Investigating preschoolers’ problem solving strategies in computer-mediated collaborative environments

Abstract
This study aims at investigating gender’s influence on the collaborative behaviours among preschoolers in the context of a collaborative problem-solving task with computers. The collaborative task was mediated using the puzzle-solving game ‘Incredible Machine’. Their approaches towards the problem-solving task were examined while they worked in one of three gender groups (girls, boys, mixed). In order to classify the verbal interactions during their collaboration, Mercer’s and Yelland’s model was adopted as a means to understand the cognitive dimension of children’s talk around computers. In addition, Inkpen’s taxonomy of mouse usage across the group members’ was adopted in order to deeply understand their expressed low level interaction styles. Analysis of results demonstrated significant deviations for all gender pairs, which are presented and discussed in detail.

Keywords: collaborative learning; gender studies; verbal interactions; early childhood education

1. Introduction
A number of studies have reported on the potential of computers to support valuable educationally collaborative activities not only in elementary settings (Inkpen, 1997a) but also in the context of early childhood education (Belay et al., 1991; Hoyles et al., 1994; Howe et al., 1992; Light, 1993; Light et al., 1994; Yelland, 1995; 2005; Virla et al., 2006). Thus, revealing the positive outcomes of collaborative learning with computers. In this context, verbal discussion of ideas and hypotheses is a key component of the learning outcome. This may be best facilitated when the children are sitting side-by-side, face-to-face, both focusing on the same artifact (Inkpen, 1997b; Inkpen et al., 1995 a; 1997b). A number of studies revealed that many of the children preferred playing electronic games in groups and often appeared to be more successful in the games as a result of their collaborations (Inkpen, 1997a; Inkpen et al., 1995b; Scott et al., 2003). Therefore, it is of no surprise that various researchers attempted to build theoretical constructs to explain the interactions taking place during collaborative learning.

Barnes (1976; Barnes & Todd, 1978; 1995) was amongst the first researchers to devise an analytic method to interpret collaborative learning in classrooms and specifically how children verbally interact while they engage in tasks. His results support the idea that children are more likely to engage in open, lengthy discussion and argumentation while talking with their peers, without the presence of their teacher. This type of talk enables them to acquire a more active and independent “property” of knowledge.

Johnson et al. (1990) and Hymel et al. (1993) in a review of the research literature related to cooperative learning, identified six prominent elements necessary to achieve a successful cooperative learning environment. These were: common objective so that the learning outcome results from common effort and face-to-face interaction in which children must engage in direct, verbal interactions to truly cooperate. Such interaction is expressed as mutual help and influence, support and encouragement, knowledge and information offer, material exchange, feedback to schoolmates. Positive interdependence is another necessary element in which each child can only succeed if all the members of the group succeed in learning. Moreover, in social skills training children must be taught the necessary collaborative skills, such as low tone of voice, self-esteem, attitude towards peers and school work, motivation, helping and sharing, expressing disagreement, acceptance of and mutual concern for people different from themselves. Furthermore, awareness of individual accountability so that each child in the group contributes an
equal share of work to the project and is responsible for learning the assigned material. None of the team members should be left to dominate in the team and impose their opinion or submit the solutions and the answers. Finally, children must be given group evaluation opportunities to evaluate and discuss among themselves just how the group is functioning and ways in which it could be improved.

Many studies varied in their methods of promoting positive interdependence, while numerous researchers have noted that girls and boys interact differently with computers, think about computers differently, approach computers differently, have different motivations and preferences, and have even shown differences in the ability to use various interaction styles (Abnett et al., 2001; Hall et al., 1991; Inkpen, 1997b; Inkpen et al., 1995a; 1997a; 1997b; Lawry et al., 1995; Lockheed, 1985; Upitis et al., 1996; Wilder et al., 1985). While children are engaged in face-to-face social interactions, they exhibit rich collaborative behaviors, thus communicating more effectively and enjoying working together when using technology that supports these interactions (Scott et al., 2003).

Many studies have reported that boys and girls appear to differ in the way they share mouse control. Howe (1997) in a review of research about gender and classroom interaction, refers to numerous studies in which extreme asymmetries of mouse control have been observed in mixed groups, with the boys being always dominant (Abnett et al., 2001; Barbieri & Light, 1992; Siann et al., 1990; Underwood et al., 1993). Also, casual observations indicated that mouse sharing was a problem for both sexes in the Integrated Play condition where two children played together on one computer (Inkpen, 1997a). Children’s mouse sharing behaviors are characterized by the number of exchanges, requests and refusals (Inkpen, 1997a). An exchange occurs when mouse control is transferred from one partner to another. A request occurs when a partner asks for mouse control, which could be a verbal statement or a physical motion attempting to take mouse control. A refusal occurs when one child makes a verbal statement or physical action, declining to give mouse control to their partner, such as saying “no” or physically pulling the mouse away.

Inkpen (1997a) also observed four types of methods the children used to request the mouse: (a) no-contact; (b) verbal; (c) touch; and (d) pull. A no-contact request occurred when one partner made a motion towards acquiring the mouse but did not actually make physical contact with the partner. A verbal request occurred when a child asked the partner if they could have the mouse. A touch request occurred when a child touched the partner’s hand to signify they wanted the mouse. Finally, a pull request was one in which the child physically tried to take the mouse away from the partner.

**Effects of gender differences on collaboration**

Gender has been found to be of significance when considering the ways in which children interact when using computers. Inkpen (1997b) supported that research must be conducted in order to understand the complex nature of gender differences, thus preventing researchers from making false assumptions. For example, Huff and Cooper developed a math prototype game for girls and boys, in which compete and team mode of play were available. Researchers wrongfully assumed that girls would prefer to play in team mode and boys in compete mode. However, girls preferred to play in compete mode because the sense of identity and character was important for them. Boys preferred to play in team mode because they recognized that if they worked together, they could get the highest score in the whole class. Despite their competitive behavior, they were willing to cooperate with one person in order to have a higher level of success and compete with the rest of the class (Inkpen, 1997b).

Previous research has shown how the different interaction styles between boys and girls can affect the ways in which knowledge is constructed and the quality of the learning experience
of those who participate in this (Kovalik, 2008; Swann, 1992; 1994). At the same time, many studies have reported the differences between the two sexes while working in computer mediated tasks. They have noted that children’s success when playing with a partner may depend on whether girls or boys are playing and on their playing configuration (Abnett et al., 2001; Inkpen, 1997b; Inkpen et al., 1995a, 1995b; 1997a; 1997b).

When it comes to the pair framework, most studies have contrasted boy, girl and mixed pair arrangements (Howe, 1997). As stated by Howe, gender differences in children’s interaction around computers could be extremely significant; in a research review related to this, she came up with the following conclusions. Single-sex groups (boy, girl) talk more in computer environments than mixed groups (Lee, 1993; Tolmie & Howe, 1993). Girls are more likely to request help from boys than the reverse (Lee, 1993; Underwood et al., 1993). The help that boys give can be resented especially if it is physical (Siann & McLeod, 1986). Boys dominate computers physically at all but the youngest age levels (Barbieri & Light, 1992; Siann et al., 1990; Underwood et al., 1993). There is more antagonism in all-male groups (Guntermann & Tovar, 1987; Lee, 1993 Underwood et al., 1993), more agreement in all-female groups (Guntermann & Tovar, 1987), and mixed groups are characterized by a lack of social contact (Underwood et al., 1990). Finally, girls who work in mixed groups enjoy the computing experience less than boys in mixed and single-sex groups and girls in single-sex groups (Barbieri & Light, 1992).

A number of studies have investigated the nature of student’s social activity, particularly verbal interaction, in different small group work learning situations (Abnett et al., 2001; Kumpulainen & Wray, 2002; Mercer et al., 2003; 2007; Monaghan, 2005; Wegerif et al., 1998; Wray & Kumpulainen, 2010). Swann (2003) by referring to “schooled language”, supports that girls and boys develop certain ways of using language, through their participation in diverse educational language events; but boys’ speaking styles allowed them to dominate classroom interaction, so that girls had limited opportunities to contribute. However, Hymel et al. (1997) claimed that when boys and girls work in on-computer tasks, they tend to use group language, viewing the task as a cooperative one. Previous research has revealed that children are more likely to refer to the dyad (“we/us”) and less likely to themselves (“I/me”) and their partners (“you”) while playing cooperative games (Beaumont et al., 1997). Nevertheless, the SLANT project looked at children’s interactions around stand-alone computers in ordinary classrooms and found that children’s talk together around computers is often of limited educational value (Mercer, 1994; Wegerif & Scrimshaw, 1997).

A taxonomy of collaborative actions

According to Mercer (1995) knowledge and understanding can develop when peers talk and collaborate without the presence of their teacher. The psychologist Paul Light claims that, when the use of language is essential for planning-determination and decision-making, language appears to facilitate problem-solving and promote understanding (in Mercer, 1995). There is also empirical evidence that problem-solving activities which encourage children to reach agreement have more significant educational benefits (Mercer et al., 2003; Wegerif & Mercer, 1997), providing unique opportunities for the development of children’s spoken language capabilities (Mercer et al., 2007).

Yelland (2005; 2011), in a review of the literature on the use of computers in early childhood education, claimed that computers have afforded opportunities for young children to use higher order thinking skills, engage in creative and critical thinking, deploy strategic and meta-strategic strategies in problem-solving and in problem-posing situations, (Yelland, 1998; 2002). Moreover, the use of new technologies may support young children’s social development and knowledge building processes. In this context Clements recommended that children should work together, preferably in pairs, since this encourages collaboration and motivates them to
work more effectively. Children, also talk more when working at computers in pairs, which can facilitate thinking through problems and the discussion of possible solutions. The resolution of conflict in the problem-solving experience has been found to be of particular relevance in these collaborations (in Yelland, 2005).

Yelland (1994; 1995) and Mercer (1995; Wegerif & Mercer, 1996; 1997; Wegerif et al., 1998) have studied the way talk emerges from children’s collaboration in on-computer tasks. Yelland (1994; 1995) has categorized children’s interactions in attempting to characterize the nature of their problem-solving strategies. The categories were:

1. Asking for information/explanation
2. Offering information/explanation
3. Agreeing with the information/explanation
4. Disagreeing with the information/explanation
5. Ignoring the information/explanation
6. Deferring to the information/explanation
7. Asking for a proposal
8. Offering a proposal
9. Agreeing with the proposal
10. Disagreeing with the proposal
11. Ignoring the proposal
12. Deferring to the proposal
13. Making supportive comments
14. Making non supportive comments
15. Independent moves
16. Tension release
17. Non task or incoherent language

Categories 3 to 6 and 9 to 12 reflect immediate responses to the offer of information or explanation, and the offer of a proposal respectively.

However, Mercer (1995; Wegerif & Mercer, 1996; 1997; Wegerif et al., 1998) and the SLANT project team developed a different way of understanding the cognitive dimension of children’s talk around computers. They typified three distinct types of talk, which are described as “social modes of thinking” (Mercer, 1995). These are:

- **Disputational talk**: characterized by disagreement and individualized decision making. There are few attempts to pool resources, or to offer constructive criticism of suggestions. Disputational talk also has some characteristic discourse features – short exchanges consisting of assertions and challenges or counter assertions.

- **Cumulative talk**: speakers build positively but uncritically on what the other has said. Partners use talk to construct a ‘common knowledge’ by accumulation. Cumulative discourse is characterized by repetitions, confirmations and elaborations.

- **Exploratory talk**: partners engage critically but constructively with each other’s ideas. Statements and suggestions are offered for joint consideration. These may be challenged and counter-challenged, but challenges are justified and alternative hypotheses are offered (Barnes et al., 1978; 1995). Compared with the other two types, in exploratory talk knowledge is made more publicly accountable and reasoning is more visible in the talk.

Monaghan (2005) described exploratory talk as one of the most likely to result in the features of effective talk, although students are rarely explicitly taught how to engage in this kind of talk. Several studies have used Mercer’s framework to enquire into classroom interaction (Edwards, 2005; Howe & Mercer, 2007; Littleton et al., 2005; Mercer et al., 2003; Monaghan, 2005; Patterson, 2009).

Our research focuses on the investigation and evaluation of preschool students’ expressed collaborative behaviors. Our objective was to investigate these behaviors as they appear from
their effort to cooperatively complete a computer-mediated problem-solving task. Their performance towards the task was examined while they worked in boy-, girl- and mixed pairs. In this context, we concentrate in answering the following questions: Are there statistically significant differences:
1. In the verbal communication between the 3 pair arrangements according to Yelland’s revised typification scheme?
2. In the number of occurrences of Mercer’s types of talk between the groups?
3. In the mouse sharing behaviors for all pairs?
4. In the methods all pairs of children used to request the mouse from their peers?

   The rest of the paper is organized as follows. First the method of the study is presented, followed by the results which are discussed in detail in the following sections.

2. Method of the study

2.1 Research goal

This study describes our interest in identifying the quality and the type of preschool children’s talk while engaged in collaborative problem-solving activities. Mercer’s as well as Yelland’s typology was utilized as a conceptual tool of analysis for in-depth interpretation of the cognitive dimension of children’s talk around computers. We are also interested in identifying the mouse sharing behaviors of children and whether mouse control caused any problems while collaborating. Thus, Inkpen’s taxonomy was utilized to interpret children’s mouse sharing behaviors when having one mouse to solve the task. Overall, we focus on how gender and grouping affects attitudes and discourse of children playing a puzzle solving game. The aforementioned issues were examined separately for boys and girls in order to deeply understand their interaction styles.

2.2 Subjects and setting

The study took place in two public Kindergartens in Greece. 42 children participated (21 boys and 21 girls), aged 4.5-6, mean age 5.631, sd=0.44. They were all Greek, came from urban areas, volunteered to participate and had received permission from their parents. Children were assigned a partner from their class corresponding to a particular gender-dyad and played on one computer (Integrated Play condition). For that reason 3 categories of groups were created, with 7 teams each: (a) girls: a pair of girls, (b) boys: a pair of boys, (c) mixed: one girl and one boy.

2.3 Equipment

The technical equipment included: (a) a computer, (b) the Incredible Machine, (c) a video camera, (d) the Pinnacle software for the analysis of the videotaped files, in order to capture children’s conversations and actions towards the game, (e) the Excel program in order to synchronize children’s talk and action and (f) the SPSS Statistical Package 15.0 for the statistical analysis.

   Incredible Machine is a puzzle-solving electronic game, created by Sierra On-Line Inc. It features a wide variety of simulated tools used to construct machines in order to solve particular challenges. The video camera was placed behind the computer table in such a way to capture children’s faces, discussions and body movements so as not to be distracting their attention from the problem-solving task. The videotaped files were analyzed, focusing mainly in children’s verbal interactions and the types of talk that might have emerged from their collaboration. Excel was utilized to record children’s dialogues and actions. In particular, we recorded the speakers, the time they spoke or made an action, the time their talk or action lasted, what they said and what they did (action). We achieved the synchronization of speech and action so as if someone
who reads the captured dialogues will feel that they are present at the session. Finally, SPSS was utilized to show if there are statistical differences in children’s collaborative behaviors.

The experimental equipment included: (a) structured interviews which assessed children’s attitudes and subjective satisfaction towards the collaborative play, (b) analysis of their answers to categorize them using Yelland’s classification, (c) Mercer’s model to analyze children’s talk around computers and (d) Inkpen’s taxonomy to capture their mouse sharing behaviors. The structured interviews included eighteen open-closed questions dealing with children’s knowledge of computers and the collaborative behaviors they developed when playing electronic games with another partner.

2.4 Procedure

Each experimental session lasted 30 minutes. Children were welcomed upon arrival and given a brief introduction to the game. They were given only one computer and it was up to them to sort out how they would play (figure 1, right). They were encouraged to work out any problems they might have among themselves, were permitted to talk freely with their partner and collaborate as they wished. The problem-solving activity started when a seat in front of the computer was taken.

An original problem-solving activity was created. The goal of the puzzle was to make all hot-air balloons fly (figure 1, left) and its scenario was told through a short story-telling. Children were told that the 4 hot-air balloons had to fly a long way to get to their destination, but they could not take off. Only one of the four hot-air balloons could fly, while the remaining encountered a mechanical problem. For that reason their help was essential so that all balloons could take off for their journey.

![Figure1](image)

*Figure1: The initial configuration of the puzzle (left) and a snapshot of the process (right).*

The researcher performed the task so that children observe what happens to the 4 hot-air balloons. They were shown how to manipulate the objects on the right of the screen, their possible functions, their availability and how they could be moved from the parts bin onto the playing screen. Once the game was completed, structured interviews were carried out to both participants to get more information on their collaborative behaviours all through the problem-solving task.

3. Results and Discussion

Children’s collaborative behaviours towards the problem-solving task were analysed, as these resulted from the video transcripts and the structured interviews. For our data analyses we implemented nonparametric tests, the Friedman chi-square procedure, which is considered appropriate when evaluating a small sample and can be used with nominal or ordinal test variables.

3.1 Analysis of the Collaborative Behaviors assessed through the Videotaped Sessions
3.1.1 Collaborative Attitudes

Only in 2/7 boy pairs the collaboration between the two participants was not satisfactory. In particular, neither the verbal communication was evident, nor the mouse distribution from one user to another. Overall, during the session they exhibited social behavior and were exclusively working on how to come up with a solution to the problem-solving task.

For girl pairs, differences were observed in the ways the two girls tended to collaborate. Verbal communication was not evident only in 2/7 girl pairs, while observations of mouse sharing revealed that quarrels could occur. They were also not focusing on how to accomplish the goal of the game, implying the off-task activity of their cognitive processing. As a result, they talked about the things they did the previous day, their appearance and when the game would finish so that they could leave. The remaining 5 pairs were totally devoted in completing the problem-solving task without picking on irrelevant topics.

For mixed pairs, casual observations revealed that children were facing more difficulties in their collaborations than boy- and girl-pairs, an observation consistent with Underwood et al. (1990), indicating that mixed pairs are less inclined to engage in transactions. Often one of the members of the team, either a boy or a girl, was reluctant to offer verbal instructions and take mouse control or even make a request.

3.1.2 Verbal Communication

Our observations revealed rich dialog implying that children engaged in detailed discussions about how to solve the puzzle in the game and sharing ideas. This constitutes an important observation since the discussion of thoughts and ideas may be an integral part of the learning process.

Initially, Yelland’s classification scheme was utilized to comprehend the nature of children’s problem-solving behaviors towards the collaborative task. But since it is very analytical, we converted it to a simpler one which comprises 3 categories:

1. Y1: Offer of information/explanation (categories 1 to 6)
2. Y2: Offer of a proposal (categories 7 to 12)
3. Y3: Other (categories 13 to 17)

![Figure 2: Summary of the number of occurrences that characterize the nature of the problem-solving behaviours for boy-, girl- and mixed-pairs.](image-url)
For all pairs, a Friedman test demonstrated significant differences in the number of occurrences of Yelland's revised typification ($\chi^2=13.04$, $p=0.0015<0.05$). Figure 2 shows that “offer of information/explanation” was the mostly expressed category of Yelland’s revised typification and “offer of a proposal” the least used.

Mercer’s model was another conceptual tool for analyzing and interpreting the cognitive dimension of children’s talk around computers. Besides the 3 distinct types of talk he typified, we propose a forth category named “off-task activity”. It is used to describe a situation in which children’s talk or activity does not focus on the problem-solving task of the game, e.g. playing around, discussing break time and afternoon off-school activities, “absent minded” activity (figure 3).

For all pairs, a Friedman test demonstrated extremely significant differences in the number of occurrences of Mercer’s types of talk ($\chi^2=30.80$, $p=0.0001<0.05$). Figure 3 demonstrates the differences in the types of talk children used to solve the task. It is evident that mixed pairs’ talk is characterized by individual decision making and children tend to have more arguments than boy- and girl-pairs. It is also clear that children assigned to the mixed pair condition tend to build positively but uncritically on what the other partner has said. Their talk is characterized by many repetitions, confirmations and elaborations. The distribution graph shows that children assigned to the boy- and girl-pair conditions engage critically but constructively with their partner’s ideas, whereas children in the mixed pair condition do not (3%). Finally, the graph demonstrates that girl-pairs’ talk tends to be off-task; girls sometimes do not focus on the task, instead they talk about what they did the previous day, about their clothes and their toys.

**Figure 3**: Distribution graph showing the number of occurrences of each type of talk according to Mercer’s model for boy-, girl- and mixed-pairs.

For **boy pairs**, a Friedman test demonstrated no significant differences in the number of occurrences of Mercer’s types of talk ($\chi^2=6.35$, $p=0.096>0.05$). In 2/7 boy pairs the verbal communication between the two boys was not evident, while the rest exhibited continuous verbal interactions that reinforce the collaboration (Johnson et al., 1990; Hymel et al., 1993). In the low interaction pairs, the boy who had mouse control tried to solve the task without addressing to his partner for help and feedback. The boy who had no mouse control made no effort to involve in the task. Instead, he was passively watching, while another boy complaint he also wanted to play but his partner would not let him.

For **girl pairs**, a Friedman test demonstrated significant differences in the number of occurrences of Mercer’s types of talk ($\chi^2=11.44$, $p=0.01<0.05$). When girl pairs exhibited
interaction, it was expressed as mutual help, feedback, support and encouragement, but also as a recall of the goal of the game when one of the members was on the verge of showing fatigue. However, girls were in general reluctant to help their partners with ideas on how to come up with a solution. A girl after making great effort, addressed to her partner for help because she was unable to find a solution. The following excerpt shows Penelope’s unwillingness to help her partner, whereas Maria-Katerina constantly seeks for help:

Maria-Katerina (MK) and Penelope (P) (6 years old)
- MK: Take the mouse, I got tired!
- P: (no correspondence)
- MK: Come on, take it! Try something!... Try...
- P: Yes!
- MK: I want you to play a lot, a lot, a lot... What happened? Are you tired?... Try a little bit, because...Do something!!!
- P: (she takes control of the mouse)
- MK: Do something! You don’t do anything!!!

For mixed pairs, a Friedman test demonstrated significant differences in the number of occurrences of Mercer’s types of talk ($\chi^2=16.74$, $p=0.001<0.05$). Cumulative was the dominant type of talk when mixed pairs discussed about the problem-solving activity and exploratory was the least expressed. Mixed pairs exhibited unwillingness to participate in the game, either because their partner was indifferent to their presence or due to fear and shame. Even though in some pairs children made great effort to approach their partner and give them instructions, children who possessed the mouse were indifferent and unwilling to include their partner in the whole process. Only one pair exhibited rich verbal interaction in the form of mutual help, support and encouragement, offer of information and knowledge.

The discussion patterns in this study were similar for boy-, girl- and mixed pairs. However, the results concerning Mercer’s model revealed significant differences for mixed pairs across collaborative condition, while the results for boy- and girl-pairs did not. This may be partially attributed to the small sample size gathered but it also suggests that girls and boys may interact differently when they are asked to play with a partner of the opposite sex. Table 1 illustrates an example of children’s continuous discourse according to Yelland’s and Mercer’s model.

Table 1: Leonidas and Ioannis exhibit same numbers in the “offer of information/explanation” and in the “offer of a proposal” (Yelland’s revised typification). Their talk is characterized “exploratory” (Mercer’s typification; M1=disputational talk, M2=cumulative talk, M3=exploratory talk, M4=off-task activity).

<table>
<thead>
<tr>
<th>Actor</th>
<th>Time</th>
<th>Verbal contributions</th>
<th>Practical contributions</th>
<th>Yelland’s Typification</th>
<th>Mercer’s Typification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y1 Y2 Y3</td>
<td>M1 M2 M3 M4</td>
</tr>
<tr>
<td>L</td>
<td>00:09</td>
<td>Take the lens…</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>L</td>
<td>00:13</td>
<td>Place it there!</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>00:14</td>
<td>He is showing him where in the playing screen.</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>00:17</td>
<td>What we’ll we…?</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>What we’ll we do with that now?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>00:18</td>
<td>I figured it out!</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>00:19</td>
<td>Over here we haven’t placed any lens because…</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>00:20</td>
<td>We should place lens here because a</td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
reflection will be made…

L 00:21 Because it will fly and it will… 1
L 00:22 He gets up and explains what he should do by pointing on the playing screen. 1
L 00:38 Don’t move it back there? 1 1
L 00:39 He is still stand-up. 1 1
L 00:40 The lens, the lens, the lens… He is stand-up and shows him on the playing screen which lens to take. 1 1
I 00:43 Awesome! It took off! 1 1
L 00:45 The lens now? 1 1
L 00:52 Further down… 1
L 00:53 He is pointing where in the screen. 1
L 00:54 …so as to be the same! 1
I 00:55 The lens? 1 1
L 00:57 Yes, there! 1
I 00:59 Now? What shall we do now? 1
L 01:00 Clicks on the mouse with his finger (touch method). 1 1
I 01:01 Great! 1 1

Finally, in our study children were rarely referring to the dyad; a conclusion coming in contrast to that of Beaumont et al. (1997). This suggests that children may not have viewed the task as a cooperative task. There were pairs of children that would refer to themselves for solving the task (“I did it!!!”, “Yes, I finally made it!”, “I made it, not you!”), overlooking the fact that their partner had contributed an equal share to the game. In other pairs, children were aware that they made no equal contribution and realized that the solution was their partner’s accomplishment. Apparently, that happened because the child had mouse control at that specific moment. Finally, when children referred to the dyad, it occurred because they had both contributed equally in completing the task. The following excerpt describes the girls’ egocentricity and antagonism towards her partner. Helen possessed the mouse during the whole session, while Sotiris made no effort to take mouse control, or a verbal intervention for the task solution. When Helen completes the task, Sotiris ascertained her accomplishment by saying: “All hot-air balloons took off!!!” while she replies: “I made it!!!” to declare her achievement.

3.1.3 Mouse Sharing

Casual observations indicated that sharing the mouse was a problem for all pairs. As mentioned in Section 1, they are characterized by the number of exchanges, requests and refusals. An exchange could occur without a partner initiating a request, or a series of requests could result in only one exchange or refusal. Therefore, there was no direct mapping between the number of exchanges, requests, and refusals. Figure 4 shows a summary of the number of exchanges, requests and refusals for all pairs.

For all pairs, a Friedman test demonstrated significant differences ($\chi^2=13.82$, $p=0.001<0.05$) in their mouse sharing behaviors. For boy pairs, a Friedman test also demonstrated significant differences in the number of occurrences of children’s mouse sharing behaviors
The number of mouse exchanges, requests and refusals varied between boy pairs. Four pairs exhibited low occurrences of exchanges (0, 1 and 4 exchanges), while 2 pairs had a higher number of exchanges (59 and 65 exchanges). Four pairs exhibited an average of 10 requests, while 2 pairs had higher occurrences of requests (65 and 76 requests). The number of refusals was similar across 4 pairs (average 8 refusals), but 3 other pairs had over 19 refusals during their session.

For girl pairs, with $\chi^2=6.00$, $p=0.050$ considered marginally significant. All girl pairs exhibited similar mouse sharing behaviour in terms of the number of mouse exchanges between the two partners. The number of requests was also similar across 3 pairs (average 12 requests), while 3 of the other pairs had a higher number of requests (31, 33 and 37 requests). However, only one girl pair exhibited the highest number of requests (70 requests). The number of refusals for each pair varied more, with 4 pairs having none, one, three, or five refusals but 2 other pairs had higher occurrences of refusals (22 and 32 refusals).

Respectively for mixed pairs, with $\chi^2=2.71$, $p=0.257>0.05$, considered non-significant. Mixed pairs demonstrated three different sharing patterns just like boy pairs. Four of the pairs made no requests and no refusals, while 1/4 made only one exchange. Therefore, little interaction between the partners, implying the low levels in their sharing patterns. Two of the other pairs had a large number of exchanges, requests and refusals, while the final pair had a very high number of exchanges, requests and refusals, suggesting that both children were active but that contention occurred over sharing the mouse.

![Figure 4: Summary of the number of exchanges, requests and refusals for boy-, girl- and mixed-pairs.](image)

For boy pairs, a Friedman test demonstrated significant differences in the number of occurrences of each category of requests ($\chi^2=8.72$, $p=0.033<0.05$). *Verbal* was the dominant method for requesting mouse control. Casual observations indicated that 3 boy pairs encountered problems in the mouse sharing. In cases in which the boys exhibited equal sharing patterns, mouse control was transferred from one boy to another because they were incapable, implying they needed their partners help.
For girl pairs, a Friedman test demonstrated no significant differences in the number of occurrences of requests ($\chi^2=3.45$, $p=0.328>0.05$). Verbal was the dominant method for requesting mouse control. Mouse sharing caused problems between the two girls during the task. Frequently, girls either fought over the mouse or asked one another who would take control before the game started. Some pairs had strong disputes during the game and in order to stop quarreling, girls would impose terms on how to play. Others demonstrated different patterns and after short quarrels, could find out a way in which both had mouse control by placing their hands on it and doing all the necessary actions together. As in boy pairs, when equal sharing patterns were observed, mouse control was transferred from one girl to another because they were incapable, implying that they needed their partners help.

For mixed pairs, a Friedman test demonstrated no significant differences in the number of occurrences of requests, $\chi^2=3.62$, $p=0.305>0.05$. Touch was the dominant method for requesting mouse control. Children were not quarrelling; however, boys and girls were reluctant to take mouse control or even request it from their partner. One team exhibited equal sharing patterns and requests to show they wanted the mouse. As in girl pairs, children tried to sort out their problems by having both their hands on the mouse. In another team, while the girl initially had mouse control, after a while she realizes her partner has not played and passes control to the boy without having asked for it. At first the boy was reluctant, but eventually he takes mouse control. Finally, mostly boys had mouse control during the session, with an exception to a team in which the girl had the mouse till the session ended. Even though her partner made a no-contact request, she would “protect” the mouse by moving it towards her. Table 2 illustrates how children fought over the mouse.

Table 2: Natasha and Asimina fighting over mouse control ($E=$exchanges, $R_1=$requests, $R_2=$refusals, $NC=$no-contact method, $V=$verbal method, $T=$touch method, $P=$pull method).

<table>
<thead>
<tr>
<th>#</th>
<th>Actor</th>
<th>Time</th>
<th>Verbal contributions</th>
<th>Practical contributions</th>
<th>Inkpen’s Mouse Sharing Behaviors</th>
<th>Inkpen’s Methods Requesting the Mouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>A</td>
<td>01:08</td>
<td>Hey!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>A</td>
<td>01:08</td>
<td>She is upset and takes her hand off N’s hand.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>A</td>
<td>01:09</td>
<td>Leave it!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>A</td>
<td>01:09</td>
<td>Touch method to take mouse control.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>N</td>
<td>01:10</td>
<td>Wait.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.2 Analysis of the Collaborative Behaviors assessed through the Structured Interviews

The structured interviews indicated children’s attitudes towards the collaborative task. In the question “Did you like playing with another child? Why?” all children answered “Yes”, showing their strong preference towards the task. 13/42 children reported they liked it because their partner was their friend, 12 because they had help and 10 stated they had fun because they had company. In a question regarding the difficulties they faced, a 33.33% declared they had no difficulties. 11.9% reported important difficulties that dealt with their collaboration and 21.43% mentioned difficulties in manipulating the objects, particularly in clicking the ball due to its small size (Table 3).

Table 3: Reasons for preferring the collaborative task and difficulties that occurred during the task.(right).

<table>
<thead>
<tr>
<th>Reason</th>
<th>Frequency</th>
<th>%</th>
<th>Reason</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>He/She was my friend</td>
<td>13</td>
<td>30.95</td>
<td>No difficulty</td>
<td>14</td>
<td>33.33</td>
</tr>
<tr>
<td>I had company</td>
<td>10</td>
<td>23.80</td>
<td>He/She wasn’t giving me the mouse</td>
<td>5</td>
<td>11.90</td>
</tr>
<tr>
<td>I had help</td>
<td>12</td>
<td>28.57</td>
<td>Manipulating objects</td>
<td>9</td>
<td>21.43</td>
</tr>
<tr>
<td>He/She let me play</td>
<td>1</td>
<td>2.38</td>
<td>Hot-air balloons wouldn’t fly</td>
<td>8</td>
<td>19.04</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>11.90</td>
<td>Other</td>
<td>5</td>
<td>11.90</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>2.38</td>
<td>No response</td>
<td>1</td>
<td>2.40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42</strong></td>
<td><strong>100.0</strong></td>
<td></td>
<td><strong>42</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Furthermore, figure 6 (left) illustrates children’s preferences playing whether alone or with a partner in the computer. A 52.38% of the boys prefer playing alone, while a 33.34% prefer...
having company. For girls, the percentage of playing either alone or with a friend is the same (42.86%). There were also 3 boys and 3 girls that preferred both. Finally, a 38.09% of the boys prefer playing with boys, while a 57.14% prefer playing with girls. A high number of girls, 66.67%, prefer playing with boys, while a quite small percentage, 28.57% prefer playing with girls. This result comes in contrast with the finding that the mixed pairs exhibited poor collaboration.

Figure 6: Children’s preferences playing either alone or with a friend, or with a boy or a girl (right).

4. Conclusion

Our study aimed at identifying and evaluating preschool children’s expressed collaborative behaviours that appear during their effort to complete a computer mediated activity. These behaviours were related to the quality and the type of talk emerging from their engagement in the problem-solving task. They were also related to their mouse sharing behaviours when only one mouse was available for completing the task.

Video analysis revealed that boys and girls interact differently in various collaborative game conditions. Close monitoring and observation revealed rich dialog implying that children engaged in detailed discussions about how to solve the puzzle in the game and sharing ideas. This is an important ascertainment, since the discussion of thoughts and ideas should be an integral part of the learning process. Verbal interactions had the form of mutual help, feedback, encouragement, offer of information and knowledge. Children’s problem-solving behaviors towards the collaborative task according to Yelland’s revised typification revealed significant differences for all pairs. “Offer of information/explanation” was the dominant type children used to complete the task. Statistically significant differences were also demonstrated in the types of talk the they used according to Mercer’s model. The discussion patterns found in this study were similar for all pairs. However, the results for girl- and mixed-pairs demonstrated significant differences. Mixed pairs exhibited poor verbal communication and their talk was characterized by individual decision making. This observation is consistent with Howe (1997) reporting that mixed groups are associated with reduced talk, social withdrawal, resentment and male dominance. Children assigned to the mixed pair condition tend to have more arguments than boy- and girl-pairs. On the contrary, Guntermann &Tovar (1987) found that mixed pairs are not associated with high levels of antagonism. Our results revealed that mixed pairs tend to build positively but uncritically on what the other partner has said. However, boy- and girl-pairs engage critically but constructively with their partner’s ideas. Finally, girl pairs’ talk tends to be off-task. The aforementioned results suggest that girls and boys interact differently when they are asked to play with a partner of the opposite sex. Besides this, dialogue was less important for learning in mixed pairs than in same-sex pairs, indicating that the former were compensating for their discomfort by learning from the software and not from each other. Likewise, Howe (1997) claimed that single-sex pairs talk more in computer environments than mixed pairs. However, this outcome may be partially attributed to the small sample size that was gathered.
Children’s mouse sharing behaviors demonstrated significant differences for all gender pairs. Our results revealed there was no direct mapping between the number of exchanges, requests, and refusals. Boy- and girl-pairs exhibited the highest numbers of exchanges, requests and refusals, in contrast to mixed pairs that exhibited the lowest. This finding suggests that same-sex pairs tend to exchange and request mouse control and refuse to pass it through more often than pairs of the opposite sex. Significant differences were also revealed in the methods they used to take mouse control. Boy pairs requested the mouse physically from their partner (pull method), indicating antagonism and tension in all-male groups. Girl pairs would ask their partner if they could have the mouse (verbal request). While, mixed pairs would touch their partner’s hand to signify they wanted the mouse (touch method), indicating the lack of social contact.

In addition, in our study children were rarely using group language, which mostly happened in girl- and mixed-pairs; suggesting that children may not have viewed the task as a cooperative task. This fact illustrates that children may not have created a spirit of collaboration.

In conclusion, our results support findings of other researchers, which indicate boys’ and girls’ various interaction styles with computers (Abnett et al., 2001; Hall, et al., 1991; Hoyles & Sutherland, 1989; Inkpen, 1997b; Scott et all, 2003; Wilder et al., 1985; Yelland, 1995). In general, these results emphasize the importance of understanding how each gender interacts with computers so as not to exclude any children; also, the need to be aware of gender differences when researching design issues related to children’s use of computers. Besides, these implications stress the importance of designing flexible hardware and software and it is imperative that the products developed do not promote the negative stereotypes of either gender. We believe that by designing gender-aware technologies, we will be able to bring children together to understand their differences.

Even though children enjoyed the game and had fun with their peers, mouse sharing appeared to cause difficulties in some pairs. As proposed by Edwards (2005), the factor of self-selecting groups on the basis of friendship may eliminate children’s conflicts and support their collaboration, because they feel more secure with friends and so become more active in novel problem-solving situations. At the same time, our results demonstrate that children need to develop collaborative behaviors either in on- or off-computer tasks. A future goal is to replicate the aforementioned context of the study with different open problem-solving environment and subsequently study the outcome using techniques such as task modeling (Tselios & Avouris, 2003). Furthermore, we propose the addition of a second mouse in the computer (Inkpen, 1997a) to further investigate the impact of this change on children’s collaborative behaviors, having ensured the potential for individual exploration and equal collaborative opportunities.

Finally, our findings provide evidence that computers can have a distinctive role for supporting group activity and the development of children’s talk. However, children need to be helped to understand how to use language as a tool for thinking together. It is therefore important to have a clear idea of what is expected of them, in order for successful learning to take place. We argue that the quality of interactions in classroom has to be improved by a method of teaching and learning that focuses on enabling children to participate effectively in dialogues with their peers and with their teachers (Wegerif et al., 2004). It is our hope that in the future more authentic mathematical learning scenarios will be created to provide opportunities for young children to engage in active learning, inquiry and problem-solving, and thus to support joint activity and stimulate collective thinking.

References


