<table>
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<th>Exploring teacher interventions in collaborative inquiry with a science learning environment</th>
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<td>Author(s)</td>
<td>Justin Ke Kaijie, Sun Daner, Looi Chee-Kit and Evelyn Teo Yileng</td>
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<tr>
<td>Source</td>
<td>5th Redesiging Pedagogy International Conference, Singapore, 3 - 5 June 2013</td>
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Exploring Teacher Interventions in Collaborative Inquiry with A Science Learning Environment

a. Justin Kaijie Ke  b. Daner Sun  c. Chee-Kit Looi  d. Evelyn Yileng Teo

a.d. School of Science and Technology  Singapore  
b.d. National Institute of Education  Singapore
This research is funded by National research Foundation in Singapore (Project #: NRF2009-IDM001-MOE-019, IDM SST Future School-Science project).

Subject domain: lower secondary science (i.e. Physics, Chemistry, Biology)

Learning platform: CSI (Collaborative Science Inquiry) learning environment

Participants: Grade 7, Grade 8
CSI System

Teacher interface

- Profile
- Subject Management
- Project Management
- Simulation Library
- Solutions Review
- Mailbox
Functions of Teacher Module

A Multifunctional authoring tool supporting:

- Guided inquiry design
- Integrating instructions
- Inserting images, video, flash, Java app
- Selecting modeling tool
- Reviewing chatting information
- Reviewing learning artifacts

Teacher interface

[Diagram of a multifunctional authoring tool with options for guided inquiry design, integrating instructions, inserting images, selecting modeling tool, reviewing chatting information, and reviewing learning artifacts.]
Student Module

• Profile
• My Project
• My Group
• My Mailbox

Inquiry phases

Chat tool

Shared workspace

Students who are online
Features

- Guided inquiry
- Individual & Collaborative modeling
- Synchronous chatting
- Peer review
- Multiple representations

Online Chatting

Synchronously writing
Research Questions

- What are the major differences between the desired TIs as proposed in the lesson design and the actual TIs observed?
- What are the major differences in TIs between different teachers when they implement the CSI lessons?
- How do different TIs affect students’ performance in collaborative inquiry?
Participants

• Teachers: 2 teachers
  Teacher K ($T_K$) (Female) and Teacher C ($T_C$) (Male), who were similar in their ages, teaching experience and background.

• Students: 43 students
  Class A ($n=21$) was taught by $T_C$, and Class B ($n=22$) was taught by $T_K$. 
### Overview

* Introduce learning objectives
* Emphasize tasks in the inquiry phases
* Remind clicking the task checklist when work is done

### Contextualize

* Present and extract the key information
* Pose guiding questions

### Q&H

* Encourage peer discussion
* Assist coordinating students’ synchronous writing
* Review and assist students’ collaborative work

### Pre-model

* Ask the students to review the “Instruction”
* Observe and assist students’ individual modeling activities
  * Encourage and assist peer review and peer discussion of individual models
* Encourage and assist peer discussion and peer work to build models together
* Observe, review and assist the collaborative modeling activities
* Present students’ typical models and misconceptions

### Investigate

* Ask the students to manipulate and observe the simulations individually
* Encourage and assist peer discussion and collaborative answering of guiding questions
* Encourage and assist the students’ collaborative work

### Reflect

* Emphasize critical reflection on work at the Pre-model and Q&H
* Encourage the students to reflect upon the process of conceptual changes

### Apply

* Emphasize and assist individual work

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#### Table 1. The general information of the CSI lessons

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Proposed TEs and Teaching Strategies</th>
<th>Forms of activity</th>
</tr>
</thead>
</table>
| Overview | * Introduce learning objectives  
* Emphasize tasks in the inquiry phases  
* Remind clicking the task checklist when work is done | Individual |
| Contextualize | * Present and extract the key information  
* Pose guiding questions | Individual |
| Q&H | * Encourage peer discussion  
* Assist coordinating students’ synchronous writing  
* Review and assist students’ collaborative work | Collaborative |
| Pre-model | * Ask the students to review the “Instruction”  
* Observe and assist students’ individual modeling activities  
  * Encourage and assist peer review and peer discussion of individual models  
* Encourage and assist peer discussion and peer work to build models together  
* Observe, review and assist the collaborative modeling activities  
* Present students’ typical models and misconceptions | Individual+ collaborative |
| Investigate | * Ask the students to manipulate and observe the simulations individually  
* Encourage and assist peer discussion and collaborative answering of guiding questions  
* Encourage and assist the students’ collaborative work | Individual+ collaborative |
| Reflect | * Emphasize critical reflection on work at the Pre-model and Q&H  
* Encourage the students to reflect upon the process of conceptual changes | Individual+ collaborative |
| Apply | * Emphasize and assist individual work | Individual |

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**CSI Lessons**

**Diffusion and Osmosis : 2 50-min sessions**
Data Sources

• Videos and audio: teachers’ verbal behavior (Instruction, questions, mediating learning)

• Students’ pre-and post-test scores
• The learning artifacts logged in the system
• Students general performance in collaborative work
Findings

1. Teacher Verbal Behavior

Table 2. Frequencies of teacher verbal behavior

<table>
<thead>
<tr>
<th>Categories of VB</th>
<th>Instructions</th>
<th>Questions</th>
<th>Mediated-learning</th>
<th>Scripts</th>
<th>Prompts</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (Class A)</td>
<td>5</td>
<td>3</td>
<td></td>
<td>18</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>TK (Class B)</td>
<td>1</td>
<td>3</td>
<td></td>
<td>15</td>
<td>38</td>
<td>13</td>
</tr>
</tbody>
</table>
Figure 1. The representations of teachers’ verbal behavior
To better regulate and monitor the class’s progress, $T_C$ pointed out students’ current inquiry phase was Overview. He asked them to focus on the reading tasks in this phase.

$T_C$: Points to the Overview projected on screen. Do not click other tabs. I want you to read the project description and the learning objective in Overview tab.

$T_C$ introduced the skills on peer review and coordination of the writing and editing.

$T_C$: Now I have two persons, later you will see your name there and your partner’s name there. For example, you can key in one sentence. Then your friend thinks that “I can improve your sentence”. So “my friend said that ...” (types on the system) and so you can continue, are you clear?
TK guided the students to construct the diffusion models which represented the process of diffusion in the Pre-model phase.

TK: There’s one particle there (referring to one circle representing the ink droplet at the beginning) but there’s so many particles there (referring to the ink particles scattered within the container of water). So you should show as many number (on both sides). Let’s say thirty (particles) here, so there should be 30 particles there. (Comparing “before diffusion” and after diffusion”) It’s not about the particles splitting but which have physically more concentrated in this area, correct or not? (The size) is hard to change.

TK: You have learnt molecules right? In chemistry, what are water molecules? Will they be exactly the same as other water molecules? If they are all water, when you draw the H₂O right, (the water molecules) should be the same, is it? Is it possible that I have another water molecule that is bigger with a lot of other atoms or things, or do they actually have the same number of atoms, and the same size of the molecule?
Assistances

Figure 2. Teachers’ assistances provided at class
### 1. Test Achievement

Table 3. The results of paired-samples t test

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pretest</th>
<th>Posttest</th>
<th>95% CI for Mean</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>n</td>
<td>Difference</td>
</tr>
<tr>
<td>$T_C$/Class A</td>
<td>10.53</td>
<td>2.503</td>
<td>14.18</td>
<td>3.187</td>
<td>17</td>
<td>-5.509</td>
</tr>
<tr>
<td>$T_K$/Class B</td>
<td>8.53</td>
<td>2.695</td>
<td>13.21</td>
<td>2.573</td>
<td>19</td>
<td>-6.347</td>
</tr>
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a. The CSI lessons could enhance students’ understanding in concepts through collaborative inquiry approach;
b. The guided-inquiry and collaborative work in CSI lessons facilitated low ability students in learning abstract concepts in a progressive way;c. Different TEs may affect students’ achievement on conceptual understanding, especially for the teacher who paid more attention on diagnosing students’ misconceptions and provided immediate assistance for conceptual understanding.
2. Learning artifacts

### Table 3. Students’ responses at each phase

<table>
<thead>
<tr>
<th>Inquiry phases</th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q &amp; H</td>
<td>Better</td>
<td></td>
</tr>
<tr>
<td>Pre-model</td>
<td></td>
<td>Better</td>
</tr>
<tr>
<td>Investigate</td>
<td>The Same</td>
<td>The Same</td>
</tr>
<tr>
<td>Reflect</td>
<td>Better</td>
<td></td>
</tr>
<tr>
<td>Apply</td>
<td>The same</td>
<td>The same</td>
</tr>
</tbody>
</table>
3. Collaboration

Class A

Figure 3a. Students were quiet during Q&H phase

Figure 3b. Students were talking during Pre-model phase
Class B

Figure 4a. Students were working together

Figure 4b. $T_k$ was involved in students’ discussion
Conclusions

1. Both teachers followed the proposed inquiry phases to execute their instruction, but variations emerged in their verbal behavior, assistances and students’ performance in collaborative work.

2. Influenced by different TIs, the students performed differently in test achievement, learning artifacts and collaborative work.
Implications

For teachers whose TEs are more similar to $T_C$’s (Teacher-guided), we suggest teachers intervene more actively at any time in students’ collaborative work and act as an adaptive facilitator in students’ peer discussion instead of only acting as a guide and mentor.

While walking about in the class, the teachers can focus more on checking students’ understanding instead of the correctness of answers and/or the completion of the tasks.

For teachers whose lessons are more similar to $T_K$’s (student-centered), we suggest more efforts be paid to providing macro-scripts on sequences of inquiry, purposes and procedures of tasks before the activities and to emphasizing them during the activities as $T_C$ did in his classes.

The teachers are also suggested to ask more exploratory questions if most students have difficulty in seeking solutions to some problems.
The teachers should guide students to conduct more productive and exploratory peer discussion, in which the teacher is consciously attempting to cede more responsibility to the students for leading and sustaining the dialogue on concepts, prior knowledge and methods.
This research is funded by National research Foundation in Singapore (Project #: NRF2009-IDM001-MOE-019, IDM SST Future School-Science project). We would like to thank the CSI team members, our colleagues at SST and our collaborators: Weikai Fu, Chaohai Chen, Jean Phua Yin Chiun, Charles Low, Kassandra Lim, Kwai Yin Loh and their students for working with us on the project.