Problem-Based
Computer-Supported
Collaborative Learning

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Outline
• Introduction
• Collaborative Learning
• Problem-Based Learning
• Teaching Problem Formulation
• Examples
• Educational Assessment for PBCSCL
• Conclusions

Quick Review
• Crowdsourcing
  − Open call
  − Large network of potential laborers
• (Jeff Howe)
• A question and a meta-question...
• (TBA)
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Why PB–CSCL?

• Problem–based: “Authentic,” content is motivated by the problem; top-down and not bottom-up.
• Collaboration: socially grounded, integrated with communication
• Scalable to complex problems.

• Students today grow up with technology.
Meeting Student Expectations

The rapid pace of technological advancement has created a gap between formal education and the expectations of learners who live in an "online experiential environment."


New Forms of Engagement

• MOOCs attract many participants
• Their lectures are effective
• Lab activities less so
• New forms of online engagement are needed
• Need assessability

Teach Collaboration

• Develop communication skills
• Develop ability to contribute to group
• Learn to resolve conflicts
• Learn to use collaboration tools

Collaborative Learning is More Fun

Students are better motivated.

Employers want engineers who have learned how to work with others.

Collaboration in learning is both a means and an end.
Students Need to Know PS

“the only legitimate goal of education and training should be problem solving.”

--David Jonassen


Students Need to Know CPS

Universities need to teach students:

Collaborative Problem-Solving
(Both Theory and Skills)

Learning from Peers

• In a collaboration, the participants may bring diverse perspectives, and they can learn from each other...

• (even if they are all physicists)

Einstein, Newton, and Pascal

decide to play a game of hide-and-seek. It’s Einstein’s turn to count to ten, so he covers his eyes and starts counting to ten. Pascal runs off and hides. Newton draws a one-meter by one-meter square on the ground in front of Einstein and stands in the middle of it. Einstein reaches ten and uncovers his eyes. He sees Newton and immediately exclaims, “Newton, I found you. You’re it!”

Newton smiles and says, “You didn’t find me. You found a Newton over a square meter. You found Pascal!”
Collaborative Problem Solving

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Foundations of CSCL
• Computer–Supported Collaborative Learning
• Constructivist Pedagogy
• Socially Grounded Learning
• Roles for Computers

CSCL Emerged in the early 90s
• Conferences on CSCL.
• Lauren J. Bricker, Steven L. Tanimoto, Alex I. Rothenberg, Danny C. Hutama, Tina H. Wong — 1995. Multiplayer Activities that Develop Mathematical Coordination. CSCL 95 Conference Proceedings.

Definition of Roschelle & Teasley
“Collaboration is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem.”

(note that having a problem is fundamental to this notion of collaboration)
Deconstructing the R&S Def’n

The JPS (Joint Problem Space) is a shared knowledge structure that supports problem solving activity by integrating:
(a) goals,
(b) descriptions of the current problem state,
(c) awareness of available problem-solving actions,
(d) associations that relate goals, features of the current problem state, and available actions.

Early Example of CSCL

CSILE (aka Knowledge Forum) -- Wiki-like forum for co-constructing knowledge through textual externalization
Bereiter & Scardemalia

Constructivism

Pedagogical framework based on the assumption that each learner must build his/her own mental representations of knowledge through interactive processes, rather than simply assimilate it by listening or reading.

John Dewey: An Early Constructivist

"The teacher is not in the school to impose certain ideas or to form certain habits in the child, but is there as a member of the community to select the influences which shall affect the child and to assist him in properly responding to these Thus the teacher becomes a partner in the learning process, guiding students to independently discover meaning within the subject area. This philosophy has become an increasingly popular idea within present-day teacher preparatory programs." (1897)
Collaborative Problem Solving

To Support Construction of Knowledge

- Provide physical objects/environments
- Situate learning socially
- Provide meaningful problems
- Be a guide on the side, rather than sage on the stage
- Offer tools for communication, externalization, knowledge processing

Socially Grounded Learning

- Learning takes place most effectively within "communities of practice."
- COP: a group of people who interact together in a social, work context.
- Apprenticeships, internships, workshops, archaeological digs, military training, cooperative education.


Other CSCL Issues

- Group formation & monitoring
- Group dynamics — leadership, coasting, focus on or distraction from the problem
- Assessment: individual vs. group.

Measure the extent

- to which a diversity of perspectives is expressed during the course of a group activity...
Werner Heisenberg, Kurt Gödel, and Noam Chomsky walk into a bar. Heisenberg turns to the other two and says, “Clearly this is a joke, but how can we figure out if its funny or not?” Gödel replies, “We can’t know that because we’re inside the joke.” Chomsky says, “Of course it’s funny. You’re just telling it wrong.”

Jigsaw–Puzzle Activity Structure

• To foster engagement by all group members, structure the activity to provide individual responsibilities.
• Each student finds or builds and learns a different piece of knowledge required in the solution, and is responsible for bringing it to the group.

Constructivism in CS Educ.

• Before moving on to Problem–Based Learning, we return to the subject of computer tools that support the expression of algorithms in novel ways.
• Recall our discussions of transparency and liveness in Lecture 3 ...
• (refer to Lecture 3 handout, slides 69–102)

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Problem-Based Learning

- Howard Barrows (1928-2011), medical educator
- Students were unmotivated with the traditional pedagogy
- PBL took the forms of diagnosing simulated patients, solving authentic clinical problems, analyzing knowledge deficiencies, emulating practitioners.

Problem-Based Learning (def)

“an instructional method that initiates students’ learning by creating a need to solve an authentic problem. During the problem-solving process, students construct content knowledge and develop problem-solving skills as well as self-directed learning skills while working toward a solution to a problem.”

(Hung, Jonassen & Liu, 2008).

Motivational Aspects

- Old-school pedagogy: “drill and kill” – lack of intellectual motivation
- PBL pedagogy: the problem motivates the learning of disciplinary knowledge

PBL -- Possible Downsides

- Potentially higher costs of facilitating multiple learners or groups at different stages of solving.
- Challenges of obtaining authentic problems and real tools
- Curriculum may be incompletely covered.
- Dewey argued for balanced approaches between student-centered and curriculum-centered.
Aspects of PBL

• Who does the formulation (instructor or students)?
• Brainstorming and information gathering * (aside: “Support for Creativity”)
• Solving process -- is it hosted on a computer? CoSolve-like system?
• Assessment (traditional or PBL-oriented)?

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Teaching Problem Formulation

• D. Jonassen's process
• Coding
• Computational Thinking
• Software Engineering and Problem Posing

Scaffolding Problem Formulation

• Providing Preformulations
• Providing Formulation Examples
• Low-fidelity prototypes
• Iterative formulation
Collaborative Problem Solving

- Problem Formulation and Software Engineering
  - Teaching of problem formulation shares much in common with teaching of software engineering.
  - (refer to Lecture 2 handout, slides 107–113)

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PBL in Digital Signal Processing

- Course on DSP at the Univ. of Victoria (British Columbia, Canada) Dept. of Electrical Engineering.
- PBL component added to improve student engagement and ability to solve problems.
  - Custom-made software: EasyDSP

PBL in DSP at U. Vic. (cont.)

- Two examples of problem categories were given to students:
  - Speech signal enhancement:
    - unshielded mic. cable -> 60 Hz hum. & Low S/N ratio.
    - students select SP blocks, justify the selections, tune parameters.
  - Webcam face image enhancement for printing:
    - Low res., inexpensive sensor, overexposure, poor contrast.
    - students identify methods (e.g., de-noising, sharpening, histogram equalization, removal of specular regions), implement the sequences of steps, and tune parameters.

Lessons learned:
- 1st offering was an intensive learning experience for the instructors.
- challenging to teach: 70 students with one T.A. and instructor.
- only 15% of students chose to formulate their own problems, in spite of extra credit for this.
Collaborative Game Design and PixelMath

- Problem: Design a game that involves image processing. The game should be fun and educational.
- Collaboration: Work in teams of 3 or 4.
- Make use of the PixelMath software
- Context: “Introduction to Image Processing and Python” (U.W. course)

Example Game for Students

- “Transcentration” (related to the card game “Concentration” and relating image processing transformations to the formulas that express them)

Problem-Based vs Project-Based

- Problem ~ Project
- Often differences of scale
- “Term project” but not “Term problem”
- Both may involve design and/or analysis.
- Problem ~ comports with the Classical Theory. A project might not.

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Educational Assessment for PBCSCL

- The challenge of assessment
- Facet-based instruction
- Event history approach
- Object-centered assessment
- Hybrid methods

The Challenge of Assessment

- Did each student learn what s/he was supposed to learn?
- What did each group accomplish?
- What did each group learn?
- Unobtrusive vs intrusive assessment

Facet-Based Pedagogy

- A facet is a conception or misconception about some aspect of a concept.
  - “Objects in motion tend to come to rest.”
- In disciplines such as physics, catalogs of common facets can be built in advance.
- Assessment reduces to diagnosing what facets a student holds.


INFACT

- INFACT — Integrated, Networked, Facet-based Assessment Capture Tool.
- The instructor (with computer assistance) diagnoses facets based on students’ forum postings.
- The diagnosis can inform the teacher’s suggestions to students or even re-grouping of teams.

The INFACT Pedagogical Cycle

• Monday: Teacher posts a problem.
• Tuesday: Students independently propose solutions or approaches. Then “curtain” is lifted, so they can see groupmates’ answers.
• Wednesday: Online group discussions.
• Friday: Each group posts its consensus solution.

Event History Approach

• Each student action is logged as an event.
• The event history is analyzed, and contributions are measured in terms of their intrinsic properties. E.g.,
  – Average length of discussion post;
  – Amount of turn-taking;
  – Use of particular PS operators;

Assessing P.S. Collaboration

Object-Centered Assessment

• Begin with the solution. (e.g., a constructed object)
• For each of its components, examine the history of actions applied to it.
• Determine the functional role played by each student in each action.
• Ascribe quality the solution or solution piece to the quality of a student’s action.

Hybrid Assessment Methods

Articulated assessment:

- Unobtrusive assessment happens continually, behind-the-scenes.
- On demand (of decision-making processes or teachers), either in-situ interviewing or separate quizing or testing is administered.
- Triggering depends on both demand for assessment, and an evaluation of the quality of the current assessment through probabilistic reasoning.

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Conclusions

- Collaborative Learning is a mainstream approach to pedagogy in STEM fields.
- Problem-based learning is also mainstream.
- CSPBCL puts the two together.
- Students should learn how to manage work, control agents, as well as formulate and solve.
- Assessment methodologies should include a mix of session based and traditional.
- Allowing students to work in international teams can add relevance for the global nature of future work.

Research Issues

- How best to foster the learning of problem formulation.
- How best to integrate general computational tools and communication tools with problem-solving tools.
- Design and analysis of means to interlink problem-based learning and traditional curricula.
- Design and evaluation of articulated assessment systems for measuring student learning during collaborative problem solving.
- Design of supports for creativity plus disciplined solving.
But what if one has no collaborators?

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Thank you