High School Teachers' Approaches to Promoting Self-Monitoring in Physics Problem Solving by their Students

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What Troubled Us

Research:
Shows traditional teaching $\Rightarrow$ weak problem solving skills
Explores Learning difficulties

Research based curricula:
Shows improvement in problem solving skills
• Context rich problems - Analyze, plan, try out, revise
• Problem solving strategy - Strategic decision making
• Cooperative problem solving - Evaluate and diagnose
  [Heller et al, 1992, Huffman, 1994, Foster, 2000]

Teachers practice:
Reflects some aspects of research based curricula
Yet, seldom are they fully implemented.
Possible Solution

Analysis - What is required of teachers:
Change roles, Change concepts and habits
Coordinate new and traditional agenda [Hammer, 2000]

Leads to: • Fear of trying new practices
    • Giving up what does not work on first shot

Yet,
For change to occur teachers must face their fears

Teachers' educators: [Feldman, Hammer]

Collaborative Physics Teacher Inquiry
Teacher reflect on the very process of applying a new classroom practice

• Enrich teachers' interpretations of class events
• Support teachers in a process of change
Outline:

• Design of physics teachers' workshop:
  Collaborative teacher inquiry to promote self-monitoring in problem solving
• Professional development of participants

Results:

What does not work?
Research Based Curricula + Concerned and Experienced teachers + Collaborative Inquiry

What works?
R.B.C. + Teachers with Ownership and Experience + Management Framework for Collaborative Inquiry

What happened to teachers?
Teachers tried R.B.C., refined it to meet their needs.
• "Teachers curricula": Diverse, incomplete
• Change in teachers' perceptions: Long time-scales
Design of Teachers' Workshop

Workshop goals: To help teachers to
• Tailor existing curricular developments
• Develop in their own instruction

Important elements:
• Introductory constructivist workshop:
  Introduce research, Induce concern
• Yearlong meetings:
  Leader imports Research + Curriculum
  Teachers Autonomous to implement
  Discussion: external + internal innovations

Formative evaluation
2 workshops, ~ 7 Motivated, experienced teachers, teacher centered practices.
Diverse schools, ~ 30 students per teacher
Matriculation exam
Results

Teachers' concerns

Students problem solving
Short time accountability (Matriculation)

Fear of trying new practices
Giving up what does not work on first shot

Our conclusion

Research Based Instruction + Concerned and Experienced teachers + Collaborative Inquiry

Does not work!

No magic solutions,
Teachers need to design, try, fail, and refine their own solutions, \( \Rightarrow \) Support is needed
Third Workshop - Did Work

Introductory workshop:

Beyond concern $\Rightarrow$ Ownership

Yearlong meetings: Management framework where teachers follow action research steps:

- Analyze existing practice
- Suggest new practice
- Try
- Evaluate and Refine
Flag man (presenter) method:

Presenter:

Documentation:

What happened, difficulties

Peers: Feedback

Revision:

What’s next? What's the solution?

All:

Discussion of presenter’s experience
Evaluation: What’s wrong

Set goals
Construct materials

All: Analyze, Plan instruction

All: Trying Out

Presenter:

Documentation:

What happened, difficulties

Peers: Feedback

All: Analyze, Plan instruction

Set goals
Construct materials

All: Trying Out

All: Revision: What’s next? What's the solution?

All:

Discussion of presenter’s experience
Evaluation: What’s wrong

Class

Teacher

Group
Management framework implementation

9 learning cycles, interwoven with other activities

In person setting transferred to computerized setting: (1st accessibility, 2nd teachers' request)

Friday: Editing documentation
  Presenter e-talks to workshop leader

Monday: Distributing documentation
  Presenter sends documentation to e-forum

Monday-Wednesday: Reading, writing feedback
  Peers read documentation and write feedback at home

Wednesday: Distribution - feedback
  Peers send feedback to e-forum

Thursday 1800: Distribution - questions
  Presenters send questions to e-forum

Thursday 2200-2300: Discussion
  All participate in e-conference
Management features  ⇒  Teacher inquiry  ⇒  What changed

Distinct steps of learning cycle

Comprehensive, clear and concise documentation

Suggestive Feedback that refer to class materials

Commitment of teachers to formulate questions

Focused, informed and tolerant discussion

Distribution of documents

Teachers tailored existing research based instruction, while changing perceptions and practice

Extended Timetable

Obligatory participation

Focused, informed and tolerant discussion
We concluded

Research Based Instruction + Teachers with Ownership and Experience + Management Framework for Collaborative Inquiry

Works

Professional development of teachers

- Tracing teachers' curricular development
  - Problem solving via strategies
  - Self diagnosis by students

Data collected in intra-net over 2 years

- Documentation: Implementation, Materials developed for class.

- Questions for e – conference
A short version: Strategy for solving problems in "work and energy"

Analysis:

Physics:
Draw diagrams adequate for the problem

Divide the problem to sub-problem, in a manner helpful to solve it. For each sub-problem write equations that represent the principal of energy conservation.

Math: …Check ...

Self diagnosis based on sample solution
Students re-submit their tests with a diagnosis of their solutions (Credited).

Sample questions for e-conference
“The strong students don’t want to cooperate with the weak ones, how do you manage to cope with the problem?”
A detailed version: Strategy for solving problems in "work and energy"

**Divide:** Does the body change its motion (linear or curved trajectory, constant or changing speed)?
Does the forces on it change? Are they conservative? Do they do work?...

**Strategic diagnosis - 1**

The student has to diagnose his solution, using a given strategy, on a diagnosis-form, for example:

<table>
<thead>
<tr>
<th>Strategic steps</th>
<th>Exist?</th>
<th>Correct?</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Did he perform</td>
<td>Define what</td>
<td>Explain what</td>
</tr>
<tr>
<td>Physics</td>
<td>&quot;Strategic steps&quot;?</td>
<td>is wrong</td>
<td>went</td>
</tr>
<tr>
<td>Check</td>
<td></td>
<td></td>
<td>wrong</td>
</tr>
</tbody>
</table>
Sample questions for e-conference
"The activity demanded students to find and correct their mistakes. I see three different groups:

1. Those who are willing and able
2. Those who tried but did not succeed
3. Those who did not bother

What, If at all, Do you think students from group 2 gained from taking part in the activity?

Strategic diagnosis - 2
Strategy represented as requirements and Not as consecutive directions

Requirements from problem solution
Planning
Identification of sub-problem: choice of a body;
Listing of known and wanted quantities in the sub – problem…
Teaching professional development

- **1st Semester**

- **2nd Semester**

- **2nd Year**

  - Class materials
  - Discussion questions
  - Specific topics
  - Doubts, quest for Systematic evaluation
  - Adapted to diversity
  - Re-evaluation of goals and means
  - Strategy adapted to diagnosis
Problem solving process

Students diversity

Physics

Development

Implementation

Discussion/Evaluation

Means to meet goals

Re-examining goals

Daring

Initial

---------------------------Initial-------------------------

-----------------------Final-------------------------
Results:
Teachers elaborated Curriculum while implementing innovative instruction
- Diverse, but not complete
- Long Time-scales

Questions:
Engineering: How to reduce time-scale?
How to benefit others?

Research:
Class observation: What an external observer sees happening in class?
To the students?