Managing collaborative teacher inquiry: Cognitive lessons from implementation in a computerized network setting

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Abstract

We describe a study conducted in the context of an action research workshop for high-school physics teachers. The teachers collaboratively explored the pedagogical question: "How can we promote self-monitoring by students in physics problem-solving?" We supported the process of implementing change in the classroom through a management framework designed to enhance collaborative teacher inquiry. This framework assisted participants in learning from their experience through a repeated learning cycle that included: developing and trying out new work patterns and materials in the class, documenting classroom experiences, obtaining peer feedback, formulating and discussing questions brought up in the classroom, and trying out improvements. A group of seven teachers engaged both in face to face and in computerized implementation of the framework through out the year. We compared the actual performance of teachers in both settings. With the supportive management framework we found that teachers improved curriculum while implementing innovative instruction. We found that using a computerized network setting proved to have a critical impact on the clarity and conciseness of the documentation and peer feedback and on the teacher's ability to formulate questions about their instructional concerns. This resulted in more informed and focused discussion.

Introduction

The pedagogical problem of promoting self-monitoring by students in physics problem solving was addressed in several instructional studies. Heller & Hollabaugh (1992) designed context rich problems to impose a need to analyze a complex situation, and plan a solution. They had students solve problems cooperatively to establish a discussion in which students question and evaluate peers ideas. Problem solving strategies (Reif, 1984) serve to guide decision-making, so an iterative perception of the problem solving process is promoted, hand in hand with students' responsibility to diagnose their mistakes and revise solution. Williams (1990) design an alternative assessment in which the students themselves diagnose and assess their own work. Developers show evidence of improving students achievements; yet, not many teachers adapt these innovations.

There are several obstacles in trying to increase the use of such innovations (Reif, 1995). Among the obstacles is the lack of time available to teachers for working with individual students, as well as the traditional approach of test-directed physics teaching, which seldom aims at solving unfamiliar problems. Teachers need to undergo profound changes in their views about the goals and methods of physics teaching, especially their readiness to pass responsibility to students, as a pre-requisite to changing their classroom practice.

Hammer (1999) argues that meeting a progressive agenda places substantial intellectual demands on teachers. In Particular, teachers need to coordinate that agenda with more traditional yet important one (e.g. covering the content or preparing students for external examinations). Schoenfeld (2000) suggest that as teachers' goals and beliefs inform their perceptions of what takes place in class, and shape their actions, so does their history in class shape their goals and beliefs. Different goals and beliefs may be activated, depending on the context. This sometimes results in things not proceeding according to initial plans and in difficulties while implementing change. For this reason teachers often fear trying out new instruction, yet, for change to occur they must be able to face these fears.

The profound changes in teachers' beliefs needed to alter classroom practice can be achieved by having teachers to reflect on the very process of applying a new classroom practice. These can be met in collaborative teacher inquiry (sometime called action research). Such collaboration often induces teachers to become concerned with the failure of traditional methods to meet reform goals and provides a framework in which teachers can suggest and try out new practices, systematically learn from actual trials, and respond immediately to difficulties. Collaborative Physics teacher inquiry has consistently been found to enrich teachers' interpretations of class information, and support them in a process of change (Feldman, 1996; Hammer, 1999; Bagno & Eylon, 1998).

Following this rationale we designed and implemented three consecutive versions of a yearlong workshop for high school physics teachers, in the form of collaborative teacher inquiry. The inquiry focused on instruction aimed at encouraging students' self-monitoring in the process of searching for solutions to unfamiliar physics problems. The implementation was accompanied by a formative evaluation, based on questionnaires and interviews with teachers, and a naturalistic analysis of video documentation of the workshops. In the first two workshops we found teachers recognized the importance of promoting self-monitoring in physics problem solving, and developed theoretical and practical pedagogical content knowledge regarding this issue. Yet, we found that teachers were either not ready to implement change in their classrooms or to attempt to overcome arising difficulties. Therefore, the third workshop attempted to provide the necessary support for enhanced teacher development.

A central element of the third workshop was a management framework for the collaborative teacher inquiry that was designed to follow the steps of action research (Mcniff, 1996). (Another major element was an introductory summer workshop to build ownership by the teachers on the pedagogical problem). The management framework was implemented partly in person and partly via a computerized network setting. The computerized network setting was initially introduced to solve accessibility problems for teachers who lived far away.

When the supportive management framework was added we found that it was successful in getting teachers to implement and refine innovative instruction. The teachers expressed their belief that the computerized setting was most effective at accomplishing this goal. A comparison of the implementation of the management framework in person vs. computerized was conducted to answer the following questions:

1. How were action research steps performed by the teachers in both setting?
2. How setting constraints affect the way action research steps were performed?

Description of management framework

The management framework for the collaborative teacher inquiry consisted of a repeated learning cycle with a clearly defined schedule and participant responsibilities in the different steps of the cycle. In each cycle all participants tried out innovative instruction in class. It was the responsibility of one of the teachers (in turns) to present a documentation of his or her class experience, and to formulate questions about his or her instructional concerns regarding this class experience. The presenters were asked to include in their documentation a description of the class activity (e.g. teaching formats and related materials given to students in class), and results (e.g. students work and other feedback on class activities). See appendix for example of the type of documentation that was received. It was the peers' responsibility to give feedback on this documentation and to participate in a discussion on the aforementioned questions. The first innovations to be tried out were based on research based curriculum that the workshop leader presented, however, the teachers were autonomous to decide what type of instruction to use. Later cycles were based on the lessons learned from former ones.

Nine learning cycles took place in the year 96-97, so all participants had to presented at least once. Seven of them took place in the computerized setting, initially to enable teachers to participate in the workshop from their homes. The computerized cycles took the place of 3 hours of in person meetings that occurred every other week in the Science teaching department in Weizmann Institute. Each computerized cycle stretched over a week (detailed description in table 3). In the in person meetings the teachers engaged in learning aspects of the pedagogical problem through a review of the academic literature (presented by the workshop leader), developing new teaching formats and related materials, designing a collaborative research project, and monitoring the workshop: discussing suggestions to improve the workshop activities.

The management framework was designed to commit every teacher to try innovations in his class, focus group discussions on concrete class information, and help teachers to learn and support each other's practice, and maintain iterative process of improving their teaching. Action research steps were embedded in the workshop in the following manner:

Step in action research: **Context**	**Analysis**	**Setting goals**	**Trying out**	**Evaluation and revision**
Implementation out of the management framework	Introductory workshop		Development of instruction and materials	
Implementation within the management framework	Peer feedback, discussion	Documentation of presenter goals for innovation he tried	Trying out	Documentation of difficulties in implementation, formulating and discussing concerns

Table 1: Context where action research steps were performed in the workshop

Defining participants' responsibilities and schedules differed between the in person and computerized settings, due to the constraints of each setting. Three major features differed between settings:

? Media: spoken vs. visual (text and figures). Since writing takes much longer the computerized setting raised a need to limit the use of on-line discussion, and transfer most of the interaction to forums - computerized bulletin boards. This resulted in distinguishing between steps of the learning cycle. The documentation, feedback, and questions the presenter formulated for the discussion were all put in the forum, in a defined schedule, while the discussion took place in a 1 hour electronic conference.

? Accessibility: In a physical setting the interaction is confined to one meeting, while in computerized setting there is a possibility for an extended timetable - several updating and information transactions.

? Norms: While in an in person setting it is normal to require that teachers attend a workshop in order to receive credit for it, it is less normal to require active participation. In a computerized setting there is no meaning for attendance, as one can turn on his computer and go away. This results in an opportunity to set a norm of demanding participation.

The management framework was enforced through definition of what counts for credit of participation in the workshop. The table below summarizes the differences between the implementation of the framework in physical and computerized setting:

In person setting

Presenter	Peers
Trying out new instructional innovations	
Obligatory, in class, before workshop meeting	In class, before workshop meeting
Documentation	
At home, before workshop meeting Obligatory, reporting class experience to peers, in workshop meeting	Obligatory, Attendance in workshop meeting while presenter reports
Feedback on documentation	
	Participation in giving feedback, in workshop meeting while presenter reports
formulating questions for discussion	
At home, before workshop meeting	
discussion	
Obligatory, Attendance in workshop meeting	Obligatory, Attendance in workshop meeting for discussion

Table 2: Description of learning cycle in an in person setting

Computerized setting

Presenter	Peers
Trying out new instructional innovations	
Obligatory, in class, before workshop meeting	In class, before workshop meeting
Documentation	
Friday, (at home) reporting to the workshop leader, to prepare for publication Obligatory, Monday, sending documentation to forum (computerized bulletin board)	Reading before electronic conference (at home) documentation sent to forum
Feedback on documentation	
Responding to feedback, in forum	Obligatory, Until Wednesday, sending feedback to forum
formulating questions for discussion	
Obligatory, Thursday evening, sending 3 discussion questions to forum	Reading before electronic conference (at home) questions sent to forum
discussion	
Obligatory, Thursday 10-11 PM, participation in electronic conference	Obligatory, Thursday 10-11 PM, participation in electronic conference

Table 3: Description of learning cycle in a computerized setting

The workshop leader role in such a cycle was to verify that participants follow the schedule guidelines, and to help the presenter to prepare the published presentation.

One can see from the tables that while in the computerized setting the steps of the learning cycle (documentation, Feedback, formulation of questions, and discussion) were distinguished and obligatory, in the in person setting they all took place in the meeting, were much less distinguished and were not obligatory. The main differences in implementation features due to setting constraints were:

Implementation features of computerized vs. in person setting
Distinct vs. combined steps of learning cycle
Extended vs. confined timetable
Obligatory vs. optional participation
Distribution of documents and textual chat vs. spoken conversation

Table 4: Implementation features

Research methods

Subjects and setting

During 1996-1997 a yearlong workshop was conducted in the science teaching department at the Weizmann Institute of Science. Seven teachers participated, All experienced (6 have over 20 years of experience), from schools of diverse levels around Israel. All are teaching students who have to take the matriculation exam (covering curriculum similar to

introductory physics in the college level). Their class size ranged between 20-35 students. From an analysis of their initial questionnaires regarding their perceptions about problem solving learning and instruction we learned that they possess a gap between practices that are teacher centered and beliefs about learning that are student centered. All the participants chose to engage in the workshop after an introductory summer workshop, and were highly motivated as documented in their feedback questionnaires to the summer workshop.

The computerized cycle was implemented through communication software (Worldgroup Manager Copyright © 1996 Galacticomm, Inc.) that connected the participants through a server located at the science education department in the Weizmann Institute running compatible software (Worldgroup server software by Galacticomm, Inc.). The software has the following features used in the workshop:

? Electronic mail (Text + attached files).
? Electronic bulletins boards (Forums) that no one but the participants could enter. A forum has a manager (the workshop conductor) who is the only one who can approve or erase mail sent to the forum.
? Electronic conferences open up to 10 participants.

Data

The data for comparison is taken from a trial session of the two settings during the first third of the year. Two cycles of the management framework implemented in person took place in October and November of 1996, and four cycles implemented in computerized setting took place in December 1996 and January 1997. (Initially we planned to have 3 cycles in each setting, with the third after 2 computerized cycles, but due to the teachers' request one in person cycle was replaced by a computerized cycle).

? Computerizes cycle data consists of e-mails and attached files sent to the forum (Documentation, peer feedback, Questions for discussion), and the protocol of the electronic conference.
? In person cycle data consists of transcripts of videos of the workshop meetings, and of documents distribute distributed by the presenter to the participants.
? Teachers' feedback on the trial session was gathered twice, in the end of the trial session, and in the end of the year, through feedback questionnaire and transcripts of discussions. In the questionnaire, participants had to give feedback both from a presenter point of view, and from a peer point of view

Analysis tools

The analysis tools consist of categories to describe the actual performance of the learning cycle by the teachers.

Categories for comparison of documentation and peer feedback on it:

Medium - (defined externally in computerized setting) did the presenter also use textual medium?

Length - what is the amount of verbosity of document or conversation transcript?

Continuity - is documentation/feedback presented as a complete unit, or as fragmented cluster?

Structure - what was the documentation/feedback organization, and who defined it?

Extent of description - is class experience description complete and detailed?

Clarity of formulation - is documentation/feedback presented clear?

Scope - what are the main issues the documentation/feedback focus on?

Interaction between presenter, peers and workshop leader - did the peers asked for clarifications? In what timetable? What roles did the workshop leader take?

Categories for comparison of discussion:

Timetables - (defined externally in computerized setting) in what sequence did the steps of the learning cycle take place? (E.g. when were the questions for discussion formulated?)

Length - what is the amount of verbosity in the discussion? How much time was did the participants deal with one question?

Discussion rules - is discussion spontaneous, or guided by formal rules?

Who formulates questions for discussion - presenter, peers, leader?

Structure - How did the discussion evolve?

Interaction Style - was the discussion relaxed or aggressive? To the point or personal?

Main issues - what are the main issues the questions/discussion focus on?

Personal styles - did personal styles change? (E.g. passive participants took active roles and vice versa, patient participants turned to be impatient).

Results

The actual performance, of the learning cycle steps, by the teachers is summarized in the following tables. The tables also include a brief summary of the teacher's feedback on the trial session from a presenter and peer's point of view.

Documentation

	In person	**Computerized setting**
Medium	Mostly conversation	All Textual
Length	Short document (up to 1 page) + 1 hour of presentation, High volume of verbosity	Long document (up to15 pages), smaller volume of verbosity
Continuity	Fragmented, cut by peers questions, and occasional discussions	Complete unit

Structure	Organization around questions of peers and workshop leader	The presenter organizes by categories: class description, activity description, and materials…
Extent	Detailed description of class experience	Detailed description of class experience
Clarity	Low, live report with little editing	High, documentation prepared for publishing
Scope	activity description Presenter considerations Students reactions Speculations on students psychology	In response to peers questions as: How long did it take? Who did what? Why did you do so? How did students respond? Why?
Interaction	Peers and workshop leader can ask for clarifications while presenter reports documentation	Peers and workshop leader can ask for clarifications after reading documentation
Presenter feedback		"Writing documentation helped to distinguish what was important"
Peers feedback	"Documentation was not focused"	"Reading documentation was like entering another teacher world, and enabled me to use materials developed by peers"

Table 5: Documentation – teachers' performance in person vs. in computerized setting

Peer feedback

	In person	**Computerized setting**
Medium	All conversation	All Textual
Length	Short interruptions (1-3 minutes)	Long document (up to 2 pages)
Continuity	Fragmented	Complete unit
Structure	Short questions while presenter reports	Different font used within the documentation
Extent	Clarification questions and remarks	Complete suggestions for improvement, clarification questions
Clarity	Low, live report with little editing	High, documentation prepared for publishing
Scope	Some categories of documentation, mainly activity description, presenter considerations, students reactions. No reference to materials. Speculations on students reactions	All categories of documentation Speculations on reasons for the activity results
Interaction	Immediate response of presenter for clarification questions Workshop leader guides the interaction	Some times no response of presenter for clarification questions. Workshop leader has a similar role as peers

Table 6: Peer feedback - teachers' performance in person vs. in computerized setting

Formulating questions

In the physical setting, although they were asked to do so, the presenters did not formulate questions for the discussion. The questions arose spontaneously from clarification questions in the peer feedback. Only in the computerized setting did the presenters formulated questions for the discussion. At first presenters were very troubled by the need to formulate questions, and expressed their feeling that they didn't understand what is expected from them.

One initially formulated questions that were completely irrelevant to what she tried out, another claimed that he just can't formulate questions, while a third presenter kept asking for clarification of what is expected from him. Most teachers started with formulating questions that had a summative evaluation nature (e.g. did the class activity help my students?) and not of formative evaluation nature (e.g. questions aimed at refining the activities). The workshop leader directed the teachers to formulate formative evaluation questions to support refinement of teaching formats and materials. The result were questions that dealt with the following issues:

? Management considerations (e.g. "should I demand my students use a strategy in their problem solving, or should I just recommend them to do so?")

? Diversity considerations (e.g. "The strong students don't want to cooperate with the weak ones, how do you manage to cope with this problem?")

? Rewriting materials to meet students preferences (e.g. "students don't like to be guided while solving problems, maybe I should write problems with several hints in them?")

In the feedback discussion for the trial session the teachers initiated a discussion of "what is a good question?" in particular for an in person vs. computerized discussion. They recommended that pedagogical considerations in the activity would be discussed in computerized setting, while questions regarding materials development would be dealt with in person.

Teachers' discussion

	In person	Computerized setting
Timetable	Questions formulated while presenter reports class experience	Questions formulated after presenter reports class experience
Length	Ranged between several minutes to 1 hour per question	20 ± 5 minutes per question
Discussion rules	Spontaneous	Participants were asked to write no more than 2 lines
Who formulates questions	Peers + workshop leader	Presenter
Structure	Divergent discussion, not focused on initial question, interrupted by clarifications of documentation	Discussion focused on presenter questions, takes place after documentation completed
Personal style	Teachers change their style of communication, some who were not verbal turned verbal in the computerized forum, and vice versa, same about being patient in the discussion	
Interaction style	Discussion contains personal criticism (are you sane?)	Discussion does not contains personal criticism

Table 7: Discussion – teachers' performance in person vs. in computerized setting

Discussion

The teachers' performance in the computerized setting was better than their performance in the in person setting in several aspects:

? Comprehensive, clear and concise documentation and peer feedback that refer to materials distributed for students (Problems, problem solutions, working sheets)

? Commitment of teachers to formulate questions.

? Focused, informed and tolerant discussion

In the following WEwill suggest how these aspects relate to the implementation features of the management framework in the computerized vs. the in person setting that consisted of:

? Distinct vs. combined steps of learning cycle

? Extended vs. confined timetable

? Obligatory vs. optional participation

? Distribution of documents and textual chat vs. spoken conversation

In particular we would analyze two ways in which the computerized work was done: Through forums, and through electronic conference.

Forum

The forum work distinguished both documentation from discussion, and peer feedback from formulation of questions. In person those would be closely related (peers would respond

while, or immediately after, the presenter reports his class experience). In the forum the following scenario would take place:

Documentation: The presenter writes at home a document reporting his class experience

Editing: The presenter interacts with the workshop leader, to revise his documentation

E-mailing: The presenter sends his documentation to peers

Reading: The peers read the documentation at home

Writing feedback: The peers write their responses.

E-mailing: the peers send their feedback.

This may seem too detailed, but it has several benefits:

Effect on documentation: Making distinction between writing a document and sending it gives the presenter the delay time needed to rethink and revise his document, which is less likely to happen when he speaks. The need to distribute the document, which resembles a publication, although it is for small known group, results in higher editing standards. The extended timetables made it possible for the presenters to submit their initial documentation for the workshop leader, and receive some editing suggestions. The distinction between the steps of peer feedback and the report of the documentation does not leave the possibility of clarifying questions while the documentation is presented, so the documentation should be as complete as possible.

Effect on the peer feedback: Participants got a full picture of what happened in class before responding. They had time to concentrate on the materials distributed for students (e.g. physics problems, solutions, worksheets) which requires personal concentration not possible in a conversation. They looked at the documentation at their home, where they have their own materials, they can compare to and attach to the feedback.

Effect on formulation of questions: The presenter also had the opportunity to look at a complete document describing his own experience. The participants said in their feedback questionnaires that this helped them to recognize their main concerns. The presenter had time to read peers feedback before formulating his questions for the discussion, so he could incorporate his peers concerns and suggestion with his own.

Effect on discussion: The peers came to the discussion well informed about the presenters' class experience, and their was no need to distract discussion by many questions about what happened in class. The class experience served as an anchor for speculations brought up in the discussion by teachers.

Electronic conference

In the electronic conference, as in the forum, people had time to rethink what they sent to peers, avoiding saying things that may be regretted later. As there is no physical way to feel

the gaps in the electronic conference there is a need for an anchor to keep the discussion going. This has several effects:

Effect on formulation of questions: The teachers were committed to formulate questions that would serve as an anchor for the discussion.

Effect on discussion: Personal style was more tolerant, representing the participants' effort to keep the discussion going.

The implementation of the management framework in a computerized setting made the teachers work hard. They kept saying they work much harder than any other in-service workshop they had participated in. Yet, they all asked to continue the workshop for another year. They reported in their feedback questionnaires that what they mostly enjoyed was the quick benefits of new materials and instruction for their next day class, as well as a continued consultation with their peers.

The comparison between computerized and in person setting implementation of the management framework makes explicit the critical implementation features one has to take into account to enhance the productivity of such framework.

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Appendix

Sample Documentation: Summary of Document Teachers Sent to the List

Teaching format: student diagnosis of their problem solution using a "strategy"

1. **Course of teaching format** - what was planned and what actually happened in class

"The lesson after an exam, The students gets unchecked copies of their exams, and a diagnosis form. Student has to diagnose their solution, on a diagnosis-form, and to submit their diagnosis. Their grade will be an average of their initial grade and their diagnosis grade".

2. **Directions students got**: problem, diagnosis form

explanation	Correct?	Exist?	**Strategic steps**
Explain what went wrong	Define what is wrong	Did you perform	Description
		"Strategic steps"?	Physics
			Execution
			Check

3. **Summary of some results: Samples of** students work (solutions, Student diagnosis), impressions:

"Half found most of their mistakes, but not those regarding the pattern of the field lines…
The other half consists of those who always wait until I'll tell them what to write.
I talked with the students and heard 3 views:

? Didn't help. Because I didn't get the right answer
? I want diagnosis based on sample solution
? Helped me, since it made me summarize what I know, I think now you should give a "normal" quiz".