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PRIMECLIMB: DESIGNING TO FACILITATE MEDIATED COLLABORATIVE INQUIRY

Computer-Support for Collaborative Climbing

Abstract. We present the design of a two-player mathematical problem solving environment for 12 and 13 year old children. The system was explicitly designed to facilitate social collaboration by incorporating principles of Mediated Collaborative Inquiry, socio-cultural theory and theories of group interaction. We demonstrate that it is possible to incorporate these social theories of collaboration into learning environments in very specific ways through aspects of system design. These principles guide the physical setup within the classroom environment, the design of the activity and resources, and the progression of challenge within the activity.

1. INTRODUCTION

Roschelle argues that since learning occurs through a social process of inquiry (Koschmann, 2002), a social perspective must be considered to successfully create educational activities (Roschelle, 1992). He proposes a Mediated Collaborative Inquiry (MCI) perspective that focuses on the interaction among people rather than between the computer and user. This view seeks to enable learning by supporting communicative practices (Roschelle, 1996), with the computer model providing common ground for learners to take action and discuss ideas (Teasley & Roschelle, 1993).

Social theories of group processes and productivity have examined how group activity structure affects members working together. McGrath (1984) notes that most human interaction involve people who each have influence over one another's behaviours and that gaining satisfaction often requires cooperation or coordination of group behaviour. Steiner (1972) proposes that collaboration is enhanced in a "promotive interdependence" allocation scheme of rewards, in which payoff refers to rewards minus cost. Under such a scheme each person receives greater payoff when their behaviour is highly beneficial to their team members, and reduced payoff when actions are less beneficial to others. Promotive payoff systems strengthen task motivation and encourage interpersonal acceptance so long as a strong shared effort is perceived as necessary and likely to succeed. When success is neither guaranteed nor extremely unlikely (i.e. the challenge is balanced between frustration and reward), "the group resembles a chain that is no stronger than its weakest link... because the group product reflects what members can accomplish when they must operate conjunctively – tied together like mountain climbers" (Steiner, 1972).

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2. SYSTEM

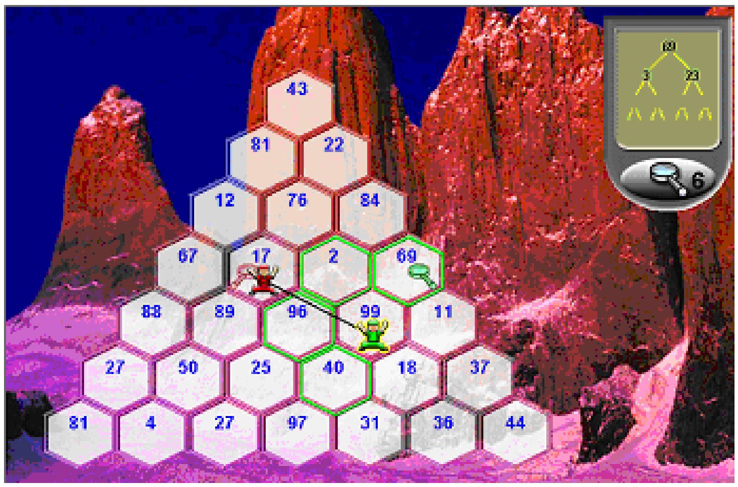

Figure 1. PrimeClimb Screenshot (Level 3)

2.1. Structure

PrimeClimb is a two-player mathematical computer game built upon Steiner's mountain climbing metaphor. This collaborative environment was designed to facilitate mediated collaborative inquiry between two children working on co-located computers. A child controls each digital character, and a safety rope binds the two characters together. At the beginning of each level, the players start at the bottom of a mountain, each standing on a different hexagonal tile. The goal of the game is to reach the top of a mountain by moving from tile to tile. A move is initiated when a player clicks on a destination tile. Only one move can be made at a time; however, turn taking is not imposed as a single player can make multiple consecutive moves.

In order to succeed, players must learn how to avoid falling. The only rule in the game regarding falling is this: if a player moves to a tile with a number that has a shared common factor with the number of the tile that their partner is on, the player will slip, fall and dangle by the rope below their partner. At this point the fallen player swings two rows below their partner and must grab back onto the mountain by choosing one of three possible tiles, but a similar rule of falling applies in this case. If the fallen player chooses a tile whose number shares a common factor with that of their partner, then the partner falls. For example, in Figure 1, if the red player (located on tile 17) moves to tile 96, he or she will fall because 96 shares a common factor with 99 (the number of the green player's tile). Consequently, the red player will fall and swing two rows below the green player until he or she clicks on one of the tiles 97, 31 or 36. Should the player choose 36 (shared factor of 3 with

99 again), the green player will in turn fall. When any player falls below the last row of the mountain, both players restart at the bottom.

There are two additional rules that dictate how players may move. The first is that a player can only move to a tile that is adjacent to the tile he or she is on. The second is that a player can only move to a tile that is no more than two tiles away from his or her partner. Highlighted tiles (40, 96, 2, 69 in Figure 1) show the student (in this case, the green player's screen) the possible destinations at any time in the game. Thus, players never have to think about these rules and instead can focus on deciding where to move.

There is a hint-giving tool in the game called the Magnifying Glass. When used on a number (on the mountain), the tool displays the factor tree of that number in a display at the top right of the screen. A click on the Magnifying Glass button activates the tool and changes the mouse cursor to the shape of a magnifying glass; a subsequent click on a number applies the tool and the results are correspondingly displayed as the mouse cursor changes back to normal.

2.2. Design

The socio-cultural perspective situates human cognition as socially grounded (Crook, 1994). This perspective raises a major concern for CSCL environments: the incorporation of technology into the classroom has the potential risk of adversely affecting the interpersonal communications that provide the interpretative opportunities of cognitive development. The emphasis on the social aspects of learning as facilitating cognitive development has been called the socio-cognitive view of learning (O'Malley, 1989). It shifts the educational goal from the traditional one of acquiring the correct cognitive model to one of using computers to create social circumstances that catalyze discussion of competing solutions with the belief that there does not exist a single correct cognitive model (Koschman, 2002).

Roschelle and Teasley base their analysis of collaborative learning on the notion of the shared conception of the task. They argue that the social discussion to establish common ground allow learners to solve a problem together by building a Joint Problem Space. The activity and resources provided by the computer can actively mediate collaboration by providing a shared context for disambiguating language (e.g. by establishing shared referents), producing conversational turns, inviting and constraining interpretations, and generating new ideas (Roschelle & Teasley, 1989). The following sections discuss the design of PrimeClimb in this socio-cognitive light.

2.2.1. Environmental Design

Unlike traditional computer-mediated communication environments that operate at a distance (Wolz & Palme, 1997), the physical setup of PrimeClimb is physically proximal to facilitate face-to-face interaction. However, simply being physically co-located does not guarantee conversation or collaboration; how learners sit in relation to the computer and to each other is also very important (Stewart, Bederson, et al, 1999). A prototype version of PrimeClimb has been previously evaluated in a variety of physical configurations (Scott, Mandryk & Inkpen, 2002).

The current PrimeClimb setup aims to maximize traditional face-to-face interaction. Each child controls a laptop and the laptops were placed back-to-back so that the children played facing one another. Laptops were used to minimize the physical distance between the players while allowing learners to achieve eye contact simply by looking up from the screen.

The face-to-face configuration was chosen over the side-by-side alternative because it was observed in pilot studies that if placed side by side, a more dominant peer might take physical control of their partner's digital character by reaching over and grabbing their mouse. By seating the players face-to-face they have greater control of their own characters. Even if a more dominant player makes demands on their partner, it is the partner who must ultimately issue the move to the computer.

The back-to-back laptop has another advantage. Since the learners cannot view each other's screens, they must verbalize their thoughts. There is an interesting dynamic at work here: the physically proximal CSCL activity mediates the collaboration by providing a shared context for the learners but the learners at the same time must articulate their thoughts and cognitions in the absence of a shared view – all this despite the fact that their screens are nearly identical.

2.2.2 Game Activity Design

Players must climb up the mountain together because the safety rope that binds them also restricts them to be at most two tiles from each other. Where one player can reach depends on where their partner is located. This effect is amplified in that as climbers progress, the safety of one player's move depends entirely on the number of their partner's tile; thus, in order for a climber to avoid falling, attention must be paid to their partner. When one player falls, the team's goal of reaching the top is in jeopardy; the fates of the players are literally tied together.

Climbing safety is augmented by the magnifying glass, which is a shared, indirect hint-giving limited resource that has local effect. Both players share the number of Magnifying Glasses given for each level, but only the player who uses the tool can see the resulting factors. As the tool resource is allocated to the team instead of an individual player, the limited nature of the tool encourages the team to debate and plan its use.

2.2.3. Level Design

Student motivation requires a delicate balance of task challenge (Steiner 1972). There are 12 levels in PrimeClimb, each with a different mountain. The notion of increasing difficulty is demonstrated between levels as well as within a single level.

Mountain sizes differ between each level. The height of the mountain increases in size by one row every time a level is completed (with one exception that provides a moment of relief).

Within a level, the shape of the mountain imposes a different dimension of difficulty that is particularly apparent as players approach the peaks. There are fewer choices for moves there because of the triangular shape of the mountain; however, these choices must be examined more carefully as climbers at the top have more to lose. The nature of the game is such that once a player falls, it is very easy for the team to rapidly lose ground. This is because a bad choice made by a player when swinging will result in their partner falling. This produces a heightened sense of shared responsibility whenever the dyad approach the mountaintops with neither player wanting to make the first fall that may result in restarting the laborious climb.

3. FUTURE WORK

The activity structure, resource management and physical setup of PrimeClimb were designed to facilitate a sense of shared responsibility in the task among the pair of learners. We have conducted a study with 46 children to examine the effects of these specific design factors on verbal discourse. In a future paper will use interaction and conversation analysis to explore this data.

4. AFFILIATIONS

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