Project teaching and learning in science: The US experience

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Project-based learning

Project-based learning involves completing complex tasks that result in a realistic product or presentation to an audience. Five key components of effective project learning:

1. Centrality to the curriculum
2. Driving questions that lead students to encounter central concepts
3. Investigations that involve inquiry and knowledge building
4. Autonomy - processes that are student driven, rather than teacher driven
5. Realism – projects are authentic and real world.

Thomas, J.W. (2000). A review of research on project-based learning. San Rafael, CA: The Autodesk Foundation. Available at http://www.bie.org/index.php/site/RE/pbl_research/29 .

Theoretical underpinnings

- Can trace contemporary origins to medical student preparation with goal of improving doctor's diagnostic skills using case studies.
- Cognitive research also supports approach. Motivations research show
    - more motivated by learning and mastery of subject matter demonstrated by sustained engagement
    - discouraging public comparability and favor task engagement reduce threat and encourage focus on learning
    - emphasis on student autonomy, collaborative and authentic performance maximize student engagement.
- Expert-novice research also supports PBL since encourages development of meta-cognitive and self-regulatory capabilities of experts and helps overcome the absence of planning and self-monitoring skills common among the novice learner.
- "Situated cognition" demonstrates that learning is maximized f the context for learning resembles real-life content in which the material will be used.

Example: New Tech High Schools

Network of 41 schools, three defining differences

1. Use PBL including team work, inquiry and technology. (centrality to curriculum, questions, inquiry)
2. School culture that empowers students and teachers - trust, respect and responsibility. (autonomy)
3. Integrated use of technology - every student has a computer with collaborative learning environment (realism)

See: http://www.newtechfoundation.org for video clip and examples

Project-Based Science

In PBS, like PBL, students are active participants, set their own learning goals, and investigate real-world issues. Five essential elements in PBS;

1. Driving question
2. Investigation
3. Production of tangible, meaningful artifacts
4. Collaboration with peers, teachers, members of community
5. Use of tools and technologies such as the Internet to support inquiry

Krajcik, JS, PC Blumenfeld, RW Marx,& E. Soloway (1994). A collaborative model for helping middle grade science teachers learn project-based instruction. *The Elementary School Journal (94)* 483-497.

Theoretical underpinnings

- Roots found in John Dewey (influenced Václav Příhoda), Jerome Bruner and Robert Karplus.
- Elements of PBL overlap with inquiry-based learning, science-technology-society, and problem-driven science. PBS is different in that it focuses learning on questions the students find meaningful shifting responsiblity for learning to students (Krajcik, Czerniak, Berger, p.4)
- Inert knowledge vs. Meaningful knowledge
- content knowledge, procedural knowledge and meta-cognitive knowledge
- Social constructivist model of teaching

8th grade classroom example

- 10 week unit “Why do I need to wear a helmet when I ride my bike?”
- Physics of collisions, motion, velocity, acceleration and force
- Anchor event 1: video of bicycle injury
- Anchor event 2: demonstration with rolling egg down a ramp
- Series of labs that linked back to demo
- Final product, designed a helmet to protect the egg and results of the effectiveness of their helmet design

Rivet, AE & JS Krajcik (2008). Contextualizing instruction: Leveraging students’ prior knowledge and experiences To foster understanding of middle school science. *Journal or Research in Science Teaching 45 (1)* 79-100.

Classroom Example: Evolution

- American context for evolution
  - Poor understanding among population, politically controversial, conflicts with some religious beliefs, teacher intimidation
  - Traditional teaching with disconnected examples do not help involve students
  - Need to find how to connect evolutionary theory to students daily life
  - Start with real-life concerns of students to create need and usefulness of evolution

Cook, K. (February 2009) A suggested project-based evolution unit for high school: Teaching content Through application. *The American Biology Teacher* (71) 2, 95-98.

Evolution: Real Life

MRSA in Your Neighborhood (MRSA is a bacterial infection that resists antibiotics and in recent years has closed several schools and resulted in several deaths)

1. Teacher ask students to "determine how bacteria develop antibiotic resistance" (driving question 1)
   - Give students three possible explanations which they must evaluate, or may add their own.
   - After several weeks, a final presentation and a product for parents

2. Why is understanding the evidence, history and applications for evolution important for participation in a democratic society? How does understanding evolution relate to an understanding of the nature of science? (driving question 2)
   - Create website on evidence, history, and application of evolution, include popular misconceptions about evolution

Evolution: Outline

- Week 1: Prior knowledge
  - Activity on Salmonella resistance in chickens, video on tuberculosis in Russian inmates (investigation, tools)
- Week 2: Introduce MRSA problem
  - Lab, add resistance gene to *E. coli*, form teams, begin gathering information, prepare product for general audience (collaboration, artifacts, investigation, tools)
- Week 3: Expand
  - Using video, web, and hands on lab, explore invasive species, student teams select topic and research presentations (collaboration, artifacts, investigation, tools)
- Week 4 - 5: Evidence for evolution
  - Activities and web research on evidence, critically analyze historic texts of Darwin, Wallace, Lamarck. Produce web page.
  - (collaboration, artifacts, investigation)

Simpler Classroom Example: Chemistry posters

- Stand alone advanced placement chemistry class in typical high school
- Used new computer-based lab (CBL) probes (tools)
- Students individually selected a lab from a book of investigations (autonomy, question, investigation) but collaborated on procedures
- Prepare results in format of a poster presentation for public display (artifacts)
- Students taught teachers about CBL using their work (meaningful artifacts, collaboration)

Rigeman, S. (June 1998). The convergent evolution of a chemistry project: Using laboratory posters as a Platform for web page construction. *Journal of Chemical Education (75)* 6, 727-730.

Chemistry posters results

- Students enjoyed different lab report format and were proud of posters
- Students engaged by technology
- Since working on different labs, collaborated instead of competed
- Became trainers for teachers
- Students learned chemistry - able to explain in own words their results

Some Research Findings

- PBS students performed as well as other students on national standardize test but still need support transferring understanding to new problems.[1]
- IT enhanced PBL undergraduate chemistry students performed better on post test and final exam, computer models improved understanding.[2]

[1]Schneider, RM, J Krajcik, RW Marx, & E Soloway (2002) Performance of students in project-based classrooms on a National measure of science achievement. *Journal of Research in Science Teaching (39) 5* 410-422.

[2]Barak, M, & YJ Dori (2005) Enhancing undergraduate students' chemistry understanding through project-based learning In an IT environment. *Science Education (89) 1,* 117-139.

Challenges

- Teacher discomfort and experience with process of science (we tend to teach like we were taught) or with PBS
- Limited student experience
- Lack of time and resources
- External pressures such as head master or parents.
- Curriculum issues such as shallow coverage of many topics vs. deep coverage of few topics

Questions and Discussion

- How does PBL change the role of the teacher in the classroom?
- What are the challenges for a teacher?
- What are the challenges for a student?
- What do teachers need to successfully teach using PBL?
- What are the real benefits to using PBL?
- How are the US and ČR classrooms and schools similar or different?