Conceptual change in science is facilitated through peer collaboration for boys but not for girls

Patrick J. Leman[1]

Yvonne Skipper[1]

Dawn Watling[1]

Adam Rutland[2]

[1] Department of Psychology, Royal Holloway, University of London

[2] Department of Psychology, Goldsmiths, University of London

Abstract

Many studies have demonstrated the learning benefits of peer collaboration, but surprisingly little research has considered how gender influences the dynamics of interaction and learning outcomes in Science. In the present study, same-sex pairs of boys and girls aged 9 years (N=499) engaged either in a series of science collaboration tasks, a series of free play tasks, or did not interact with a partner. All children who collaborated on the Science tasks advanced in basic level understanding of the relevant task (motion down an incline). However, only boys showed advances in conceptual understanding at a three week post-test. Analysis of pairs' conversations indicated that boys' pairs included more behavioral assertion and also more discussion of conceptual ideas than girls' pairs. Results are discussed in terms of the links between gender, behavioral style, and the development of conceptual knowledge through peer collaboration.

Conceptual change in science is facilitated through peer collaboration for boys but not for girls

Studies have consistently demonstrated that peer collaboration facilitates learning in science (e.g., Howe, 2009; Phelps & Damon, 1989). However, relatively little research has sought to explore how far these benefits are influenced by gender (Leman, 2010). The lack of research into gender and collaborative learning in science is surprising for at least two reasons. Firstly, gender has a profound influence on children's interactions and conversation dynamics from a young age (Leaper & Smith, 2004) and it is important to establish whether this influence extends to the effectiveness of interaction in promoting learning. Secondly, gender differences in achievement and participation in science (e.g., Halpern, Benbow, Geary, Gur, Hyde, & Gernsbacher, 2006) suggest a need to examine how far the talk that children produce when learning science reflects or contributes to these broader societal differences (Nosek et al, 2009).

Subtle messages about the association between gender and science are communicated and learned by children through their interactions with others. For instance, Tenenbaum and Leaper (1999) found that fathers used more challenging, conceptually-based scientific language with sons than with daughters (daughters, in contrast, tended to be asked more challenging questions about interpersonal dilemmas). From a developmental perspective, findings from parent studies are important because early and informal experiences are likely to serve as the basis for children's future engagement with a discipline: if parents ask more demanding questions of sons than daughters this may stimulate greater conceptual understanding and, as a consequence, boys may develop more interest in science (Crowley, Callanan, Tenenbaum, & Allen, 2001).

Parent-child talk frames children's early experiences. However, in peer talk children may be freer to adopt different roles and subscribe to own gender norms on their own terms, or may experience ideas and attitudes that differ from those of their parents. In peer relations children can reproduce and construct gender norms for themselves (Duveen & Lloyd, 1992). In other words, peers are important socialising agents and the extent of peer influence is arguably more marked at school than at home (Schibeci, 2006).

From early childhood gender influences conversation dynamics. Girls’ conversations tend to be more affiliating and boys’ conversations more dominance-oriented (Leaper & Smith, 2004). Gender affects conversation content too. Girls focus more on relational concerns, while boys focus more on action (e.g., Leaper, 1991). These socialised styles are further ingrained by gender “cleavage” in social relationships with both boys and girls interacting more and more frequently with same-sex peers from preschool onwards (Smith, Davidson, & Ball, 2001).

As previously discussed, fathers engage in Science conversations differently with sons and daughters (Crowley, et al., 2001 and this can impact children’s learning. However, it remains unclear whether gendered conversation differences between peers also affect learning. For instance, Leman and Björnberg (2010) found that although boys and girls engaged in very different styles of discussion, 9 year olds progressed equally, regardless of gender, on a moral judgment task. Other studies (e.g., Johnson, Johnson, Scott, & Ramolae, 1985; Leman, Ahmed, & Ozarow, 2005; Zapiti &Psaltis, 2012) have found similar results across childhood, suggesting that gender differences in conversations matter relatively little in terms of developmental progress through collaboration (Howe, McWilliam, & Cross, 2005). However, previous studies have examined unitary learning outcomes of interaction (i.e., pre- to post-test change on a single dimension). In the present study, we sought to establish whether girls and boys reproduce differences in the level of conceptual language in same sex interaction that have been identified in parent-child interactions.

We compared the pre- and posttest performance on Science tasks of (a) children who had interacted with a same sex peer on a science task, for three 10 minute sessions over the course of a week, (b) children who had interacted with a same sex peer on a non science-related, puppet play task, and (c) a no interaction control group. We then analysed the characteristics of interactions and content of the conversations of children who had engaged in the science task, comparing the interaction dynamics and contents of boys' and girls' conversations.

In light of previous research we proposed four hypotheses. First, we expected that children who engaged in interaction on science tasks would show improvement in performance at posttest on both basic and conceptual tests of understanding compared with the play and no interaction groups. Secondly, we predicted that there would be no difference in pre- to posttest performance comparing boys and girls who had engaged in Science collaboration. Thirdly, we expected gender differences between boys and girls pairs in the behavioral dynamics, but not the content of conversations: we predicted that girls pairs would be more affiliating and boys pairs more assertive when engaged in discussions about Science. Finally we predicted no differences in conversation content (i.e., what children discussed relating to the Science task).

Method

Participants

Children (N=499) were recruited from five primary schools in a large metropolitan area of South East England. Children were in their fifth or sixth year of formal schooling, average age 9 years (248 boys and 251 girls). The sample was drawn from an area of high ethnic diversity and most children came from families with lower than average incomes. Previous research has demonstrated that ethnicity has an influence on interaction dynamics and that ethnicity can also interact with gender in interactions (Leman & Lam, 2008). Therefore we decided to include, in the present analysis, only children from the majority (white European) and principal minority (South Asian) ethnic groups. We also sought carefully to balance the ethnic mix of pairs such that there were roughly equal numbers of all-white, all-Asian, and mixed ethnic pairings. The sample thus included N=160 white European children and N=339 South Asian children. South Asian children include those of Indian, Pakistani, Sri Lankan and Bangladeshi descent. Most are second generation British Asians (i.e., the children of immigrants to the United Kingdom).

Materials

Children all completed the pre-test of basic and conceptual Science knowledge. Children were then split into one of three groups and either did not participate in the interaction phase or interacted with a same-sex partner on either Science tasks or puppet play tasks. Following the three interactions, children completed a post-test examining their Science knowledge. In addition, around three weeks later they completed a similar delayed post-test of Science knowledge.

Interaction tasks

The aim of the Science interaction tasks was to increase children's understanding of how four variables of gradient, weight, starting point and surface material could impact motion down an incline. On the first interaction day children worked together on two computer based tasks, each examining the impact of two of the aforementioned variables on the motion of a truck down an incline. Children were given a five minutes to experiment with each task and to complete a worksheet which asked about the impact that each variable had individually and also how the two variables interacted to influence how far the truck travelled. Children were also asked to give reasons for their answers.

On day two children were presented with a ramp and a truck which they could experiment with. The ramp could be manipulated allowing them to experiment with all four variables simultaneously. Children were given a chance to experiment and completed a worksheet which asked which combination of all four variables led the truck to travel furthest and the reason why they thought this was so.

On the final day children watched a short video which showed a scientist who had invented new skis. He was testing the skis to ascertain whether they were faster than traditional skis. Children watched the video and then answered questions designed to test whether they could transfer the knowledge of the truck tasks to a different context, for example, they were asked about which variables he would need to keep the same to make sure he was conducting a fair test.

Children in the play condition were asked to make up a play with a focus on teaching on both days. On day one children were given the scenario that one animal puppet was new to the jungle and the other was teaching him/her about their new home. On day two children were given a school scenario where one puppet was the teacher and the other was the pupil and they were going to have a day at school. On the final day children were told that it was one puppet's birthday and that they were going to have a birthday party. On both days children chose a puppet each and worked together making up the play for ten minutes.

Children in the control group did not interact with a partner, but completed the Science quizzes.

Science knowledge

Materials consisted of a Science quiz which tested both basic and conceptual knowledge of how the four variables of gradient, weight, starting point and surface material could impact motion down an incline. To test children's basic Science knowledge they were presented with each variable individually, for example they were shown a picture of a truck at the top of a hill and one in the middle of a hill. They were then asked to indicate which truck would travel the furthest.

To test children's conceptual knowledge they were presented with an example truck showing each of the aforementioned four variables, for example a truck at the top of a steep hill, covered in carpet with no weight in the back. Children were shown how far it would travel along a scale positioned at the bottom of the hill. The example always showed that the truck would travel to the middle of the scale. Children were then presented with a number of pictures of the truck and asked to predict how far it would travel. In these questions at least two factors were changed from the example. However, we developed three different versions of the test each featuring a different example truck so the test was slightly different at each of the three time points.

Procedure

Consent was obtained from teachers, parents and children to take part in the study. On the first day, all children in the class completed the pencil and paper Science quiz. The following day, children whose parents had consented to their participation in the interaction phase were put into pairs to work on either the Science tasks (N=160) or the play tasks (N=158). All pairs were single gender, (69 pairs of boys and 85 of girls). Additionally we sought carefully to balance the ethnic mix of pairs as far as the sample allowed, there were N=34 all-white, N=82 all-Asian and N=44 mixed ethnic pairings.

On the second and third days children worked with the same partner as on the first day for ten minutes to complete either the play or Science tasks. Those who did not participate in the interaction phase formed the control group. On the final day all children then completed another Science quiz. Finally approximately 3 weeks later children completed the Science post-test. Once they had completed the study the children had the aims of the study explained to them and were also given a small gift to thank them for their participation.

Conversation measures

Conversation content

In order to establish children's use of different categories of explanation (conversation content) two coders reviewed all conversations in order to identify how many times each participant made reference to one of four different categories of explanation. Table 1 gives descriptions of the measures of conversation content. A count was made each time an instance of a category was made. The categories were developed from a prior thematic analysis of conversations and were a comprehensive reflection of children's talk on the topic. In instances where two categories were combined in one utterance (e.g., "Put the carpet on because it is more bumpy") a code was given for each category represented (in the above example, procedural and basic).

Behavioral style

We established the levels of assertion and affiliation in conversation using Leaper's (1991) Psychosocial Processes Rating Scheme (PPRS). This involved separately rating each participant's behavior at regular intervals (every 30 seconds) on two seven-point scales where 1 represented the lowest levels of assertion and affiliation, and 7 the highest levels. Assertion in conversation includes verbal and nonverbal measures and ranges from unassertive (i.e., nondirective behavior such as sitting passively) to highly assertive behavior (i.e., strong disagreement or aggression). Affiliation ratings ranged from unaffiliative (i.e., ignoring or rejecting another child) to highly interdependent behaviour (i.e., clear cooperative activity).

**** researchers coded an approximately equal number of conversations each. Again, reliability was established by comparing a similar proportion of each coder's ratings with a second, independent rater (altogether, *** conversations or ***% of the sample). Agreement between coders was *****.

Results

Science learning from pre- to post-test

Basic level knowledge

In order to examine differences in progress from pre- to post-test, a change score was calculated by subtracting scores at time 1 from scores at time 3. The subsequent repeated measures ANOVA examining the impact of task on basic Science knowledge suggests that children who did the science tasks improved more than those who were in the play and control groups $F(2,418)=8.25$, $p=.000$. Follow up Bonferroni corrected comparisons indicated that differences between science and play were significant $t(283)=3.48$, $p=.001$ differences between science and control were also significant $t(279)=3.67$, $p=.000$. Differences between play and control were not significant $t(280)=.47$, $p=.641$. See Table 2. We also examined differences between boys and girls in the Science condition but found no differences in basic science knowledge. That is, after engaging in science collaborations both boys and girls showed similar improvements in basic level knowledge.

Conceptual level knowledge

To examine changes in conceptual knowledge, a difference score was calculated, subtracting children's scores on the conceptual measures at pre- and post-test. A repeated measures ANOVA examining the effects of task on children's conceptual science learning showed a significant interaction between time and task, $F(2,395)=5.66$, $p=.004$. Children who did science tasks showed greater improvements over time compared to the children who played together or those who did not interact. Follow up corrected comparisons indicated that differences between science and play groups were significant $t(264)=-2.09$, $p=.038$ as were differences between science and no interaction, $t(268)=-2.98$, $p=.003$. However, differences between play and no interaction were not significant $t(264)=-.97$, $p=.334$, see again Table 2.

Once again, we explored gender differences within the science condition. Analysis of the difference score revealed that boys showed greater improvements than girls in their conceptual knowledge after collaborating on science tasks, $t(133)=-2.40$, $p=.018$. A related t-test indicated that between pre- and post-test boys showed improvement on the conceptual questions $t(56)=3.24$, $p=.002$, whereas girls did not, $t(77)=.502$, $p=.617$.

Analysis of gender differences in conversations

Children's interactions on the Science tasks were video recorded allowing coding of their conversations. Interactions were coded in terms of both the content of discussion and the interaction style. In terms of content, interactions were coded to ascertain how many interactions involved procedural (how to do the task), basic (the impact variables had independently) conceptual (the interactions between variables) applied (a discussion of the variables in a real-world context) and social (off topic discussions). The number of each of these types of interactions was coded. Additionally, Leaper's (1991) scale was used to code how assertive and affiliative each interaction was every thirty seconds. An average score of assertion and affiliation was then calculated for each pair across each day allowing examination of differences in interaction styles.

A series of independent t tests was conducted to examine gender differences in conversational content. Although the majority of interaction revolved around procedural discussions, the analysis revealed only one significant gender difference, with boys using more conceptual explanations than girls (see Table 3). A marginal result suggested that boys engaged in more applied discussions. In terms of behavioral style, boys were marginally more assertive than girls.

Conversation predictors of science learning

In order to examine conversation predictors of learning, two linear regression analyses were performed on the change (i.e., post-pre-test) scores on basic and conceptual responses respectively. All conversation content and behavioural measures were included in the model. Gender was also included. The regression analysis for changes in basic level scores did not produce a significant model, R square = .050; $F(7,136) = .97$, $p=.458$ (using the enter method).

However, the analysis for changes in conceptual level was significant, R square = .144; $F(7,129) = 2.93$, $p=.007$ (enter method). Less use of basic talk significantly predicted change in conceptual scores, $\beta=-.22$, $t(129)=2.30$, $p=.023$. Related to this, greater use of conceptual talk significantly predicted improvement in conceptual scores, $\beta=.23$, $t(129)=2.64$, $p=.009$. Finally, greater levels of behavioural assertion in conversation also predicted conceptual change, $\beta=.20$, $t(129)=2.25$, $p=.026$.

Discussion

The present study examined gender differences in children's peer collaborations and the consequences of those collaborations in terms of science learning. We hypothesised that children who engaged in a series of collaborations on a science task (understanding motion down an incline) would show greater advances in scientific knowledge than children who engaged in a similar period of peer play, or who did not engage in any interaction. This first hypothesis was confirmed, and fits the majority of findings in the area that demonstrate that peer interaction promotes learning (e.g., Howe, 2009; Phelps & Damon, 1989). We also tentatively predicted no gender differences between basic level and conceptual level learning. However, whereas both boys and girls progressed on basic level understanding, only boys showed significant improvement in conceptual level understanding. It is important to note that, at this age at least, boys and girls do not differ in their performance in classroom science tests (e.g., Shepardson & Pizzini, 2010). So it would be an error to assume that girls are somehow less equipped to grasp conceptual aspects of science problems. Rather, in our study, collaboration was effective only in helping the girls to learn basic level information, whereas it helped the boys to learn basic and conceptual level information. Thus conceptual development for girls may occur more often through independent study or teacher-led learning (e.g., Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012).

Having established that girls' and boys' advance differently in terms of conceptual understanding through collaboration, an obvious question is whether aspects of girls and boys conversations are associated with this difference. Our results suggested gender differences in behavioral dynamics. Boys were slightly more assertive in their interactions with one another, which is consistent with a good deal of previous research that identifies male conversations as more dominance oriented (e.g., Maccoby, 1990). Girls were marginally more affiliative which, again, fits some previous studies (e.g., Leman et al., 2005). Thus, broadly, our second hypothesis was confirmed regarding behavioural aspects of interaction. However, we also predicted no gender differences in the content of conversations, and this was not confirmed. Specifically, boys used more conceptual level language in their interactions than girls.

In some respects the present findings are somewhat unsurprising: boys talk more about conceptual aspects of the tasks and as a consequence they develop better conceptual understanding. Many other researchers have found a similar link between conceptual talk and development (e.g., Mercer, Dawes, Wegerif, & Sams, 2004; Millar, Lubben, Got, & Duggan, 1994). However, results from our regression analyses indicate that both use of conceptual language and behvioral assertiveness are associated with development of conceptual understanding. Correspondingly, less use of basic language was also associated with development of conceptual knowledge (suggesting that not only more talk, but a greater focus on concepts as a proportion of a conversation, are important).

An important feature of the present results is that both behavioral dynamics and the content of conversations predict conceptual learning. It has previously been argued that dialectical argumentation leads to learning through collaboration, whereas consensual argumentation does not (e.g., Asterhan & Schwarz, 2009; Howe et al., 2005). If so, it may be that our findings reflect a matching of behavioral characteristics associated with gender and contrasting conversational styles that align with dialectical (boys') and consensual (girls') respectively. For instance, Linn and Hyde (1989) have suggested that women's styles of learning are better adapted to cooperative learning environments, whereas men's more adapted to combative environments.

In this respect, boys' greater assertiveness and pursuit of dominance in interaction may act against reaching consensus, but leads to conflict and in turn a greater exploration of contrasting conceptual aspects of a problem (see Chan, 2001). Girls, in contrast, seek more consensual conversations and less conflict, hence conversations focus more on surface level discussion aimed at solving the problem at hand. Thus conflict (or socio-cognitive conflict; Doise, Mugny & Perret-Clermont, 1975) is more a feature of boys' socialised conversational styles and, in turn, stimulates more consideration of conflicts between perspectives and conceptual level understanding on science tasks, such as these.

Understanding the interplay between the behavioral dynamics and content of conversations is therefore crucial to explain the developmental benefits that arise from collaboration (Psaltis, Duveen, & Perret-Clermont, 2009). While girls' conversational styles may be oriented towards achieving cooperation and consensus, boys' interaction styles may be better suited to learning certain types of information through collaboration because greater conflict and disagreement stimulates a deeper exploration of underlying concepts.

References

Asterhan, C. S. C., & Schwarz, B. B. (2009). The role of argumentation and explanation in conceptual change: Indications from protocol analyses of peer-to-peer dialogue. *Cognitive Science, 33,* 373-399.

Chan, C. K. K. (2001). Peer collaboration and discourse patterns in learning from incompatible information. *Instructional Science, 29,* 443-479.

Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science, 12,* 258–261.

Doise, W., Mugny, G. & Perret-Clermont, A.-N. (1975). Social interaction and the development of cognitive operations. *European Journal of Social Psychology*, 5, 367-383

Duveen, G., & Lloyd, B. (1992). *Gender identities and education*. London: Harvester Wheatsheaf.

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, A. M. (2007). The Science of Sex Differences in Science and Mathematics. *Psychological Science in the Public Interest*, *8*, 1-51.

Howe, C. (2009). Collaborative group work in middle childhood: Joint construction, unresolved contradiction and the growth of knowledge. *Human Development*, 39, 71-94.

Howe, C. (2010). Peer dialogue and cognitive development. A two-way relationship? In K. Littleton & C. Howe, *Educational dialogues: Understanding and promoting productive interaction* (pp. 32-47). London: Routledge.

Howe, C., McWilliam, D. and Cross, G. (2005). Chance favours only the prepared mind: incubation and the delayed effects of peer collaboration. *British Journal of Psychology*, 96, 67-93.

Howe, C. J., Tolmie, A., & Rodgers, C. (1992). The acquisition of conceptual knowledge in science by primary school children: group interaction and the understanding of motion down an incline. *British Journal of Developmental Psychology, 10,* 113–130

Johnson, D., Johnson, R., Scott, L., & Ramolae, B. (1985). Effects of single sex and mixed sex co-operative interaction on science achievement and attitudes and cross handicap and cross sex relationship. *Journal of Research in Science Teaching, 22,* 207–220

Leaper, C. & Robnett, R. D. (2011). Women are more likely than men to user tentative language, aren't they? A meta-analysis testing for gender differences and moderators. *Psychology of Women Quarterly, 35,* 129-142.

Leaper, C., & Smith, T. E. (2004). A meta-analytic review of gender variations in children's language use: Talkativeness, affiliative speech, and assertive speech. *Developmental Psychology, 40,* 993–1027.

Leman, P. J. (2010). "Gender, collaboration, and children's learning," in K. Littleton & C. Howe (Eds). *Educational Dialogues: Understanding and Promoting Effective Interaction,* pp. 216-239. Oxford: Taylor & Francis.

Leman, P. J., & Bjornberg, M. (2010). Conversation, development, and gender: A study of changes in children's concepts of punishment . *Child Development*, 81, 958-972.

Leman, P. J., Ahmed, S., & Ozarow, L. (2005). Gender, gender relations and the social dynamics of children's conversations. *Developmental Psychology, 41*, 64–74.

Linn, M.C., & Hyde, J.S. (1989). Gender, mathematics and science. *Educational Researcher, 18,* 17-19.

Maccoby, E. E. (1990). Gender and relationships: A developmental account. *American Psychologist, 45*, 513-520.

Mercer, N**.,** Dawes, R., Wegerif, R., & Sams, C. (2004). Reasoning as a scientist: ways of helping children to use language to learn science. *British Educational Research Journal, 30*, 367-385.

Millar, R., Lubben, F., Got, R., & Duggan, S. (1994). Investigating in the school science laboratory: conceptual and procedural knowledge and their influence on performance, *Research Papers in Education, 9,* 207-248.

Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J. & Jo Handelsman, J (2012). Science faculty's subtle gender biases favor male students, *PNAS*, *109*, 16474-16479.

Osborne, J. F., Erduran, S., & Simon, S. (2004). Enhancing the quality of argument in school science. *Journal of Research in Science Teaching, 41*, 994-1020

Phelps, E. & Damon, W. (1989). Problem solving with equals: Peer collaboration as a context for learning mathematics and spatial concepts. *Journal of Educational Psychology, 81*, 639-646.

Psaltis, C., Duveen, G., & Perret-Clermont, A-N. (2009) The social and the psychological: Structure and context in intellectual development, *Human Development*, *52*, 291-312.

Schibeci, R. A. (1989), Home, school, and peer group influences on student attitudes and achievement in science. *Science Education, 73,* 13–24.

Shepardson, D. P. & Pizzini, E. L. (2010). Gender, achievement, and perception toward science activities. *School Science and Mathematics, 94*, 188-193.

Smith, R. B., Davidson, J., & Ball, P. (2001). Age-related variations and sex differences in gender cleavage during middle childhood. *Personal Relationships,8*, 153-165.

Tenenbaum, H. R. (2009). "”You'd be good at that”: Gender patterns in parent-child talk about courses. *Social Development*, 18, 447-463.

Tenenbaum, H. R., & Leaper, C. (2002). Are parents' gender schemas related to their children's gender-related cognitions?: A meta-analysis. *Developmental Psychology, 38*, 615–630.

Tyler-Wood, T., Ellison, A., Lim, O., & Periathiruvadi, S. (2012). Bringing Up Girls in Science (BUGS): The effectiveness of an afterschool environmental science program for increasing female students' interest in science careers. *Journal of Science Education and Technology, 21*, 46-55.

Zapiti, A. & Psaltis, C. (2012). Asymmetries in peer interaction: The effect of social representations of gender and knowledge asymmetry on children's cognitive development, *European Journal of Social Psychology, 42*,578-588.

Table 1.

Categories for coding conversation content

Category	Description
Procedural	Discussions about how to do the task and which variables to try: e.g., “Put the carpet on,” “Make it a steep slope,” or “Let’s do the next question”.
Basic	Discussions about the basic properties of the variables, descriptions: e.g., “Carpet is bumpy,” “Steep is faster”
Conceptual	Discussions about the concepts of the variables, deeper understanding: e.g. “The bumpy carpet creates more friction” or “The heavy weight gives more force”
Applied	Discussions about the variables in the real world: e.g., “My bike goes faster down a hill”
Social (off-topic)	Discussion unrelated to the topic: e.g., “What did you have for lunch today”

Table 2.

Mean scores and standard deviations for performance on pre- and post-tests by gender and interaction group (science, play, no interaction)

		Pre-Test		Post-test	
		M	*sd*	M	*sd*
Basic level knowledge					
Science group	Boys (N=72)	3.00	*.93*	3.53	*.75*
	Girls (N=85)	2.67	*.96*	3.46	*.72*
Play group	Boys (N=85)	2.84	*.77*	3.15	*.80*
	Girls (N=106)	2.76	*.81*	2.86	*.76*
No interaction	Boys (N=110)	2.77	*.91*	2.91	*.83*
	Girls (N=74)	2.56	*1.01*	2.64	*.98*
Conceptual level knowledge					
Science group	Boys (N=72)	18.07	*4.23*	20.19	*3.16*
	Girls (N=85)	19.56	*3.07*	18.96	*3.54*
Play group	Boys (N=85)	18.79	*3.49*	18.84	*3.57*
	Girls (N=106)	18.28	*3.74*	17.83	*3.35*
No interaction	Boys (N=110)	18.19	*4.01*	17.83	*3.34*
	Girls (N=74)	18.40	*3.59*	17.76	*3.55*

Note: Basic and conceptual knowledge and pre- and post-tests were assessed using different materials, so although equivalent in their assessment of the underlying knowledge the mean figures are not directly comparable.

Table 3.

Gender differences in mean use of conversation measures

	Boys (N=72)	Girls (N=85)	t(155)
Conversation content			
Procedural	7.92 (4.42)	9.00 (5.56)	1.27
Basic	3.39 (2.66)	4.15 (3.10)	1.64
Conceptual	1.06 (1.54)	.31 (.71)	4.00*
Applied	.07 (.26)	.01 (.11)	1.89†
Social (off-topic)	1.33 (2.69)	1.09 (2.14)	.62
Behavioral measures			
Assertion	2.84 (.86)	2.57 (.92)	1.99*
Affiliation	5.01 (.90)	5.26 (1.09)	1.80†

† $p<.10$, * $p<.05$