Inquiry based Science and Technology Enrichment Program (InSTEP) for Middle-School-Age Female Students

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Problems

- Students in the United States tend to lose interest in science as they progress through middle school and high school. (Gilbert & Calvert, 2003; Scantlebury & Baker, 2007).
- Female students’ attitudes toward science have been reported to become increasingly negative (Alexakos & Antoine, 2003) compared with those of boys by the tenth grade.
- Multiple studies pointed to the possibility that girls, in particular, benefit from hands-on, inquiry-based learning (Cavallo & Laubach, 2001; Heard, Divall, & Johnson, 2000).
Most inquiry exercises span several class sessions and can continue for weeks at a time (Erdogan, 2005).

Due to time limitations with state and national requirements to complete core curricula, most teachers are reluctant to implement inquiry projects in their classrooms (Falk & Drayton, 2004).
Students Engaging in Inquiry

Science as Inquiry

- Ask questions about objects, organisms, and events in the environment
- Communicate investigation Procedures, data, and explanations to others
- Plan and conduct simple investigations
- Use evidence and Scientific knowledge to develop explanations
- Use appropriate tools and techniques to gather and interpret data

(Carin, Bass & Contant, 2005)
Investigation using various tools
Students planned and carried out experiments to determine the water quality of various types of water using pH strips, pH & temperature sensors.

Discussion from evidences
Once the students mapped their results with the aid of the laptop sensors, students presented their findings in a data table they created for the class. Students discussed issues related to water quality (e.g., how pH is developed, how water quality can be improved).

Reflections
They were able to act as scientists (using sensors with computers) and suggest different solutions to real-world problems (e.g., water quality and air quality) in our environment.
InSTEP was to establish strategies to overcome common stereotypes of science/scientists for female middle-school students and improve their attitudes about science.

Interactive Technology Tools

- pH/temperature sensors: Water quality
- Google Earth: Air quality
- GPS (Geographic Positioning System): Locate clues using latitude and longitude
Research Questions

Question 1: How does guided inquiry based teaching affect participants’ **attitudes** about science and science-related careers?

Question 2: How does guided inquiry based teaching affect participants’ **content knowledge** in the selected science topics covered in InSTEP?
Data Collection

- Pre & Post attitude surveys
- Pre & Post content knowledge tests
- Selective interviews
InSTEP used guided inquiry as the instructional method and created small to medium inquiry projects, which were enhanced with technology.

Participants:
44% Hispanic
22% White
17% African American
11% Asian
6% Other

InSTEP teachers:
• 3 Science teachers
• Science education faculty at the university
Attitudes Toward Science Test (ATST)

Based on Science Opinion Survey by National Association for Educational Progress (NAEP, 2006).

Consisted of a total of nine questions using a five-point Likert-type scale.
- interest in science,
- student confidence/desire to do science,
- attitudes toward scientists and science-related careers.
### Table 1. Rotated Factor Pattern Following an Oblique Pattern

<table>
<thead>
<tr>
<th>Attitude Questions</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: I enjoy science.</td>
<td>.674</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q2: Science is related to everyday life.</td>
<td></td>
<td>.887</td>
<td></td>
</tr>
<tr>
<td>Q3: When I graduate, I would like to choose a career in a field related to science and/or technology.</td>
<td></td>
<td>.816</td>
<td></td>
</tr>
<tr>
<td>Q4: Science classes have often made me feel nervous.</td>
<td>.681</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q5: I usually do well in science classes at school.</td>
<td>.722</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6: Science is not difficult for me to understand.</td>
<td>.787</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q7: I am interested in many scientific ideas that are not taught/offered in my school.</td>
<td></td>
<td>.717</td>
<td></td>
</tr>
<tr>
<td>Q8: I feel comfortable asking questions about science out loud.</td>
<td>.524</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q9: Computers, GPS, DVD, trains, airplanes, and cars do not relate to science.</td>
<td></td>
<td></td>
<td>.846</td>
</tr>
</tbody>
</table>

**Factor 1:** Confidence in Science (Q1, Q4, Q5, Q6, Q8), **Factor 2:** Career in Science (Q3, Q7), **Factor 3:** Relatedness of Science (Q2, Q9).
Table 2. Pre-test and Post-test Changes in Attitudes Toward Science Test (N = 123)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-test Mean (SD)</th>
<th>Post-test Mean (SD)</th>
<th>t</th>
<th>p&lt;</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitudes Toward Science Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATST</td>
<td>.899 (.500)</td>
<td>1.085 (.482)</td>
<td>-2.816</td>
<td>.006</td>
<td>.482</td>
</tr>
<tr>
<td><strong>ATST Three Factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence in Science</td>
<td>.868 (.642)</td>
<td>1.000 (.615)</td>
<td>-1.707</td>
<td>.090</td>
<td>.149</td>
</tr>
<tr>
<td>Career in Science</td>
<td>.444 (.833)</td>
<td>.813 (.802)</td>
<td>-3.723</td>
<td>.000</td>
<td>.334</td>
</tr>
<tr>
<td>Relatedness of Science</td>
<td>1.430 (.476)</td>
<td>1.562 (.505)</td>
<td>-2.013</td>
<td>.046</td>
<td>.192</td>
</tr>
</tbody>
</table>

*Note.* Pre-test vs. post-test scores, *p* < .05.

**Factor 1:** Confidence in Science (Q1, Q4, Q5, Q6, and Q8),
**Factor 2:** Career in Science (Q3 and Q7),
**Factor 3:** Relatedness of Science (Q2 and Q9).
Quantitative Data Analysis for ATST

The results of the t-test found that inquiry-based instruction improved girls’ willingness to choose a career in science and increased their ability to relate to the concepts of science in the real world ($p < .05$).

Unexpectedly, the mean difference between the pre- and post-test for confidence in science was not statistically significant at $p < .05$ although there was a slight increase of $0.132$ at the post-intervention level.
Content Knowledge Test (CKT)

- Consisted of 10 questions covering DNA, latitude and longitude, force and motion (e.g., gravity and centrifugal force), and water quality (e.g., pH).

The CKT questions focused on students’ ability to understand terms and solve problems. Sample CKT items were:

1. Describe the process of neutralization.
2. Deoxyribonucleic Acid or DNA is important because…
## Quantitative Data for Analysis for CKT

### Pre-test and Post-test Changes on Content Knowledge Test (N = 123)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>t</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Content Knowledge Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CKT</td>
<td>.354 (.170)</td>
<td>.671 (.162)</td>
<td>-15.148</td>
<td>.000</td>
<td>.411</td>
</tr>
<tr>
<td>Content Knowledge Test Learning Objectives</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latitude &amp; Longitude</td>
<td>.258 (.213)</td>
<td>.502 (.246)</td>
<td>-9.164</td>
<td>.000</td>
<td>.833</td>
</tr>
<tr>
<td>Water Quality</td>
<td>.469 (.275)</td>
<td>.931 (.171)</td>
<td>-14.707</td>
<td>.000</td>
<td>1.605</td>
</tr>
<tr>
<td>DNA</td>
<td>.311 (.328)</td>
<td>.638 (.352)</td>
<td>-7.970</td>
<td>.000</td>
<td>.722</td>
</tr>
<tr>
<td>Force and Motion</td>
<td>.354 (.171)</td>
<td>.668 (.161)</td>
<td>-14.845</td>
<td>.000</td>
<td>1.346</td>
</tr>
</tbody>
</table>

*Note. Pre-test vs. post-test scores, *p* < .05.*
Quantitative Data for Analysis for CKT

On the post-intervention measures, participants reported significant changes in the students’ overall content knowledge of specific science concepts below (t = -15.148, p = .000).

1. Latitude and Longitude
2. Water Quality
3. DNA Properties
4. Force and Motion

The results here support the hypothesis that inquiry-based learning has a substantial effect on students’ overall content knowledge of selected science concepts.
Has your outlook on science/scientists changed after attending InSTEP?

“InSTEP really taught me a lot because the teachers didn’t just stand in front of the class and teach us about science. We actually got to do the projects!

“It was very exciting to work with the sensor technology I haven’t used before for the water quality testing. I actually appreciate science a lot more now. Science seemed boring before and now it is new and exciting.”
The InSTEP results are encouraging, given that female middle school students’ attitudes toward science tend to decline with age.

The study results showed that teaching science as a guided inquiry enhanced with technology could highly influence middle school female students’ views on science and science-related careers positively.
Future studies with **long-term interventions** need to examine strategies to enhance students’ confidence levels.
This research was supported by a grant from the Motorola Foundation. I also thank the InSTEP teachers who contributed to this research.
Current/Future Research

The GreenTech (Green Earth enhanced by Inquiry and Technology) project investigates how inquiry-based learning methods can improve 6th grade students’ attitudes toward science and content knowledge using a theme, Green Earth.
Science Teacher Training Component