Teacher Quality Enhancement: 
Lessons Learned from the 
Force Concept Inventory

Nancy C. Grim Hunter
TQE Director
Chicago State University

BCEE
August 2, 2006

Purpose

• Describe the Newtonian force concept belief systems held by preservice teachers in physical science and physics students
• Compare the quality of force concept instruction (measured pre/post by FCI)
• Determine any significant correlations between the FCI competency levels and the following variables:
  - Instructional methods (inquiry/constructivist vs. verification)
  - Science/Math Anxiety
  - Perceptions of Difficulty
  - Student Background Variables—Parental educational level, number of math/science courses taken in high school/college, & gender.

Hypothesis

1. The Physical Science 110 class will receive a higher quality level of instruction using a guided-inquiry/constructivist approach with hands-on laboratory activities than the Physics 211 verification-style lecture and laboratory exercises.
2. It is surmised that student’s with college-educated parents or a course history background that includes more than 3 science classes in high school or college will have a positive correlation with the FCI scores.
3. A high anxiety level or a high perception of difficulty in science and math is hypothesized to have a negative correlation with the Force Concept Inventory scores.
4. Gender is not expected to play a significant role.

Student Population

• African American (92%)
• Hispanic (6%)
• Other Minority Groups (1%)
• Caucasian (1%)
• Typical Range of Ages: 18 to 25
• Average Age is 28
• Mainly Commuter Students plus one 800-bed dorm
• ACT entrance score is 18
• Average time to graduation is 6 years.

Student Groups

• Ex Post Facto Participants (n = 48)

<table>
<thead>
<tr>
<th></th>
<th>Ph Sci 110 (61)</th>
<th>Ph Sci 110 (01)</th>
<th>Phys 211 (01)</th>
<th>All Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian American</td>
<td>30.0%</td>
<td>81.25%</td>
<td>93.67%</td>
<td>79.33%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>25.0%</td>
<td>6.25%</td>
<td>8.13%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Native American</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Other</td>
<td>0.0%</td>
<td>12.5%</td>
<td>9.0%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Total Male/Female</td>
<td>20/3/17</td>
<td>18/2/4</td>
<td>12/7/5</td>
<td>48/12/36</td>
</tr>
<tr>
<td>Age Range</td>
<td>20 to 38</td>
<td>18 to 45</td>
<td>18 to 25, 31</td>
<td>18 to 45</td>
</tr>
</tbody>
</table>

Forces Concept Inventory

• Newtonian Force Concepts
  - Beliefs accepted by scientific community:
    • Correct Scores
      – Kinematics
      – First Law
      – Second Law
      – Third Law
      – Superposition of Forces
      – Other Forces
  - Common-Sense Misconceptions
    • Beliefs not-accepted by scientific community:
      • Error Scores
        – Kinematics
        – Impetus
        – Active Force
        – Action-Reaction Pairs
        – Concentration of Influences
        – Other Influences

Hestenes, (1992)
Analysis & Results

Although Physics 211 was better prepared initially, the Ph Sci 110 sections had a slightly larger growth in concept attainment:

<table>
<thead>
<tr>
<th>Average % Scores</th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Score Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph Sci 110 (61)</td>
<td>14.45</td>
<td>29.31</td>
<td>+10.84</td>
</tr>
<tr>
<td>Ph Sci 110 (01)</td>
<td>14.66</td>
<td>26.72</td>
<td>+12.06</td>
</tr>
<tr>
<td>Phys 211 (01)</td>
<td>16.65</td>
<td>38.56</td>
<td>+11.91</td>
</tr>
<tr>
<td>All Participants</td>
<td>21.11</td>
<td>31.77</td>
<td>+10.66</td>
</tr>
</tbody>
</table>

CSU Physical Science Classes

Analysis & Results

Positive Correlations with FCI scores:
- Number of high school math courses (p < 0.05) (Pre-test)
  - Algebra is a first gatekeeper (p < 0.05) (Pre-test)
- Number of post-high school science courses
  - Post-high school math courses (Post-test)
  - High school algebra + high school science (Post-test)
  - Post-high school science > high school science (Post-test)
  - Post-high school math > high school math (Post-test)
- Constructivism > Verification (p = 0.08) (Post-test)
- Parent Education Level (Mother’s level has double the impact) (Pre-test) [Effect disappears at Post-test]

Analysis & Results

Positive Correlations:
- Mother’s educational level with number of post-high school science & math courses taken (both p < 0.01)
- Father’s educational level with number of post-high school science & math courses taken (both p < 0.05)
- Father’s educational level has strong although not significant effects on the number of high school science and math courses taken
- Educational women and educated men become standardized parents (p < 0.01)
- A father’s educational level leads to more anxiety in math (p = 0.06) yet his offspring seem to perceive math as less difficult
- A mother’s educational level may influence the offspring to perceive science and mathematics as less difficult and has a strong yet not significant influence over math anxiety
- Science anxiety with math anxiety (p < 0.01)

Analysis & Results

Positive Correlations with FCI scores:
- Anxiety of Science (p < 0.05) (Pre-test)
- Anxiety of Math (Pre-test) — nearly significant
- Anxiety of Science and Math (Post-test) — high anxiety and high scores may indicate a positive use of anxiety

Negative Correlations with FCI scores:
- Perception of Difficulty in Math is slightly more negative than Perception of Difficulty in Science (Pre-test)
- Perception of Difficulty in Science has a stronger negative correlation than Perception of Difficulty in Math (Post-test)
- Inverse Relationship between Perception of Difficulty and FCI scores
  >>> A high FCI score may be a result of a low Perception of Difficulty and vice versa

Analysis & Results

Negative Correlations:
- Perception of Difficulty in Science has a small negative correlation to the Perception of Difficulty in Math
- Perception of Difficulty in Science with Anxiety in Science (p < 0.05)
- Perception of Difficulty in Math was negatively correlated to the Anxiety in Math (p < 0.01)
Analysis & Results

- Gender has no effect on the FCI scores in this study (p = 0.0025). However, we acknowledge that so few males were a part of the study and more data needs to be collected to validate this result.

Future Explorations

- Explore to what extent culture impacts anxiety and perception of difficulty as well as achievement
- Identify additional gateways to success
- Explore the future impact of instructional strategy as transferred to future students
- Explore the change in FCI scores at the extremes
- Explore the relationships between all the variables studied.

Contact Information

- Nancy C. Grim Hunter, Director
- Teacher Quality Enhancement Project
- Chicago State University
- 9501 S. King Drive
- Chicago, IL 60628
- ngrim@csu.edu
- 773.995.2097 VM
- 773.995.4455 fax
- www.csu.edu/tqe/