Investigative Case Based Learning for the 21st Century

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bioquest.org/nie2011
Agenda

Overview of Investigative Case Approach
- Engage with a case
- Investigative Case Based Learning Defined

Research
- Research Basis for ICBL
- Effectiveness
- Needed Research

21st Century Learners and Skills
- Changes
- How ICBL aligns
- Linking ICBL to Cyberlearning tools

Waterman & Stanley 2011
Jiaming sat down across from one of his favorite clients, Mrs. Seng. His fellow web developer, Siti, joined them by computer conferencing shortly after. Today’s discussion was focused on the web advertising for the client’s new line of instantaneous gas water heaters. As usual, Mrs. Seng provided useful background materials. Her project would fit easily into their work schedules and the meeting ended well.

While Jiaming returned to his office, Siti looked up a few unfamiliar terms used during the meeting. Just what was a carbon footprint? What did it have to do with water heaters? Siti enjoyed the variety of things she learned as a web developer.

Although Jiaming and Siti both lived in the same neighborhood and worked for eSolutions, only Jiaming rode the train to work. Siti preferred to work from home. She couldn’t imagine riding ten stations down the line every day. The pair made an excellent team, but they had very different lifestyles.

“I wonder,” Siti said to herself, “if it makes much of a difference to our carbon footprints?”
Case Analysis

• What is this case about?

• What do you already know about these topics?

• What do you need or want to know about to understand this situation?

<table>
<thead>
<tr>
<th>What Do I Know?</th>
<th>What Do I Need to Know?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Waterman & Stanley 2011
The ICBL Discussion Method

• What did you do?

• What did I do?

• What might we have students do next?
We Chose: Singapore Carbon Calculator as a Tool for Investigation

TASKS

• First, compare the Carbon cost of transportation for Jiaming and Siti.

• Then, design and run an experiment using this simulation to answer other questions stemming from the case analysis.

http://www.climatechange.sg/html/?link=1

Waterman & Stanley 2011
One hypothesis tested was: If a person works from home, then their energy expenditure will be less than a person who works from an office.

Shaded columns are Kg C/yr for working at home.
Additional Resources

Online, Singaporean Climate Change book
www.climatechange.sg/

International ecological footprint calculatorhttp://www.myfootprint.org/

Waterman & Stanley 2011
What is ICBL?

Investigative Case Based Learning

• Began as Problem Based Learning (PBL), as used in Medical Schools to teach science, diagnostic thinking, and engage medical students in thinking of patients as people.
  • Rigid, 3 day scheme for using cases.
    • Time consuming (6 hours per week)
    • Emphasizes content coverage
    • Requires very low student:teacher ratios

• Needed to be adapted for non-medical settings, and for science!

Waterman & Stanley 2011
MW Joined with ES and BioQUEST in 1996 and they developed

- Investigative Case Based Learning:
  - A variant of PBL, specifically for engaging all kinds of students in scientific problem solving
  - Short cases which can be used for a wide variety of purposes such as
    - Beginning a new topic
    - Introducing a new piece of equipment
    - Framing a lab exercise
    - Promoting wholistic thinking: science in societal contexts

http://bioquest.org/icbl
BioQUEST is....

BioQUEST actively supports undergraduate biology education through collaborative development of open curricula in which students pose problems, solve problems, and engage in peer review.

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Core Features

• Problems/cases are real and meaningful contexts.
• Cases are complex and multidisciplinary.
• Learners collaborate to identify what they need to learn.
• Learners identify and use resources.
• Learners conduct investigations using tools of the discipline with work in the museum, studio, field, lab, or on computers

Waterman & Stanley 2011
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Theoretical Foundation for ICBL/PBL

• People construct knowledge uniquely, often socially (How People Learn, 1999, NRC)

• Metacognition improves learning (How People Learn, 2000)

• People want to learn when they have a question (Knowles, Andragogy, 1970s)

• Situated cognition: more is learned when the context in realistic and meaningful (Brown et. al, )

• Student centered investigation (Felleti and Boud, 1998; Jungck et. al, 2000, many others)
Research on Effectiveness

Most studies done with medical students and medical model PBL, but not all:

- Engineering
- Preservice teachers
- Biology students
- Nursing
- Others

- Most are Pre-Post and Quasi Experimental Designs, some Case Studies, Time Series
Research on Effectiveness:
Based on Review by Hmelo-Silver 2004

• Flexible and useful knowledge (integrated, able to apply to different contexts)
  • No differences in content acquisition in undergrads, may be slightly less in medical students
  • PBL Med students somewhat better at clinical problem solving, applied questions
  • PBL: Superior in correctly identifying diagnoses

• Problem solving skills (self-awareness of learning, ability to apply strategies)
  • More elaborated explanations during applications
  • Greater accuracy over time in hypothesizing
  • More concepts used in explanations
Research on Effectiveness
Based on Lundeberg, 2008, review of research

- biology students learning with cases gained more knowledge than did traditionally instructed students.
- if critical thinking is defined generally, no effect is seen in student performance.
- if critical thinking is defined in terms of skills used in scientific inquiry (data analysis, question formulation,) students learning via cases outperformed students in traditional classes.
- students developed ethical and global awareness to a greater extent than those not taking part in case discussions.
- students assess problems from myriad perspectives due to complex nature of case scenarios.
- A recent national study found that faculty who use case studies believe their students develop both stronger analytical cognitive abilities, and a deeper understanding of the topic.
- the use of case-based learning in science education can significantly promote knowledge acquisition, the development of critical thinking skills in students, and content retention.
- improved student motivation because these tools have the potential to create cognitive dissonance and curiosity and by using relevant, engaging materials.

Waterman & Stanley 2011
Needed Research

Recommended for funding by NSF: a Research Collaborative Network for Case Study and PBL. Annual meetings, research and practice focus.

• How do case study methods specifically affect learning, and for whom?
• What is the nature of collaboration during case study and the learning during collaboration?
• How do learners become self-directed learners? What kinds of scaffolding are needed?
• How do individual teachers implement ICBL?
• Reliable, easy to use assessments of learning outcomes need to be developed.
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Changes for society, for education

• LIVE Singapore, a joint project with MIT SensableCity group

http://www.youtube.com/watch?v=2aEPkyOBtRo&feature=player_embedded
One Response:

Singapore MOE 21st Century Competencies

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How Does ICBL Align with the 21stCC?
1. **Civic Literacy, Global Awareness & Cross-cultural Skills**
2. **Critical and Inventive Thinking**
3. **Information and Communication Skills**

<table>
<thead>
<tr>
<th>Part of Case Module for ICBL</th>
<th>Action by Participants</th>
<th>Alignment with 21st Century skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Narrative</td>
<td>Read aloud, read silently. An example of inventive thinking is in the case itself. Gender issue for female working from home?</td>
<td>1-Topic raises global issues 2 - case had example of people whose work is to think inventively 3 - communication verbally while reading</td>
</tr>
<tr>
<td>Case Analysis: Know/Need to Know</td>
<td>Individual and group thinking, sharing about what you already know, and question generation.</td>
<td>1 - draw on prior knowledge and experiences 2 - evaluating what you already know that is relevant 3 - collaboration and small group communication</td>
</tr>
<tr>
<td>Explore case resources</td>
<td>Examine the things we offered</td>
<td>2 - evaluating/being critical about the resource 1 - global, seeing resources from different countries 3 - many were examples of online resources sieved from a large amount</td>
</tr>
<tr>
<td>Experiment</td>
<td>Groups designed and conducted chromatography experiments</td>
<td>2 - had to come up with the question and procedures 3 - reading procedural information and translating it into action</td>
</tr>
</tbody>
</table>

Waterman & Stanley 2011
Another Response:  
*Reconceptualize the Disciplines to Fit with Reality*

- *A New Biology for the Twenty-First Century* (National Research Council, U.S., 2009) calls for
  - problem centered
  - interdisciplinary biology education.

  “Solving complex, interdisciplinary problems will require that students go far beyond their life science majors both in understanding what connections exist across disciplines and how to make those connections.” Labov (2010): regarding the New Biology
And: *Teach 21st Century Learners*

- 2008 National Science Foundation (U.S.) report *Fostering Learning in the Networked World: The Cyberlearning Opportunity and Challenge*

  “Cyberlearning is not just the term to describe online searching for information, gathering data, analyzing public data sets, database mining, or the use of virtual laboratories and simulations; *cyberlearning also describes a mode of self-directed learning that is increasingly discordant with our broadcast style of teaching.*”
Linking ICBL to Cyberlearning Tools

Examples

• Remote sensing
• Modeling
• Data visualization tools
Liam and Solana looked forward to their family reunion every year. They were finally going to Maryland's Chesapeake Bay, where two generations ago several members of their family had been oystermen and crabbers. After hearing many stories from their great uncle about this "cradle of the sea," they were anxious to experience the area for themselves, although they knew this section of the Bay no longer supports commercial shell fishing.

While waiting in line to purchase tickets for a boat tour of the bay, Liam and Solana heard a series of screeches. They scanned the docks for the source of the mayhem. A large gull that had settled on a covered boat hurriedly flew away midway through the screeches. After several more seconds, the noise stopped.

“What was that?” Solana asked. “It sounds like birds are being attacked, but I don’t see anything.” Liam just shrugged and pointed out a mallard still floating a few feet from the dock and a tern still sitting on the nearby pilings despite the noise. “Can’t they hear? They’d have to be deaf to ignore that,” Solana said.

The woman working at the nearby snack stand looked up and offered an explanation. “Well, it’s a tape the marina owner is using to scare the gulls away. Seems like there’s more every year. The folks who rent slips here were upset by the damage the gulls caused. Gull droppings cause holes in the boat covers if they aren’t cleaned quickly. We’ve tried everything to keep the gulls away.

“The marina owner found an ad for this tape on the Internet. He says there are six different gull distress calls, which are all supposed to sound just like the real thing. The tape plays every couple of hours during the day. It worked great last summer, but lately some of the gulls seem to ignore it.”

“Do you think the gulls just get used to it?” Solana asked.

“Well, the owner of the next marina over keeps a few dead gulls out on the dock. He claims it keeps the tapes working, but I….”

“Look at that,” Liam interrupted. “Someone used duct tape to block the speaker at this end of the dock.”

Squinting her eyes to get a better look at the speaker, the woman nodded. “I bet the guy in the 22-foot Sea Ray did it,” she offered. “He claims that it’s the new landfill causing the gull problem in the first place, and we should get rid of that rather than disturb his peace.”

“Well, at least the tape still seems to be working on him,” observed Liam, laughing.

Figure 8.1 Gull populations often become a nuisance to people in areas such as marinas.
Using remote sensing to investigate the bay and teach hypothesizing, data analysis and interpretation

http://mddnr.chesapeakebay.net/eyesonthethebay/index.cfm

http://bioquest.org/icbl
Remote Sensing Closer to Home


Waterman & Stanley 2011
Satellite Imaging

http://earthshots.usgs.gov/Singapore/Singapore

Waterman & Stanley 2011
And in just a few years

http://earthshots.usgs.gov/Singapore/Singapore

Waterman & Stanley 2011
MoSSSea: Modeling the Salish Sea

http://faculty.washington.edu/pmacc/MoSSea/movies/SSS_daily_salish.mov

Waterman & Stanley 2011
Online tools for data visualization
Used for interdisciplinarity, global perspective questioning and hypothesizing, examining relationships among variables, interpreting data

Singapore One Map
www.Onemap.sg

Worldmapper
www.Worldmapper.org

Gapminder: A Data Centered View of the World
www.Gapminder.org
Warmer temperature means more mosquitoes so watch out!

NEA urges extra vigilance and undertakes extra measures to combat expected rise in cases.
Where is the Dengue Now?

http://www.onemap.sg/index.html

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Objective: Tools for Visualizing Data

Land Area

www.worldmapper.org

http://bioquest.org/icbl

Waterman & Stanley 2011
Total Carbon emissions by country

http://bioquest.org/icbl
Maps are categorised. Choose a category from the left menu, then a map from below.

### Education Maps

<table>
<thead>
<tr>
<th>Map</th>
<th>Title</th>
<th>World Total</th>
<th>Unit</th>
<th>Year</th>
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<tbody>
<tr>
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<td>Youth Literacy</td>
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<td>million people aged 15-24</td>
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<td>million people over 15</td>
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<td>Illiterate Young Women</td>
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<tr>
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<td>Illiterate Women</td>
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<td>million women over 15</td>
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<td>Science Growth</td>
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<td>million PPP US$</td>
<td>2001</td>
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<td>Secondary Education Spending Growth</td>
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<td>million PPP US$</td>
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<td>Tertiary Education Spending</td>
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<td>Tertiary Education Spending Growth</td>
<td>155318</td>
<td>million PPP US$</td>
<td>1990-2001</td>
</tr>
</tbody>
</table>
Mini case: Global Carbon Emissions

What else might affect Carbon emissions?

Waterman & Stanley 2011
Selected References

• Lundeberg, Mary Anna. 2008. Case Pedagogy in Undergraduate STEM: Research We Have, Research We Need. White Paper Commissioned by the National Academies of Science Board on Science Education. Online at: http://www7.nationalacademies.org/bose/Lundeberg_CommissionedPaper.pdf
• Funding:

http://bioquest.org/icbl

Waterman & Stanley 2011