Problem-Based Learning in STEM Education

ASTE 2009 International Conference
January 8-10, 2009
Hartford, CT

Nicholas Massa
Springfield Technical Community College

Michele Dischino
Central Connecticut State University

Judith Donnelly
Three Rivers Community College

Fenna Hanes
New England Board of Higher Education

Problem-Based Learning in STEM Education

The Photon PBL Project

What is Problem-Based Learning?

Used extensively in medical education since the early 1970's, PBL teaches students the process of solving genuine real-world problems by:

- working together in small groups to define and frame the problem
- identifying required resources
- generating specific problem solving strategies
- applying those strategies to test alternative solutions
- converging on an optimal solution

Problem-Based Learning in STEM Education

The Photon PBL Project

Characteristics PBL Environment

- Learning is student centered
- Learning occurs in small groups
- A tutor acts as facilitator
- Authentic problems are presented *before* any preparation or study has occurred
- The problem itself is used to introduce concepts and problem solving skills
- New information is acquired via self-directed learning

Problem-Based Learning in STEM Education

The Photon PBL Project

Benefits of Problem-Based Learning:

- Improves students' understanding and retention of knowledge
- Promotes a "deep approach" to learning
- Improves critical thinking and problem solving skills
- Improves motivation for learning
- Improves students' ability to transfer skills and knowledge to new situations

Problem-Based Learning in STEM Education

The Photon PBL Project

A good PBL problem should…

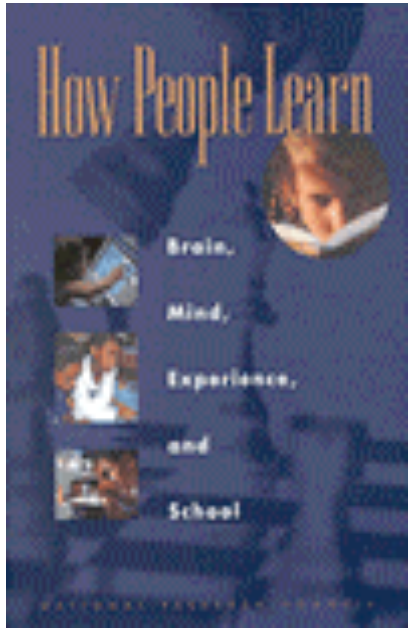
- Be open-ended with more than one possible solution
- Be ill-structured, with insufficient information to facilitate inquiry
- Engage students' interest, and motivate them to probe for deeper understanding of the concepts being introduced
- Be based on real-world issues and situations
- Require students to define what assumptions are needed (and why), what information is relevant, and/or what steps or procedures are required in order to solve them
- Require cooperation and teamwork among team members
- Be linked to prior knowledge
- Incorporate course content and objectives
- Connect new knowledge to concepts in other courses and/or disciplines

Problem-Based Learning in STEM Education

The Photon PBL Project

PBL addresses Bransford's *How People Learn* findings:

1. People come to learning experiences with preconceptions. Uncovering prior knowledge allows preconceptions to be examined and misconceptions recognized.
2. Learning concepts and skills within a meaningful context enables students to organize their learning in ways that facilitate retrieval and application.
3. Metacognition, or thinking about how one thinks, is essential for reflective practice to develop



Problem-Based Learning in STEM Education

The Photon PBL Project

The problem with PBL…

- PBL thrusts students into an uncertain, self-directed learning environment where the responsibility for learning is placed on the student, often eliciting fear and anxiety
- Frustration and anxiety can lead to disengagement from the learning process among students and can create a stressful situation for faculty trying to transition to PBL from more traditional instructional methods

Problem-Based Learning in STEM Education

The Photon PBL Project

Addressing the problem…

The Photon PBL Project

- **Three year NSF ATE project ($750,000)**
- **Project Goals:**
  - Create 8 multimedia PBL “Challenges” in photonics technology in collaboration with photonics industry and university partners
  - Recruit and train over 28 (now over 50) HS & college STEM educators to field test PBL Challenges in their classrooms
  - Create a comprehensive teacher’s guide for implementing PBL Challenges in STEM classrooms
  - Conduct research on the efficacy of PBL in STEM education

Problem-Based Learning in STEM Education

The Photon PBL Project

Photon PBL Challenge Structure:

Three levels of difficulty (or autonomy) to scaffold the development of students' problem solving skills.

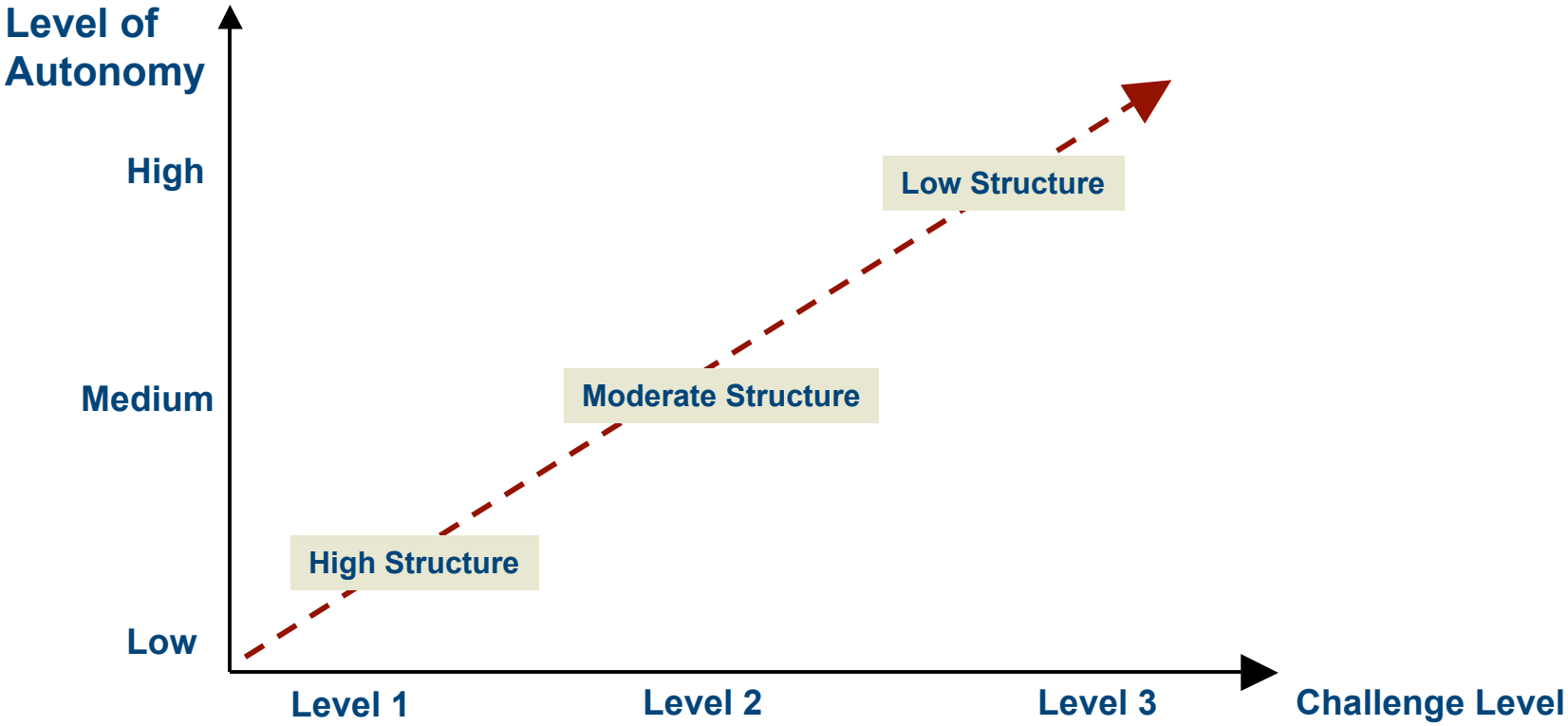
- **Level 1 (Low Autonomy: High Structure)** – **Case Study**: Highly directed. Student is an active participant in structured, instructor led problem solving activity to develop rudimentary problem-solving skills. Low autonomy.
- **Level 2 (Medium Autonomy: Moderate Structure)** – **Guided Problem**. Students have more responsibility in framing the problem statement and generating viable solutions. Some guiding information and resources are provided, but students work in small teams to identify remaining information and required resources through self-directed learning and brainstorm alternative viable solutions.
- **Level 3 (High Autonomy: Low Structure)** – **Open Ended Problem**: Students are presented with a real-world problem with little or no information other than the problem statement. Students work collaboratively to develop and test problem solutions.

In each case, the actual problem solution is presented only AFTER student solutions have been presented. Solutions are then compared and contrasted to provide an opportunity for group reflection.

Problem-Based Learning in STEM Education

The Photon PBL Project

PBL Continuum



Problem-Based Learning in STEM Education

The Photon PBL Project

Photon PBL "Challenges"

- PhotoMachining – *Laser Wire Stripping*
- IPG Photonics – *Fiber Laser Burn-In Testing*
- BU Photonics Center – *DNA Microarray Fabricator*
- UPenn Orthopaedic Research Lab – *Laser-Based Tissue Measurement*
- Penn State Electro-Optics Research Lab – *Infrared Technology for Search & Rescue*
- Cal Poly Lighting Center – *Light Bulb Output Measurement*
- Drexel University/Onsite Neonatal Partners – *Portable Phototherapy Treatment for Infant Jaundice*
- Rayval – *Holographic Display Technology (Tentative)*

Problem-Based Learning in STEM Education

The Photon PBL Project

Photon PBL Challenge Website:

http://vilenski.org/pub

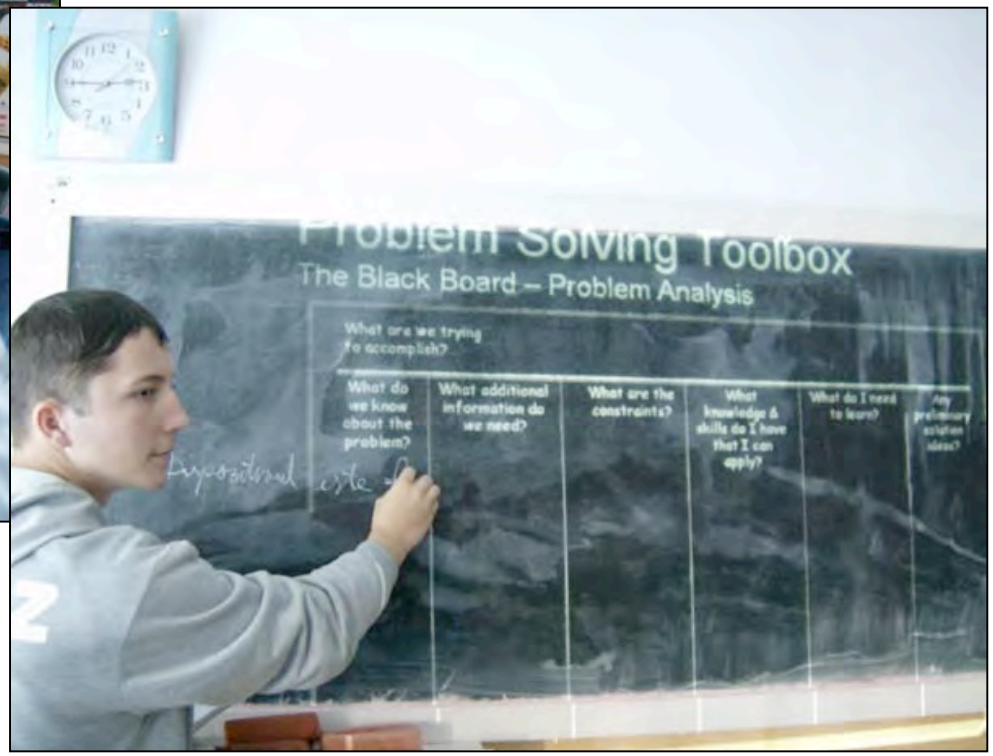
(Passwords Attached)

Photon PBL Project Conference Papers and Related Resources

http://photonprojects.org

Problem-Based Learning in STEM Education

The Photon PBL Project



Romanian HS Students using Photon PBL "Whiteboards"

Concluding Remark

Providing students with an educational experience that most closely emulates the world in which they will apply their knowledge and skills will produce proficient individuals capable of adapting to the ever-changing workplace of the 21st century