Study Team Strategies and Teacher Training

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Bartholomew Consolidated School Corporation (BCSC) is one of nine school districts across the state of Indiana that participated in the Indiana Mathematics Initiative (IMI), a collaborative project with Indiana University. During the 2007–2008 school year, BCSC received funding from IMI to support several professional development sessions for elementary, middle, and high school teachers.

This paper describes the professional development workshop that was used to train mathematics teachers, along with science teachers, on how to increase student communication and accountability in cooperative learning groups through the use of "study team strategies." This professional development and the study team strategies can be used with any mathematics program, as well as other disciplines, to increase student communication and accountability, as they work in cooperative learning situations. (To read about a different IMI-funded professional development program in BCSC, see "Building a Professional Learning Community through Text Protocols" by Dale Nowlin. (http://www.indiana.edu/~iucme/perspectives/14nowlin.pdf))

Rationale

BCSC adopted the College Preparatory Mathematics (CPM) program for all Algebra 1 and Algebra 2 classes. The CPM program is an inquiry-based program in the spirit of the National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (2000). Cooperative learning is at the heart of the CPM program. Instead of the teacher using the traditional method of demonstrating by example, students work in "study teams" to solve problems. The program is designed to get students engaged in tasks with a higher cognitive demand, as they develop conceptual understanding of the mathematics.

After the first three years of using the CPM program, it became apparent through classroom observation and teacher self-reflection that students were not communicating with each other in their study teams in effective ways. One goal of the study teams was that students were to share their mathematical reasoning, justify their procedures, and support each others' learning. However, what often happened was that students would sit together, but work individually, on the problems or, at best, check answers with each other.

The CPM resource material includes study team strategies to encourage student-to-student communication and to increase individual student accountability while they work cooperatively in study teams. The purpose of this professional development was to increase teacher knowledge and classroom implementation of the study team strategies. An additional goal was to connect the study team strategies with the work the district had already begun on Costa and Kallick's *Habits of Mind* (2000). Habits of Mind are described by Costa and Kallick as "having a disposition toward behaving intelligently when confronted with problems, the answers to which are not immediately known" (p. 1). They describe sixteen behaviors, or

"Habits of Mind," which they feel are "indicative of the efficient, effective problem solver" (p. 2). These include, for example, being persistent, "thinking and communicating with clarity and precision" (p. 8), flexible thinking, the use of metacognition (i.e., thinking about thinking), and asking questions.

It was decided to include mathematics and science teachers because the Habits of Mind work was being used in both departments, and both departments emphasize cooperative learning. It was hoped that if students heard common language from both departments, it would increase the probability of their actually using these strategies.

Workshop Format and Goals

The workshop was designed to take three hours, although it could easily be expanded to a longer time-frame, even a full-day workshop. The goals were as follows:

1. Teachers will increase their knowledge of study team strategies.
2. Teachers will increase their knowledge of Habits of Mind.
3. Teachers will see connections between study team strategies and Habits of Mind.
4. Teachers will increase their use of study team strategies in their daily lessons.
5. Teachers will actually experience the strategies as the facilitators model them.
6. Science teachers will learn some of the CPM alternative approaches to algebra.

In keeping with goal 5, the study team strategies were introduced in the context of doing mathematics. The mathematics included in the workshop was selected with both math and science teachers in mind. Aligning with goals 1 and 4, following each activity there was a short debriefing session on the strategy itself, and teachers brainstormed on possible situations or specific content with which that particular strategy would fit in lesson planning. To accomplish goals 2 and 3, there was also a debriefing session at the end of each activity in which participants identified which Habits of Mind they saw in action or thought the particular study team strategy encouraged. The workshop did not include experience with all twenty study team strategies listed on the card. It was decided that classroom implementation would be more likely if the workshop focused on those strategies that would most easily be included in math and science lessons.

Study Team Strategies

A summary of the study team strategies is given in Appendix A. (A copy of these cards and more information on the strategies can be found at http://www.cpm.org/teachers/study.htm.) This sheet was given to all participants on card stock. It was used as a reference during the workshop and throughout the following school year. None of these strategies are unique to the CPM program and can be used by any teacher with any program. However, the strategies do fit well with the CPM program because of its emphasis on the incorporation of cooperative learning as part of the daily routine. This also goes along with the workshop goal of increasing the use of the strategies in both mathematics and science classes.

Team Assignments

As teachers arrived for the workshop, they were each given a playing card. As the workshop began, teams were determined by the cards. The four participants who were given aces became one team, the participants with two's formed another team, and so on. Teachers stayed in these teams throughout the workshop.

One study team strategy specifically aimed at increasing individual accountability is "Numbered Heads." Within the study teams, each member was given a new number from 1 to 4. Throughout the workshop specific tasks were given to individuals within a team by their number.

Activity One: The Importance of Study Teams

In the first activity teachers were paired within their teams using "Numbered Heads." Persons 1 and 2 were paired and persons 3 and 4 were paired. Participants were given the prompt, "Why is it important that we have students work in cooperative teams in our math and science classes? What is gained by having students work together?"

This prompt was used to introduce another study team strategy: "Think-Ink-Pair-Share." Participants were given one minute to think and then one minute to ink, or write, their own personal ideas relating to the prompt. This is followed by a pairing. Persons 1 and 2 paired off to share their ideas with each other, as did persons 3 and 4 within each group.

The "Share" part of the strategy comes after two minutes of shared pairing when the two pairs within each team get together and compare their ideas as a team of four. This activity served a dual purpose of (1) having the teachers create a list of reasons that having students work in teams benefits their learning and of (2) having the teachers practice the "Think-Ink-Pair-Share" strategy. Following the activity, the teachers shared with the whole group ideas of how they might use this in their classroom. Some of their suggestions included using the strategy as a way to discuss a reading assignment, as a way to review a unit by responding to a prompt like, "What are the topics you should understand from this unit?" or as a way of getting started on an in-depth math or science problem.

Activity Two: Habits of Mind

Included in the handout to participants was a twenty-page summary of the Habits of Mind, with one or two pages devoted to each of the sixteen habits. Eight of the Habits had been chosen to be examined, and each of the eight teacher teams was given one of the Habits.

Using a "Jigsaw," a between-groups strategy, each team was given the task of studying and learning about their assigned Habit of Mind and preparing a one- to two-minute presentation to the larger group. The group of teachers had a wide range of expertise on the Habits of Mind. Some had been involved in a book circle in which they read one of Costa and Kallick's books; others had done no previous work with the Habits of Mind. This part of the workshop gave all teachers some exposure to eight of the sixteen habits and gave them a chance to experience the Jigsaw between-teams strategy.

As a follow-up activity, teachers were asked to identify any Habits of Mind they had observed themselves or others using in the workshop up to this point, including the work with the Think-Ink-Pair-Share and the Jigsaw activities. Participants then had a short brainstorming session in which they identified possible uses of the Jigsaw between-teams strategy within their classrooms. Some ideas that came out included having each student study team be responsible for the material and/or homework questions from one lesson within a unit of study, when, for example, studying quadrilaterals in geometry, having each team become experts on one of the types of quadrilaterals and its properties and share with the class, and dividing up a topic like properties of exponents and having each team present one of the properties to the class.

Activity Three: Multiplying Binomials

The next session showed how algebra tiles and an area model are used as one method for multiplying binomials. This topic was chosen for the benefit of science teachers and math teachers not involved in teaching Algebra 1. It was felt that these teachers would probably see students using this "non-standard" algorithm for multiplying binomials, and it would benefit the teachers and their students to have all math and science teachers become familiar with the topic. The study team strategy chosen as the vehicle for this learning was "Pairs-Check." Pairs were formed within each team, so that as much as possible each pair had a teacher familiar with the algorithm. A binomial multiplication problem was given to each pair, one of whom was designated as the recorder and one as the communicator. The communicator for the first round was the person who was familiar with the algorithm. In this version of Pairs-Check, the communicator tells the recorder how to do the problem, while the recorder writes out the steps as described by the communicator. The recorder is allowed to ask questions but cannot do other talking. The recorder is only allowed to write what the communicator tells him/her. Communicating with accuracy and listening with understanding both become crucial aspects of the strategy.

After completing one problem, the two partners switched roles and completed a second problem. After completing two problems, the communicator-recorder pair checked their answers with the other communicator-recorder pair in their study team. If both pairs agreed on the two answers, they moved on to another pair of problems.

There was a follow-up discussion on the area model for multiplying binomials. Most teachers had been familiar with the "FOIL" method and liked the fact that the area model method seemed more grounded in conceptual understanding. They also said they felt that it connected this algebra concept with the rectangular area model used in elementary school for teaching two-digit by two-digit multiplication as well as multiplication of fractions or mixed numbers.

Following that discussion, participants brainstormed on possible classroom uses of the Pairs-Check strategy and on its connection to Habits of Mind. It was generally thought that this strategy fit well any time they were practicing a skill that had already been taught.

Activity Four: Setting Up and Solving Equations

The next study team strategy modeled and used was "Hot Potato." This strategy was actually practiced in two scenarios. The first was solving equations. This was used as a quick vehicle for teaching the strategy itself. Each team was given a linear equation with one variable that required several steps to solve. Using Numbered Heads, one person in each team was chosen to start. That person completed one step toward finding the solution and explained the step to the team. He or she then passed the sheet to the next person to the right. The second person checked what the first person had done and corrected any mistakes. Then the second person completed and explained the next step in solving the equation. This process continued until the equation was solved and checked; the sheet was passed around the group like a hot potato.

The Hot Potato strategy was then practiced, while science teachers were shown how guess and check tables are used as one method to introduce solving applications, and as a way to transition into writing equations. Each group was given the following problem to solve.

> The chemical formula for ethyl alcohol is C_2H_60. That means it is composed of carbon, hydrogen, and oxygen in a certain pattern or ratio. The number of carbon atoms is twice the number of oxygen atoms and the number of hydrogen atoms is 6 times the number of oxygen atoms. If a certain container of ethyl alcohol contains a total of 1719 atoms, how many of each are there? Use a guess and check table to find the answer.

This problem was created because of its connection to both math and science. This particular mathematical topic was chosen because it would help science teachers become familiar with ways that some of their students might be solving and setting up equations. It would also give the science teachers a way to scaffold the task for those students who were having trouble writing equations for application problems.

The procedure is to set up an organized guess and check table and to complete the table for at least four guesses before trying to set up an equation. A variable is then chosen for the missing quantity, and the table is competed using the variable in the same way that the numerical guesses were used. This helps students see the numerical relationships among the quantities before trying to set up the equation.

This process also lends itself well to a Hot Potato strategy as each team member makes a guess and completes one row of the table. The next member can adjust the guess, based on what the preceding result was. Finally, a member can complete a line in the table for a variable and use that information to write an equation. A sample table for this problem is shown below.

oxygen	carbon	hydrogen	total	check (1719)
50	50 x 2 = 100	50 x 6 = 300	50+100+300=450	too low
400	400 x 2 = 800	400 x 6 = 2400	400+800+2400=3600	too high
200	200 x 2 = 400	200 x 6 = 1200	200+400+1200=1800	too high
180	180 x 2 = 360	180 x 6 = 1080	180+360+1080=1620	too low
Students can keep guessing until they get the solution or they can switch to variables and equations by using "x" for the number of oxygen atoms.				
x	x times 2 = 2x	x times 6 = 6x	x+2x+6x=1719 (target number)	

In this algorithm for setting up equations and solving problems, students are required to do at least four guesses even if they find the correct guess prior to that. The purpose of the four guesses is so that the students can begin to see which parts of the expressions are acting as constants and which parts are acting as variables.

This activity was then debriefed as a large group of teachers identified possible uses in their classrooms and noted any connections they saw to the Habits of Mind. Science teachers who had never seen the organized guess and check table felt that it would help special needs students write equations and solve problems without giving the equation to them. Some science teachers said they had seen students setting up guess and check tables, but as teachers they were unclear about what the students were attempting to do. Everyone agreed that a guess and check problem is an excellent way to set up equations and solve problems.

Activity Five: The Triangle Inequality

For this activity each team was given a graphing calculator and a set of Cuisenaire Rods (ten rods that vary in length from one to ten centimeters). The calculator was used to generate three random numbers from 1 to 12. Each person on the team generated a triple of random numbers and then attempted to actually build a triangle with sides whose lengths matched the three numbers. As a team, they kept track of which sets of numbers worked and which sets did not. This activity was used as an example of the Study Team strategy "Jigsaw within Groups." Within each team, the members were dividing up the data collection and pooling the results. The goal was to look at lots of data quickly in order to draw a generalization (the Triangle Inequality) from the data. This was again followed by a debriefing in which the participants brainstormed on possible classroom uses of the Study Team strategy.

Activity Six: Ones and Twos Adding Up to 10

The next activity was an extended, inquiry-based activity. Again, Numbered Heads were used to assign the team roles of facilitator, recorder, resource/materials person, and the "listening post." The facilitator made sure all members were fulfilling their tasks and, through frequent questioning, checked that all members understood the problem, solution attempts, and final solution. The recorder recorded all of the team's solution attempts. The resource/materials person was in charge of making sure the team had calculators, poster paper, and markers as needed, and was also in charge of asking the session leaders when the whole group had a question about the problem or their work. All three of these people took part in the discussion around solving the problem. The fourth person was assigned the task of "listening post." His or her duty was to observe and record the group processes by observing how the team was functioning as a team in terms of sharing, listening, and being productive.

Because this was an extended problem, several study team strategies were incorporated into one activity. The first of those was the assigning of team roles. The role of "listening post" is a useful study team strategy by itself. It can serve multiple purposes. One thing it does is give the group a chance to evaluate their own productivity and cooperation as a team. At the same time, if there is a particularly advanced student who often does more than his share of the work, the naming of that person as the listening post removes him or her, at least in the beginning, from doing the work for the team.

The following problem was given to each team to work on:

How many different ways can a sum of 10 be obtained using only 1s and/or 2s?

As the teams began work on the problem, the "Teammates Consult" strategy was used. All team members first placed their pencils in the middle of the table and discussed strategies for tackling the problem. When they had formulated a plan, the resource/materials person shared the plan with the session facilitator, and then team members were given permission to pick up their pencils and continue working on the problem.

After teams had worked on the problem for about five minutes, a "Huddle" study team strategy was called. In a huddle, one person per team is called (by Numbered Heads) to meet with the teacher. The teacher then shares some information about the problem that might be useful in the team's work. In this case, the huddle was used to clarify that a solution such as 2+2+2+2+1+1 was considered to be different from 1+1+2+2+2+2. In other words, order mattered.

In the classroom, a huddle can also be used as a way to process homework. One person per team meets with the teacher to look at homework solutions, while the rest of the class is working on new problems. That person then has the responsibility to go over homework with their team.

After about twenty minutes of work time, the teams took a break from working on the problem, and the listening post, who had been only listening and recording observations, shared with the group what he or she had observed about the group dynamics and the roles that the other team members were assigned.

A short whole group discussion followed in which teams shared with the larger group any interesting observations. After that, the listening post was invited to participate with his or her team in solving the problem.

After thirty-five minutes of total work time, a "Swap Meet" study team strategy was implemented. Two members of each team rotated to a new team to share progress being made on

the problem. A few minutes before the rotation, the process was explained to the participants, and they were given two minutes to make sure everyone on the team understood the team's work and progress on the problem. The rotation was then done, and participants were given about eight minutes to share across teams before moving back to their original teams. This strategy gives all team members a chance to verbally explain the work their team has been doing. It also helps any teams that might be floundering or might have run into a dead end with their solution strategy.

After about five minutes of additional work time, the resource/materials person from each team was called up front to get a sheet of poster paper and some markers so that the groups could write up their solution to the problem. After all posters were completed and hung on the walls around the room, the final study team strategy for this activity was implemented. All participants took part in a "Gallery Walk." They moved from poster to poster analyzing and comparing solutions.

After the gallery walk, there was a whole group debriefing discussion on the study team strategies used, including possible classroom uses and their connections to Habits of Mind.

Closing Activity

The final activity of the workshop was a "Chalk Talk" or "Silent Board Messaging." Each participant was given a dry erase marker. The whole group was divided into three smaller groups. For this activity, groups of about ten people work well. The following prompt was written in the center of each large whiteboard: "How can we get students to work in study teams effectively?"

Each group of ten people then had about fifteen minutes to participate in a silent discussion around the prompt. They could write a response to the prompt, or they could write a response to what someone else had written. Lines were drawn connecting responses where appropriate. The purpose of the silent board messaging study team strategy is to have a conversation that is not dominated by one or two vocal people. All participants have an equal voice. After fifteen minutes of "discussing," participants rotated around the whiteboards to read other discussions. After debriefing as a large group, participants completed workshop evaluation forms and the workshop concluded.

Conclusion

The feedback from teachers on this professional development experience was very positive. Both math and science teachers found it to be very helpful. Over the following school year, there was evidence in almost every math and science classroom of an increase in the use of these strategies while students worked in groups.

References

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Appendix A: Study Team Strategy Cards

Jigsaw 1 (Team as part of the class) ▪ Each study team is assigned a different part of a larger topic/task. ▪ The team researches and discusses the topic/task. ▪ The team determines how to organize and present the information. ▪ Each study team presents its part to the whole class.	**Jigsaw 2 (Within a team)** ▪ Each study team member is assigned a different part of a task/topic. ▪ Each member researches/learns about the task/topic (possibly with others with same topic). ▪ Each member then presents the information to the others in his/her study team.
Teammates Consult (Pencils in the Middle) ▪ All pencils and calculators are set aside. ▪ Students read the problem or question. ▪ Give students individual think/work time. ▪ The problem is discussed by the team for clarity. ▪ Possible strategies are shared. ▪ Teacher gives okay for pencils to be picked up and written work to begin.	**Pairs Check** ▪ Each pair has one paper and pencil. ▪ Student #1 writes what student #2 explains OR student #1 does the first problem while student #2 only watches, listens, and asks questions. ▪ Then roles are reversed for the second problem. ▪ Then each pair checks their work with the other study team pair. ▪ Continue on to the next pair of problems.
Numbered Heads ▪ Students number off in study team. ▪ The team is given a problem to solve. ▪ When the team finishes, use random numbers (1–4) to ask questions or have team members share the solution process. ▪ The numbers can also be used to assign roles.	**Participation Quiz** ▪ Pick a group-worthy task. ▪ Tell students which norm you are focusing on. ▪ Show teams how you are keeping track (overhead, posters, chalk board). ▪ Record comments while students are working. Debrief (Do not need to record everything).
Reciprocal Teaching ▪ In pairs, person A pretends that person B was absent and explains a concept. ▪ Switch roles and continue.	**Huddle** ▪ One person from each team (teacher's choice) is called to the front of the room. ▪ Teacher gives a piece of information, checks for understanding…. ▪ Student goes back to team to share.
Index Card Carousel ▪ Have the participants write one thing that they really need help with in their classroom — management, homework, getting kids to work, etc. ▪ The card gets passed around with the other participants offering suggestions on how to solve the problem.	**Swapmeet** ▪ When a group task is partially finished, one pair from each team rotates to the next team. ▪ Pairs from the two teams share ideas, solutions, thinking… ▪ Pairs return to their original teams and share what they learned.
Hot Potato ~ (Round Table) ▪ Every team has one sheet of paper, and each student has a different colored pencil. ▪ A problem is given to the group. ▪ Person #1 writes the first step of the solution process, explaining aloud, and passes the paper on to person #2. ▪ Person #2 makes any corrections and adds the next step, explaining aloud, and passes the paper on. ▪ Process continues until the problem is completed.	**I Have…., Who Has….** ▪ Each student has one card with problem and an answer to a different problem. ▪ Student #1 asks, "Who has ___ ?" & states the problem. ▪ The person with the solution says, "I have ___," and states the answer. ▪ The responding student then poses his problem, and the student with the answer on his card responds. ▪ The process continues until all the questions and responses have been given.

From CPM Educational Program, found online at: http://cpm.org/pdfs/studyTeam/coll_team_strat_cards.pdf

Carousel ~ (Around the World/Station Rotation)

- Write a different problem/topic/question on large poster sheets hung on the walls or on each table.
- Each team is given a different colored marker.
- Each team goes to a different poster, discusses the topic, and decides what to write.
- Teams rotate to all of the posters, adding to what was written by previous teams (have a time limit).
- When done, each team does a "gallery walk."
- A large group discussion/debrief can be held.

Fortune Cookie

- Choose 5–6 questions and put in an envelope.
- Each team receives an envelope.
- One person draws a question, makes one statement about the topic, then passes it on.
- The next person adds his/her statement or responds to the previous statement.
- When everyone has responded to the first statement, another person draws from the envelope and repeats the process.

Think (Ink) Pair Share ~ (Timed Pair Share)

- Teacher poses a question/problem.
- Without pencils, students think for 1–2 minutes.
- (Students may then use pencil to begin working…without talking to partner).
- Students then share their thinking and answer(s) with their partner.
- Pairs then may share with larger group.

Silent Debate

- Student pairs: One is "pro," the other "con."
- Each pair has one pencil and one sheet of paper.
- A topic is given, the pro goes first.
- The pro makes a supportive statement in writing.
- The con reads the statement and then writes a comment against the topic.
- The process repeats 3–4 times.

Give One – Get One

- Record three ideas to share related to a certain topic.
- Circulate and share ideas; for every idea given, receive one in return and record these on a piece of paper – including the name of the author.
- Begin group sharing by inviting a volunteer to share one idea received, citing the author. The named person then continues the sharing process.

Listening Post

- Students #1 and #2 work on a math problem aloud in their team.
- Student #3 listens to the discussion and can ask clarifying math questions.
- Student #4 only records what is discussed and verbalized (looks for attitudes) and may not talk.
- After 15 minutes, work stops and student #4 shares notes and observations.
- A variation is students #1, #2, and #3 work and #4 observes and then shares.

Hot Seat

- One chair/desk per team is set up in the front of the room.
- Using Numbered Heads, person #1 from each team comes to the front of the room and sits.
- Teacher gives everyone a problem to work on in a specified amount of time.
- Teams can talk but not the individuals in front.
- Check individual and team answers; two points for correct individual answers and 1 point for correct team answers.
- Person #2 from each team is up next and repeat.

Station Rotation

- Have 1 or 2 more stations than the number of student groups.
- Place a sheet of review problems (4–6) at each station. (Good idea to use a sheet protector)
- Have a blank answer sheet at each station for each group. (Good idea to have the exact number of spaces needed to answer the questions at each station. All of the spaces are in numerical order even though the group may not solve them in that order. This will make it easier to grade the papers, if you elect to do so.)
- The students work the problems as a group; when they finish, they turn in the station paper to the teacher and move to the next available station.