

## How Gender Composition influences Individual Knowledge Elaboration in CSCL

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**Abstract:** The aim of the study is to explore the gender difference in learning achievement and knowledge elaboration process in CSCL. A sample of ninety-six secondary school students, aged 16, participated in the two-week experiment. Students were randomly paired to solve six problems about Newtonian mechanics. Their pre- and post-test performances and online interactions were analyzed. We found that female students' learning performance and knowledge elaboration process were sensitive to their partner gender, but that's not the case for male students. Besides, due to a divergent knowledge elaboration process, mixed-gender dyads run the risk of disadvantaging female students in CSCL.

### Introduction

To date, there is very little research looking into the gender difference of knowledge elaboration process in Computer-Based Collaborative Learning (CSCL). Questions such as whether, in CSCL, female and male students benefit equally from the mixed- and single-gender dyads, whether the knowledge elaboration in mixed-gender dyads presents a different picture in comparison with that in single-gender dyads, and how students' learning performance is related with the knowledge elaboration process still need empirical investigation. We start with a discussion on the properties of CSCL that may play a role in students' knowledge elaboration in collaboration.

### Knowledge Elaboration in CSCL

The text-based Computer-Mediated Communication (CMC) is dominantly applied in CSCL practices. It affords the opportunity of a well-balanced knowledge elaboration. Students' interactions are preserved in a shared context, which seems to be privileged to deepen their thinking and trigger a high level elaboration. The explicit back-references may facilitate more thoughtful and reflective discussions as well. However, the reduced shared context is also expected to have reduced utility (Suthers, 2006). In addition, due to the ease of typing and exchanging messages, synchronous CSCL may generate numerous fragmented and incoherent interactions. The breakdown in interaction may exacerbate the potential problem in mixed-gender collaboration.

Making inferences to students' external representations during problem solving may unravel the process of students' cognitive elaborations (DeWindt-King & Goldin, 2003). Kumpulainen and Mutanen (1999) differentiate three cognitive processing modes. The *off-task activity* refers to the social talk that is irrelevant to collaborative task. The *procedural processing* refers to the routine execution of task without improving the ideas. The *interpretative or exploratory processing* refers to students' deep engagement in problem solving activity, which is characterized by critical thinking and a systematic analysis of problem information. Based on that, Ding (2008) endows each message with an elaboration value: -1 (off-task), 0 (procedural) or +1 (interpretative), and plots the sums of the values for each individual learner along the timeline. Such kind of visualization has revealed, at least, three patterns of knowledge elaboration process. The *divergent pattern* (on the left in Figure 1) is featured by two diverging curves. It shows an increasing cognitive discrepancy between two participants. The *cross pattern* (in the middle in Figure 1) illustrates that individual knowledge elaboration processes are closely intertwined. The participants keep a close eye on their partner's processing and take turns dominating the knowledge elaboration. The *parallel pattern* (on the right in Figure 1) indicates that the cognitive gap between the two participants keeps the same during collaboration. With the help of the patterns, we are motivated to investigate whether there is a difference between mixed-gender and single-gender dyads with regard to the knowledge elaboration process, and whether students' learning achievement is affected by it.

### Materials and Methods

#### Research Questions:

The research questions of the study were, in CSCL,

- is there a gender difference in learning achievement?
- is there a difference in knowledge elaboration process between mixed- and single-gender dyads
- is there an interaction effect of group gender and knowledge elaboration, on students' learning achievement?

## Participants

The study was conducted in a secondary school in Shanghai, China. Ninety-six students, aged 16 from two classes of grade ten, participated in the two-week experiment. There were 49 females and 47 males. Students come from families with various social backgrounds. During the experiment, they were randomly paired within the class. There were three groups according to gender: group of mixed-gender dyads (MG, n=25), group of female-female dyads (FF, n=12), and group of male-male dyads (MM, n=11). Students were categorized into four conditions: female in mixed-gender dyads (F in MG, n=25), male in mixed-gender dyads (M in MG, n=25), female in female-female dyads (F in FF, n=24), and male in male-male dyads (M in MM, n=22).

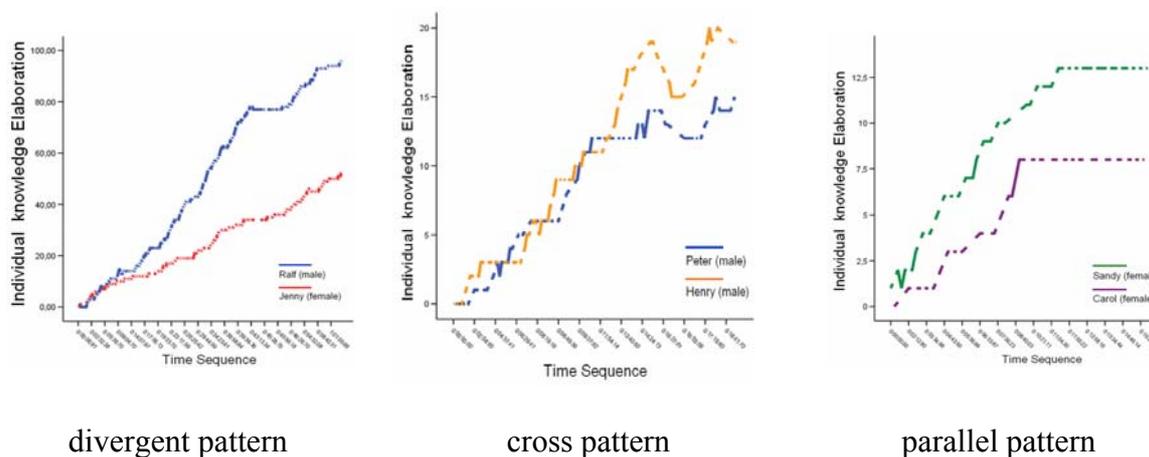


Figure 1. Knowledge Elaboration Patterns.

## PhysHint

The computer program “PhysHint” designed by the author was compiled with SQL to facilitate a synchronous online collaboration. There are five sections in the PhysHint interface. The *problem section* shows the problem information. The problem could not be read until both partners logged into the system. During the experiment, six physics problems in the database were used. The *hints section* offered each student five “hints” for each problem. To strengthen their communication, different students within the same dyad received different hints. In the *drawing section*, students were able to draw the variables and vectors using geometric forms, arrows and lines. Their drawings would be automatically shown on his/her partner’s computer. The *chatting section* resembled the online Messenger that students were familiar with. For each problem students had two chances to try their answer. At the second time they failed, a window with the “*worked-out example*” popped up.

## Procedure

All participants followed three regular lessons concerning Newton’s second law taught by the same physics teacher. Students were administered a 40-minute long pretest concerning Newton’s second law. After that, they were given a preflight training about how to use the online program “Physhint”. The experiment included six 40-minute long sessions. In each session, students were asked to solve one problem. On the last day, all students participated in a 40-minute long posttest. Both pre and posttests was paper-pencil test. Each consisted of four moderately-structured problems. The same as the problems in experiment sessions, test problems were selected from the database with the similar degree of difficulty. Students were required to solve them independently.

## Data Collection and Analyses

Students’ online messages were collected and analyzed through the “elaboration values” (see Table 1).

Table 1: Elaboration Values

Number	Description	Example
+1	on-task message elaborating on knowledge or contributing to the final solution.	<i>Student A: How many forces applied on the box?</i> <i>Student B: I think, four</i>
0	on-task message but no improvement of knowledge elaboration or problem solving	<i>(Student B: There are four forces applied on the box.)</i> <i>Student A: OK.</i>
-1	off-task messages distracting the problem solving process	<i>Student B: Guess, what will be in our next English test?</i>

There are two points that should be pointed out. Firstly, we acknowledged the importance of elaborative questions. Our previous finding indicated that female and male students had different communication styles (Ding & Harskamp, 2006). In collaborative problem solving, female students tended to use question to start the discussion or express opinions. An elaborative question not only kept the collaboration on the right track, but fostered partner's knowledge elaboration. Therefore, not only interpretative or exploratory processing would be endowed +1 point, but also the elaborative questions. Secondly, CSCL is characterized by a large amount of in-coherences in interactions, sometimes even "messy" talks. So, when we evaluated each individual message, we did not merely relate it to the previous one message, but to the whole context. In order to analyze students' online interaction, five independent coders were trained. All were sophomores majoring mechanics. They were instructed about how to code through the "Elaboration Value" system. We selected the data of all six problems. Due to the huge amount of data, each coder spent more than 20 hours on coding. The interrater reliability calculated by a Pearson product-moment correlation is 0.74.

## Results

The individual knowledge elaboration process varies stochastically across dyads. Research methodology should be adequate for identifying these effects (Cress, 2008). Therefore, we used multilevel analyses to answer our research questions. A two level modeling with individual student at level 1 and the dyad at level 2 was constructed. The dependent variable was the students' posttest scores, and the gender, group gender and elaboration patterns were the explanatory variables. Table 2 presents the results of the multilevel analyses with estimation for individual posttest scores. We first established an empty model without any independent variables (Snijders & Bosker, 1999). It showed that a large part ( $127.92/(127.90+66.88)=0.66$ ) of the total variance in students' posttest scores may be attributed to difference on group level, that is, the group gender and the knowledge elaboration patterns. Then, we added explanatory variables to the model.

In Model 1 and 2, we added the *gender* and *group gender*, respectively. In Model 1, the males were the reference group, and in Model 2 the mixed-gender dyads were the reference group. The reduction of deviance suggested that very little of the differences between students was explained by their gender (deviance=751.41,  $\chi^2=.04$ ,  $p>.05$ ) or group (deviance=751.26,  $\chi^2=.15$ ,  $p>.05$ ). Then, we focused on four conditions. Condition *F in MG* was the only condition that scored significantly lower than the other three conditions, namely, M in MG, F in FF and M in MM (deviance=745.61,  $\chi^2=5.65$ ,  $p<.05$ ). To explore the reason and examine whether the low performance of females in mixed-gender dyads was related with the different knowledge elaboration patterns, we added *Divergent Patterns* as an explanatory variable in Model 4. The reduction of deviance was highly significant (deviance=693.90,  $\chi^2=51.71$ ,  $p<.05$ ). It indicated that those who were involved in the divergent patterns scored 7.21 lower than those who engaged in cross and parallel patterns. The effect of divergent patterns was significant ( $t=-9.61$ ,  $p<.05$ ). But the effect of cross or parallel patterns was not significant.

The ANOVA test showed that there were significantly more divergent patterns in the mixed-gender dyads than that in the single-gender dyads  $F_{(2,95)}=3.40$ ,  $p<.05$ . Now, two questions arose. First, has the divergent pattern particularly disadvantaged female students? Second, has the divergent pattern only disadvantaged students in the mixed-gender dyads? We constructed Model 5 and 6 to explore the interaction effect of gender or group gender and divergent patterns. The reduction of deviance of Model 5 was not significant (deviance=690.65,  $\chi^2=3.25$ ,  $p>.05$ ). Yet, Model 6 showed a significant interaction effect of the group gender and the divergent pattern on students' posttest performance (deviance=682.83,  $\chi^2=7.83$ ,  $p<.05$ ). In mixed-gender dyads, the more divergent patterns, the lower students scored in the posttest.

In order to explore whether divergent patterns could explain the disadvantage of females in mixed-gender dyads, we constructed Model 7. In this model, we looked into the interaction effect of students' *gender*, *group gender* and the frequency of *divergent patterns*. The results showed a significant reduction of deviance in comparison with Model 6 (deviance=975.90,  $\chi^2=6.93$ ,  $p<.05$ ). For F in MG, the involvement of divergent patterns resulted that they scored 7.08 lower than other students in the posttest. In other words, the more divergent patterns in the mixed-gender dyads, the lower female students scored in the posttest.

## Conclusion and Discussion

The study was conducted in a synchronous CSCL setting that was designed to facilitate physics problem solving. Because students' learning achievement on the posttest was at the individual level while the knowledge elaboration patterns were formed at the group level, we resorted to the multilevel analyses to explicate the relationship between students' gender, group gender, knowledge elaboration process and learning achievement. It was found that in the mixed-gender dyads, the low performance of female students in the posttest may attribute to the frequency of divergent patterns. The more divergent patterns, the lower scores females in the mixed-gender dyads achieved.

A "close-up" view of one mixed-gender dyad's interaction log files uncovered several possible factors that resulted in the divergent patterns. Firstly, the male tended to use visual representation to answer his female partners' questions instead of verbal explanations. By contrast, the female student tended to use text-based

messages. The different ways of knowledge representation may impede the female's knowledge elaboration. Second, due to the CSCL properties, students' messages were in simple and incoherent form, and students worked on the problem in different tempo due to the lack of shared context. When the female student was still stuck on the force analysis, the male student has already started calculation. Thirdly, when the female complained that her partner moved too fast, the male ignored her words and continued with his calculation. The female also gave up her question and accepted the male's answer. The male's *no-explanation* and the female's *giving-up-asking* led to a divergent elaboration pattern. This finding potentially taps into the investigation regarding why female students performed worse in mixed-gender dyads than in single-gender dyads in physics collaborative learning.

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Table 2: Summary of the model estimates for the two-level analyses of students' post-test scores.

Parameter	Model							
	0	1	2	3	4	5	6	7
<b>Fixed</b>								
Intercept	72.65 (1.83)	72.41 (2.12)	73.132 (2.86)	84.97 (2.80)	84.99 (2.80)	88.13 (3.13)	81.59 (3.77)	88.36 (4.37)
Gender		0.46 (2.13)	0.456 (2.12)	10.81 (2.93)	10.81 (2.93)*	4.91 (4.17)	5.14 (3.99)	-6.56 (5.74)
Group Gender			-1.380 (3.70)	10.64 (2.83)	10.37 (2.83)*	11.22 (2.75)*	22.02 (4.50)*	11.80 (5.73)*
Female in MG vs. others				-13.41 (5.52)*	-12.53 (3.72)*	-14.31 (3.75)*	-14.67 (3.60)*	3.93 (7.76)
Divergent					-7.21 (0.75)*	-8.50 (0.98)*	-5.83 (1.34)*	-8.59 (1.63)*
Female * Divergent						2.46 (1.30)	2.50 (1.27)	7.37 (2.17)*
Groups * Divergent							-4.03 (1.39)*	-0.16 (1.95)
Female * Groups * Divergent								-7.08 (2.64)*
<b>Variance</b>								
Group Level	127.90 (33.63)	126.39 (33.38)	125.93 (33.28)	111.47(30.26)	16.16 (12.10)	9.64 (11.43)	2.89 (10.39)	0.82 (9.65)
Individual Level	66.88 (13.65)	67.34 (13.75)	67.34 (13.75)	66.11(13.49)	66.10 (13.49)	68.93 (14.07)	69.04 (14.09)	66.05 (13.48)
<b>Deviance</b>								
<b>(-2 Loglikelihood)</b>	751.45	751.41	751.26	745.61	693.90	690.65	682.83	675.90
Decrease in Deviance		0.04	0.15	5.65*	51.71*	3.25	7.83*	6.93*

\* $p < .05$