities. Four systems were designed as a means of exploring the feasibility of radically distributed control both between participants and from system designers to player. Plurality, appropriability and acompetition are supported by the explicit representation of the resources to be coordinated, a flexible, nuanced way of treating those resources and loose coupling between actors in using those resources. All of these are associated with a radical dissemination of control at the technological level that permits the creation of complex engagement.

These games support plurality. Each of these games allows players to join or leave at will. They allow any number of players to participate, and to switch roles at any point in time, to team up or dissolve teams at will, except where (as in choosing the judge in Shared Apples-to-Apples™), this would be detract from central fun of the game. Even in this case, we design to explore control over passing the role from one person to another.

These games also support appropriability. Coordination is accomplished by presenting minimal, tailored features to support essential qualities of the game, leaving the use of most resources open-ended. The games can accommodate different social needs related to how many people participate, the kinds of roles they assume and the rules for who goes next, when, and under what circumstances. Support is provided for coordination around rules and roles rather than for enforcement.

Last, the games are acompetitive. They can be played for purposes of the players for their own purposes. Game completion or progression is judged in the social space. This allows a competitive approach but does not privilege it.

Each of these qualities supports reflection about coordination, and responsibility on the part of the user as an individual agent for their own behavior in and outside the context of the game.

5.1 Evaluating these games and this work

The success of these designs rests primarily on what they show about the enterprise of building computer systems that we are engaged in as a culture. They demonstrate the possibility of designing classes of games that support emergent play, yet encode the coordinative aspects to keep play going. They demonstrate a means of doing so. They also demonstrate the challenges of attempting to get computer scientists to think about coordination in a distributed way. Therefore, although we have just begun user testing, their success does not rest only on the user experience they promote.

Each of the games discussed reveals something about the coordinative potential of the activities involved. Each promotes focus on the conditions that promote *emergence* of a differentiating behavior: of rules, of roles, of turns, and/or of action patterns that are more tightly versus loosely coordinated.

5.2 Other Aspects of Playground Games

In the current work, we have built on three important aspects of playground games that are particularly tied to interpersonal coordination. Five other aspects of playground games are availability, embodiment, repetition, simple entry, and child players. Playground games employ readily inexpensive, available materials: bones, sticks, rubber balls, chalk, rope. These are things that a child can find or afford, which can be easily carried and therefore made available, and which can be hidden when inappropriate. Our emphasis on cross-platform, mobile computing has something in common with this. Phones, of course, have many of these properties and should be the focus of further development.

We note that playground games are repetitive. Children play them over and over again, and their repetition is key to their longevity. In part, this is why most of our collaborative games have started with games that are already known to be successful as individual games. However, the meaning and entailments of repetition need exploration.

Closely related to the repetition in playground games is their embodied nature. Embodiment is also increasingly seen as important in the design of pervasive computing system [25]. We have here ignored the embodied nature of playground games, and the role of embodiment in coordination. This needs exploration.

Additionally, unlike our games, playground games usually involve activity with a very low cost of entry. Although the games we have built admit scaffolding players through teaming and through the possibility of accommodating behavior, the games themselves rely on literacy/numeracy. Additionally, most ask for a certain attainment of special knowledge not possessed by very young children. Collaborative Crossword, and Shared Apples-to-Apples™ rely on world knowledge that cannot be garnered in playing the game itself. Coordinated Password™ relies on prior knowledge of when and how words are used. Team Sudoku does not rely on special knowledge, but it does make substantial cognitive demands in terms of extended logical thinking. Perhaps the simplest examples should build on similar activities that have recently been the focus of attention for kindergarten and lower elementary children, such as Pokemon™ and Magic the Gathering™. These are interesting because, while they ultimately demand literacy/numeracy, children are brought in to the study and exchange of cards by pictures.

Playground games are usually (though not exclusively) played by children. The importance of distributed control and responsibility are most clearly seen when we think, as did Brynskov and Ludvigson [6] primarily about children. Our work also began and begins with education and with the empowerment of children.

However, the factors we have focused on---pluralism, appropriability, and acompetition---are not only important because children engage in them, but also because they are some of the underpinnings of coordinated interaction. In the past, adults have not had to think about the underpinnings of coordination. They have learned how to behave and act in culturally appropriate ways, and coordination fades into the background. But mobile, pervasive technology changes the resources adults have for interaction. By changing the resources that participants have in the moment of interaction for interaction, the designs we have presented let us see different interactive choices that the system and the users can make, choices that other systems often make for them. From this perspective, playground games are important to adult interaction.

5.3 The Object World of the Engineer

The object world of the engineer [5] is also important, that is, how engineers tend to view the world. In this paper, we report on the successful examples in order to show a vision, but this report and these games are the outcome of an extended investigation. One sobering factor that emerged in teaching these design classes was that many of the students assumed that interactive choices were unimportant and undesirable. Emblematic of this is the student who said “It’s not fair if people decide who goes next”, and garnered much enthusiastic agreement from his peers [42]. This is not a technical but a cultural assumption about what is important and desirable, and as such is rather shocking. This point of view concedes tremendous power to the designer, who may not at all understand the significance of his design choices.

The “oughts” of the design are a reflection of the culture in which the design is carried out as well as in the culture of how play goes on. Participatory design is one mechanism for helping the designer perceive the culture of the user [3, 11], but it too requires that computer scientists respect that culture and are able to see it when it differs from their own. Because of this, participatory design is particularly fragile when dealing with underpinnings and unarticulated assumptions.

5.4 Creating New Cultures

In contrast, one of the exciting possibilities implicit in the current work and in the Mock Games work as well as other pervasive game settings (for example, Uncle Roy All Around You [2]) entails a vision of taking all people “seriously as creators of their own contexts” ([6], p. 9).

Some have pointed out the importance of spontaneously arising, concerted, joint action in contexts of MMORPGs (Massive Multiplayer Online Role Playing Games) such as World of Warcraft [9]. Wikis and Blogs also form an exciting mechanism for doing this [8, 28] in the web world for creating contexts. Yet the focus and direction of action in MMORPGs is highly set by the game. Wikis and Blogs are a lot of work; authoring is a complex and self-conscious act.

Some of the most powerful ways that people have of creating contexts do not involve asking them explicitly to create culture, but rather utilize human resources that have always been used in culture building. This is what the genre of mock games is doing, and what we are elaborating on in focusing on playground games and playground-game like activities. Thus, although we start with children, our concern is not just influencing children’s behavior and views of technology, but the expectations and hopes that adults also have for technology and its role in our quality of life.

Like Brynskov and Ludvigson, we believe that inquiry into the underpinnings of interactivity is key to gender inclusiveness and diversity in computing. It is well known that girls tend to focus more on issues of coordination in interaction than do boys [41]. One way of including girls is to focus on self-conscious activities such as role-playing, but arguably as or more important is to support a broad conception of how people get done things with each other in the presence of computers. It is not just the “aboutness” of the activity which influences the desire to participate, but the nature of the participation and the definition of self inherent in that participation.

6. CONCLUSION

Coordinated action has ties to many aspects of being for the individual and the group; how we as engineers see coordination is crucial for the kinds of systems that we build. Using playground games and tuple spaces, we have shown a set of possibilities, and shown that by careful design it is possible to create systems that support plurality, appropriability and acompetition. We have neither mapped out the entire space of playground-like activities, nor completely explored the games presented here. But we have suggested a number of important values and directions in supporting the core rules of the game and its enactment.

The design of coordination with and through machines is increasingly important in the world of pervasive computing. Yet, in general, decisions about how to design for coordination are made based on locally expedient judgments. There is too little discussion about constrictions on how participants decide who goes next in interaction, what the duration of the action is, what other actions may happen concomitantly. There is too little discussion about the extent to which people play computer games compared to the extent that the games play them. There is too little discussion of how people engage in activities compared to the extent computer-based activities submerge individual control. Suchman [40] pointed out that we are capable of conforming to plans and making those plans seem like what created our behavior. Yet this is a reduced view of human capacity.

As we move into the future, of course we must evaluate the designs discussed here. We must examine the extent to which the claims made here stand up and under what circumstances. However, the importance of the work lies in three areas: drawing attention to the phenomenon of playground games, suggesting Tuple-space based mechanisms to promote the exploration of coordination, and developing a phenomenology of coordination.

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