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ABSTRACT

Cognitive Scaffolding is what a teacher does when working with a student to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts. As a psychological construct, it refers to the interaction between the knowledge and skills of teacher and student. A computer, textbook, or laboratory materials may serve as proxy for a "teacher." Considering that scaffolding is typically a dynamic process, reflecting adjustments based on student responses, arguably the most important source of scaffolding in a classroom, is the flesh and blood teacher. The teacher decides, consciously or unconsciously, how and when to use a computer, textbook, or laboratory materials. The actions of the teacher are also the primary mediator of the scaffolding effects of other classroom materials. This paper is part of a research program whose purpose it is to design instruction for scaffolding classroom inquiry in middle school classrooms. (Contains 10 references.) (Author/YDS)

Teaching Practicies That Provide Cognitive Scaffolding for Classroom Inquiry

by

Lawrence B. Flick

TEACHING PRACTICES THAT PROVIDE COGNITIVE SCAFFOLDING FOR CLASSROOM INQUIRY

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Cognitive scaffolding is what a teacher does when working with a student "to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts" (Wood, Bruner, & Ross, 1976, p. 90). As a psychological construct, it refers to the interaction between the knowledge and skills of teacher and student. A computer, textbook, or laboratory materials may serve as proxy for a "teacher." Considering that scaffolding is typically a dynamic process, reflecting adjustments based on student responses, arguably the most important source of scaffolding in a classroom is the flesh and blood teacher. The teacher decides, consciously or unconsciously, how and when to use a computer, textbook, or laboratory materials. The actions of the teacher are also the primary mediator of the scaffolding effects of other classroom materials. This paper is part of a research program whose purpose it is to design instruction for scaffolding classroom inquiry in middle school classrooms.

Problem

Science educators and teachers need a better picture of what inquiry instruction looks like as it is being practiced in a typical classroom. Current models describe inquiry as a matter of steps or phases conducted in succession or in cycles expressed in terms of expected student cognition. Descriptions of teaching practices to elicit and maintain cognitive engagement have remained at a level of generality that leaves the operational meaning up to the classroom teacher (Romberg & Carpenter, 1986). Teaching practices are typically stated in terms of "engaging students in discussion" or "doing an activity" that causes "cognitive conflict". To work out the operational form of instruction, a teacher must be skilled in a variety of strategies (see Figure 1) in order to design instruction that maintains the desired cognitive demands of inquiry while adjusting to the constraints of a typical classroom. Sometimes the teacher must settle for an approximation of inquiry instruction. As a result, instruction may looks less student centered, as the accepted view

Figure 1

Teaching Skills that Support Classroom Instruction in Science.

- Execute methods for presenting content in the form of problems that stimulate selected aspects of inquiry.
- Model or demonstrate inquiry so that students can copy the traits of an expert.
- Execute skills needed for designing, implementing, or evaluating hands-on investigations.
- Teach skills and procedures for interacting in small groups.
- Execute procedures for promoting interaction between existing student knowledge and new knowledge.
- Execute explicit instructional methods for teaching specific knowledge, process skills, or scientific attitudes.

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of classroom inquiry implies, and more teacher centered. That is, where students are not functioning sufficiently well with the content or materials for any of a variety of reasons (see Figure 3), the teacher must carry more of the burden for organizing the content, raising points for consideration, and planning subsequent steps in the instruction.

Current models of inquiry-oriented instruction do not account for classroom variables that teachers face when operating under typical classroom conditions. These models suffer from three structural problems. First, they are too highly structured and narrowly focused. For instance, as implemented, the learning cycle converges on a conceptual target that presupposes students are modifying their personal conceptions in light of scientific principles. There are other reasonable outcomes of a learning cycle lesson that are pedagogically sound stopping points but the model as applied rarely assumes other outcomes. Second, students are asked to perform complex cognitive tasks for which they are unprepared. The instructional targets for current models expect students to analyze data and synthesize conclusions without first achieving an operational understanding of what it means to do analysis and synthesis. Third, current models of instruction are presented in isolation from each other. Models do not contain heuristic supports for helping teachers decide when a model might be useful or how it would work with other kinds of instruction such as listed

Figure 3

Some traits shown by underachievers*

Say they are bored

Indulge in idle chatter

Fail to do homework

Fail to take care over work

Rarely have pen, pencils, books, etc.

Lose things

Respond better to individual attention

Disrupt other pupils' work

Are distrustful of teachers and of authority

Form unstable or weak friendship bonds

Are often late for lessons

Are absent more frequently than other pupils

Claim that what they learn is of no use

Feel that school is an imposition

Wish to leave school to earn money

Express non-involvement in their form of dress

Are disrespectful of property

Are attention seeking

Dress untidily

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* Source: Reid, D. J. & Hodson, D. (1987). Science for all: Teaching science in the secondary school. London: Cassell Educational Limited.

in Figure 1. Skilled teachers work out methods that overcome these structural problems as they occur. Observing their methods for creating an inquiry-oriented environment and scaffolding student participation should offer insight for how to begin providing operational detail on inquiry models of teaching. This approach has been used in other studies in science education. The work of skilled and practiced teachers have been regularly used to establish context and find starting points for instructional research. Tobin and Fraser (1990) observed skilled teachers to examine parameters of excellent science teaching. Effective teachers were contrasted with ineffective teachers to establish parameters of what constitutes "effective."

The purpose of this exploratory study was to analyze the practices of two skilled and experienced middle school teachers with respect to a model of instructional scaffolding. The research question was, What do skilled, experienced teachers do when scaffolding inquiry-oriented instruction?

Method

Two experienced teachers were selected from a field of eight. Seven of the eight potential subjects were teachers participating in an extended inservice program for improving knowledge and skills in teaching science. The eighth teacher with similar inservice experience was recommended as being a good candidate for this study. Five of the eight agreed to participate in an initial observation period that lasted from six to eight weeks. Based on in-class observations partially supported by video tape records, two middle school teachers were selected for in-depth study. They were selected because they not only exhibited the knowledge, skill, and intent to create an inquiry-oriented instructional environment, but also presented teaching routines that were used to provide a continuous thread of inquiry across lessons. Teachers A and B have 10 and 13 years of experience in middle level teaching respectively. Teacher A currently teaches sixth grade and sees all of the sixth graders in his school. Teacher B teaches seventh grade and sees all of the seventh graders in his school. Both teach physical education as part of their assignment. Both have been participants in several inservice programs related to improving science teaching. Both regularly attend national and state professional science teacher meetings.

Field notes were supported in part by video tape during direct observations of teaching. Each teacher was observed six times and video taped was used twice with each teacher as a means of triangulating interpretations with field notes and interviews. One extended interview session with each teacher was audio taped to document information gained from several informal discussions that took place before, during, and after instruction.

Analysis

Field notes and partial transcriptions of video and audio tapes were analyzed using an operational definition for scaffolding instruction derived from Palincsar and Brown (1984) and Palincsar (1986). A synthesis of the literature on the psychological construct of scaffolding resulted in the criteria listed in Figure 2. The validity of this definition for scaffolding is based on an analysis of the literature and on my own empirical work in examining the practices of expert teachers (Flick & Dickinson, 1997; Flick, 1996; Flick, 1995). The content validity was checked by showing Figure 2 to two science educators with 10 and 15 years of teaching experience each. They were both familiar with the literature in inquiry science teaching and the nature of science. Their assessment was that the formulation presented in Figure 2 was a more comprehensive definition of scaffolding than was typically used in the literature. They felt that all elements were appropriate to the construct and could be assessed in instruction.

Figure 2

Elements of Scaffolding*

- Selection of task that teaching a skill emerging in the learner
- Evaluation of task for difficulties it will present to learner
- Structuring opportunities for student participation
- Render the task accessible to learner
- Accentuate critical features of task
- Organize task for presentation
- Identify and represent appropriate approaches to the task
- Identify and represent approximations of successful completion
- Elicit and sustain interest
- Designing assessments to calibrate the level of difficulty

- Providing learner with feedback on her production and on correct production
- Adjust levels of instructional support toward gradual withdrawal

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* adapted from: Palincsar, A. S. & Brown, A. L. (1984) and Palincsar, A. S. (1986).

Construct validity is the more important form of validity in this case and more difficult to establish. The central question is, Does the stipulated definition differentiate between teachers who do scaffold inquiry and those who do not? To accomplish such a judgment it is necessary to settle on a valid definition of what classroom inquiry means and a valid form of assessing the outcomes of its implementation. These are steps being taken in the next phase of this research program. It is not possible to make a judgment of construct validity at this time.

Teaching episodes from both teachers were analyzed against the criteria shown in Figure 2. The analysis examined the specific classroom context across lessons and content to reach an evaluation of the level and nature of instructional scaffolding for fostering inquiry in a middle school classroom. A model of classroom inquiry based on Rowe (1973) was defined to include the following components: (a) addressing a specific question, (b) applying specific background information, (c) performing procedures for the purpose answering the question by collecting observations, (d) making inferences from these observations with the purpose of answering the question and (e) interpreting new experiences using concepts they already have or using concepts developed through instruction. This model of inquiry was validated by the same two science educators described above and, as a result, modified to include (f) presenting results to others, sharing ideas or techniques and (g) using social skills to engage in all elements of inquiry within a small group context.

Table 1 shows a detailed analysis of elements of teaching for each teacher that fit under each category of scaffolding. Each category also includes an element of teaching where additional scaffolding was possible and would have improved instruction. This analysis of contrasts shows that applying the stipulated definition of scaffolding will typically show contrasts between actual practice and "improved" practice especially for instruction not designed to meet these specific criteria.

Extended description of each teacher's practices characterized instruction based on all the observations. Each characterizations offers an analysis of both instructional practices and their relation to the elements of inquiry.

Table 1

Analysis of Instruction for Elements of Scaffolding

Elements of scaffolding	Gary	Levine
A. Selection of task that teaches a skill emerging in the learner	+ Reflection exercise is designed to address a skill or concept currently part of instruction, e.g. looking for trends in data. - Reflection tasks that focus on a concept, e.g. density, teach only that concept and do not emphasize learning skill development, e.g. reflecting on the purpose of the question.	+ Selects video emphasizing science as human endeavor based on student emerging awareness of broad scientific questions, e.g. how did life begin on earth? - Discussion sometimes falters because questions and topics become too esoteric. Target skill is not clear.
B. Evaluation of task for difficulties it will present to learner	+ Wording of the Reflection question is examined along with potential conceptual difficulties. - Some Reflections focus on a small part of an ongoing lesson and is not calibrated for the overall development of inquiry skills. These can be too difficult.	+ Mediates high level content in video or inquiry activity by linking to current student knowledge. Linked to earlier lesson on seeing problems from another's point of view. - Sometimes the zeal of teacher overrides the original nature of the task and discussion becomes too difficult for students.
C. Structuring opportunities for	+ Attention to the task is demanded,	+Video is broken into short sections

student participation	students are called on, small group discussion time is provided. - Not regular provision for <u>all</u> students to explicitly participate, e.g. instructions for small group interactions.	supported by study guide. Students write own questions about major issues to prime thinking on topic. - Wait-time is very short. Pace of class to too brisk for some students to get opportunity to speak.
D. Render the task accessible to learner	+ Notes, handouts, and class discussion provide feedback specific to student responses and offers a variety of explanations to aid conceptual understanding. - Conceptual difficulties, time, and numbers of students sometimes combine to make the task less accessible.	+ Combines short brainstorming sessions with responding to study guide to provide time to think and process information. - Teacher directs much of the classroom interactions in an effort to make efficient use of class time. There are many limits to how many issues the teacher can respond to.
E. Accentuate critical features of task	+ Feedback maintains focus on main purpose of Reflection, e.g. finding errors in data collection. - Because of variety in tasks, sometimes critical features have not been thoroughly thought through or the task it too complex.	+ Reminds students of lesson purpose and how video or activity helps address it. - Reminders are typically given by teacher and students only listen and do not have to fashion a response. Sometimes task is too complex and critical features have not been carefully examined.
F. Organize task for presentation	+ Reflection is always written on board and supported by visual aid. Students use notebooks for responses with clear format	+ Study guide, segmenting video, and preassigned student groups organizes setting for interactive presentation.

	and routine for handling logistics. -Because the tasks are written in a short timeline and tailored to the current lesson, sometimes visual or concrete supports are missing.	- Pace of class is so fast at times that structures in class can not be used effectively or frequently, e.g. effective small group interaction.
G. Identify and represent appropriate approaches to the task	+ Provides verbal and visual feedback on how to think through the Reflection problem. - All students do not benefit from feedback due to lack of attention or misunderstandings.	+ Features of study guide are pointed out, time allowed to record responses and to share responses. Provides feedback on producing responses. - Strategies for processing information rely heavily on discussion lead by teacher that limits the number of approaches that can be presented.
H. Identify and represent approximations of successful completion	+ Highlights specific student responses and helps shape correct responses. - Discussion is often fragmented, guided by student questions and some students are unable to follow train of thought.	+ Rapid and purposeful feedback focus attention on expected responses. - Ideas are dealt with quickly and few students are checked for appropriate responses.
I. Elicit and sustain interest	+ Uses relevance of problems, humor, and fast pace to keep student interest. - Some problems do not arouse interest and pace is too quick for some students.	+ High energy presentation, laced with humor, allows for student input., while reinforcing value of video and importance of content. - When discussion becomes too difficult, interest wanes resulting in minor

		disruptions.
J. Designing assessments to calibrate the level of difficulty	+ Every Reflection is graded with feedback to student and to teacher. Feedback from students is used to judge difficulty and indirectly calibrate assessments. -There is no systematic way to calibrate Reflection problems. Design is specific to instruction and varies from year to year. There are no long-term learning goals targeted by Reflections.	+ Attends to student input as a general source of knowledge for calibrating assessments. -May calibrate next task based on outcome of previous task but usually only adjusts grade in response to perceived difficulties.
K. Providing learner with feedback on her production and on correct production	+ Whole class and small group discussions are conducted so that all have opportunity to hear. Selected students get feedback and corrections. - No systematic provision to provide all students with feedback and corrections.	+ Individual and group worksheets are regularly marked with feedback. Often debriefs assessments with class. - Feedback is highly teacher-directed with little accountability on the part of individual students concerning corrected responses.
L. Adjust levels of instructional support toward gradual withdrawal	+ Students take varying degrees of control in solving problems as a function of degree of difficulty, attitude of students, and attitude of teacher. - No systematic communication that students are moving toward independence in cognitive tasks.	+ Provides explicit instruction concerning small group procedures and other classroom routines and expects students to independently perform these tasks. -No systematic communication that students are moving toward independence in performing cognitive tasks.

+ indicates actual observations of elements of scaffolding.
- indicates elements of scaffolding not observed but relevant to the instructional context.

Characterizing Instruction: Mr. Levine

Levine opened most classes with a warm-up problem presented on the overhead. Because math and science were taught in a 90-minute block, instructional patterns were somewhat conflated across the two subjects. However, there was a clear emphasis in math to teach specific problem-solving skills while in science the content was more conceptual in nature. As a discussion leader, Levine helped students engage with the warm-up problem or question through direct hints or prompts concerning the expected answer. While student responses were solicited and encouraged, Levine's instruction directed them toward a statement of the expected answer in a fast-paced and efficient manner.

Levine created cognitive supports in the form of words, phrases, techniques for processing information, or analogies for how to understand the problem. Following the warm-up, Levine introduced an activity (e.g. video, lab, creating a product, or worksheet) around which he eventually developed more discussion of the target concept. Most of the work in the class was conducted either in small group structures or as whole class discussions. There was very little individual seat work. Levine employed specific procedures to structure transitions to and from student-student interactions. The goal was to establish and maintain an atmosphere of academic work, attention, and courteous behavior. These rules became so well known by the students that only a minor prompt was needed to review them. For example the rules for small group work were: (a) quiet voices, (b) invisible walls symbolizing that small groups were not to interact, (c) polite disagreement, (d) stay focused, and (e) encourage participation and value all ideas. Levine himself modeled these behaviors in whole-class work and through this structure he established an atmosphere conducive to the divergent thinking of inquiry. However, these small group work did not generally include presentation of results to each other.

Inquiry questions were posed and specific background information was brought to bear on these questions. Students perceived the class as a safe place to offer ideas and there was a specific expectation that they speak out. Some questions tended to be broad and not directly researchable by evidence generated in the classroom. For example, students discussed causes for the extinction of dinosaurs. Other questions were more accessible to investigation. Students examined the composition and structure of rocks and devised their own classification schemes. Rarely did students actually perform procedures, collect data, and make inferences for the purpose of answering questions. The mix of these inquiry elements was informal but did lead to the application of concepts to new experiences. In the case of dinosaurs, they analyzed the research presented in a video presentation.

Levine used a video from the PBS series Scientific American Frontiers entitled "Life's Big Questions." Students were arranged in groups with a worksheet that outlined the content of the video and posed questions for recall and reflection. Levine stopped the video at appropriate points to check to see that students were attending to important points. He encouraged student note-taking on worksheets and offered questions and prompts that embellished what was presented in the video. The ensuing discussion modeled his expectations of student behavior in small groups and he reminded them of these points (i.e. stay focused, polite disagreement, encourage participation, and value ideas). In the process, student ideas were elicited and he explicitly expressed that the ideas were important and valued. Students offered interpretations and original points of view. Each video segment lasted not more than 10 minutes and Levine's structured feedback required review and synthesis on the part of students. He was careful to call on a wide range of students covering most of the class. During activity sessions and even during whole class discussions, he noted positive and negative behaviors relative to maintaining a productive and inquiry-oriented classroom atmosphere. He regularly provided specific feedback to the class about these behaviors in the form of complements and how to improve. These reminders about the conduct of work in the class was also connected with the nature of the work. That is, the desired atmosphere was important because students needed to be focused on solving a problem and discussing notes or ideas.

Characterizing Instruction: Mr. Gary

Gary opened nearly every class with a routine he called "Reflections." In a Reflection, Gary posed a question or problem for the purpose of applying a concept or developing a skill.

Reflections were structured as an open-ended question about half the time, but during every discussion Gary solicited and valued divergent points of view. This procedure established an atmosphere of inquiry through reflective thinking that students were expected to engage in. In this sense, students were regularly asked to address specific questions and apply appropriate background information. Written responses to Reflections were recorded in a special student notebook and collected periodically for evaluation. A Reflection exercise could take anywhere from 10 to 35 minutes depending upon how productive the discussion and how many supports were needed for students to produce a response. Gary provided cognitive supports in the form of prompting questions and summary statements. These were generated often enough to keep active discussion going. This could mean a new statement or question as often as once a minute or as little as one in 10 minutes as explanations and ideas were exchanged. The prompt always connected work done during the most recent lessons with a planned activity or lab. Cognitive support also came through student questions and statements that attempted to address the prompt. From the prompt, "How can you increase the density of water?," students offered the following ideas: freeze it, compress it, or turn it to a gas and compress it. Each of these ideas stimulated additional comments from the class mediated by Gary's summaries and restatements.

The pace was kept brisk with short wait-time in the course of whole class discussion. He structured wait-time in the form of brief discussions with pre-assigned partners. Typically he allowed 30 seconds for students to generate a question or a response to a problem currently under discussion. During that time he was circulating among the groups asking questions to focus or redirect attention. He also gathered examples of ideas that he could use to prompt participation from less vocal students. The transition from whole-class to partners and back to whole-class wasted no time and student attention was not allowed to wander very far.

The goal of Gary's instruction was to direct attention to the focus problem stated in the Reflection written on the board. At some point where Gary felt the discussion had ceased being productive, he introduced or reiterated a specific answer. It was presented in the context of all the ideas offered during the class and students were expected to write their own synthesis of this discussion. Many students wrote reflections during the class discussion but Gary provided a specific time to write at the end of the discussion.

The Reflection helped to introduce or follow-up a lab activity, such as measuring the density of various materials, building a small electric motor, or designing a small car. Gary closely monitored the activities by offering observations and suggestion concerning procedure and results. Questioning in this context was different from the Reflections portion of the lesson. Teacher-student interaction was far more directed, convergent, and explicit. Students had a product to produce and Gary helped them do it. It was likely that some aspect of the lab work would become the focus of the next Reflection. Formal investigations, such as testing a consumer product, combined with Reflections provided opportunities for students to perform procedures, collect data, and make inferences to answer specific questions. Reflections offered regular opportunities to interpret new experiences using the results of investigations. The presentation of results to other was usually done in the context of small group discussions during the Reflection portion of the lesson.

Results

Both Gary and Levine were active in creating scaffolds for instruction that supported learning in science in general and learning through inquiry in particular. They created learning environments and procedures that allowed students to do what they would otherwise be unable to do if unaided. They did not structure these learning environments in the same way nor did they create all the elements of scaffolding as outlined in Figure 2. While there were several differences in methods of scaffolding, there were interesting similarities in those elements of scaffolding that were not in evidence. Each teacher is discussed in turn followed by a summary analysis.

Gary taught science to all seventh graders in his middle school. His scaffolding focused heavily on creating opportunities for students to engage in reflective thinking about the concepts or tasks upon which the class was working. At the beginning of each period, students were presented with a problem to which they would respond in writing in a special notebook.

Through whole-class discussion, discussion with partners, and individual written responses, Gary scaffolded instruction that guided students through analysis of the problem and application concepts. A reflection problem might involve application of ideas to a novel setting such as examining a US map showing the location of atomic power plants and answering the question, Why are there more atomic power plants in the east than in the west? Other problems focused on ongoing investigative activity such as, Identify three possible sources of error in your data.

Gary's daily routine provided opportunities for accentuating critical features of important tasks in an investigation such as how to identify trends in data or how to write an hypothesis statement that met specific criteria. Multi-step investigative tasks or complex applications of concepts were beyond the capabilities of most of Gary's students. Through the classroom routines for examining selected problems or examining the characteristics of important procedures, Gary helped students identify approaches to performing these tasks, guided practice to approximate appropriate cognitive behaviors, and provided corrective feedback for target responses.

However, even with these routines in place and almost daily practice, many students participated marginally or not at all. During small group work or structured conferences with partners, Gary circulated around the room often answering the basic question "I don't understand what to do?" Gary observed that even several weeks into the term, some students would enter class, forgetting their notebook unaware that other class members were already reading and discussing the reflection problem written on the board. Many of these behaviors fit the description of underachievers shown in Figure 3. Gary's classes was an average, middle class students in terms of standardized test scores and socio-economic status. Yet despite the supports and advantages associated with middle class living, there was a significant portion of the class that did not respond to Gary's scaffolded instruction. We will see that this was also true for Levine's middle class students.

Levine taught science to all the 6th graders in his middle school. His scaffolding focused heavily on creating opportunities for student participation in discussion and activities. He designed specific routines and rules of behavior that promoted student input and specifically required that students listen to one another. This was particularly effective in soliciting points of view when attempting to identify a problem or understand a problem for investigation. His code of conduct and expectation of mutual respect was also invoked when soliciting background information to apply to a problem. Early in the year, he structured a lesson where students inductively answered the questions, What is science? The lesson involved several steps with students generating personal examples of "science", writing them on paper, taping them on the board, and participating in a categorization process. Scaffolding in this case involved (a) specifically requesting and publicly acknowledging all student input, (b) making and managing the large visual display on the board, (c) questioning to prompt summary and synthesis of emerging categories, and (d) reminding students of rules for whole class and small group interactions. The result is that nearly all students were involved and most receives feedback directly or indirectly by hearing other student-teacher interactions. This lesson is typical in that it reaches a successful closure.

Levine was very active throughout his lessons and his own energy often seemed like the main force that drove the discussion. Levine reflected on this general state of affairs:

> My plan is supposed to build a concept but I feel I am doing most of the thinking. Some students are actively thinking and some of these are trying to make comments. However, there are individuals you hardly have a clue what is going on.

Levine's comment captured problems with the scaffolding process with both teachers. Neither teacher was generally satisfied with participation with the class as a whole. Students in both classes were well coached in how to behave, provided with carefully selected tasks that had been rendered accessible through various kinds of support, and given feedback on their prompted input. Most students were successful in learning content objectives. However, neither teacher sensed that the students had an understanding of the direction of instruction or in some cases even the purpose of instruction. Instructional routines were designed to scaffold student participation in inquiry-oriented activities but not to understand the inquiry nature of those activity. Figure 4 is a list of observed instructional effects resulting from instructional routines.

Figure 4

Effects of Instructional Routines Based on Classroom Observations of Teachers in Study

- Communicate expectations common to entire class.
- Provide guidance for specific behavior at various stages of instructional activity.
- Provide a starting point for action.
- Structure a way to coordinate the efforts of an individual student with those of the entire class.
- Reduces emotional stress caused by uncertainty about procedures and releases more working memory for thinking about content.
- Provides check points for progress or metacognitive prompts.
- Becomes a model that can be used independently reducing the need for repeated instruction and supervision.
- Becomes a general tool for use in other academic work.
- Deviations from routines can be used to make a point or focus attention on new or alternative elements.
- Repetition inherent in the use of a routine aids in memorization of steps and the development of automaticity and the development of effective variations and adaptations.

There were elements of scaffolding as shown in Figure 2 that neither teacher employed in their instruction. Neither systematically evaluated tasks for difficulties; nor calibrated difficulty of assessments; nor gradually reduced levels of support to promote independent learning. Tasks were selected to be challenging and meaningful within the context of instruction. Instruction scaffolded student engagement with the specific problem and students were reminded of the general purpose. However, there was little attention given to the relative difficulty of the task and how or if students would eventually accomplish the task on their own. Adjustments were made at the level of procedures within a lesson but not at the level of the overall task or its purpose. In neither class were students verbally informed of the intention that they were expected to became capable of handling selected inquiry-oriented tasks on their own. For instance, Gary allowed students to take varying degrees of control in solving the daily inquiry problems (see Table 1), but there was no specific statement to students that they were learning "how" to respond to these problems. Levine communicated to students that they were expected to follow specific procedures for working together that included scaffolding for sharing ideas and roles within small groups (see Table 1), but there was no scaffolding that supported students achieving skills to tackle the tasks independently.

An analogy to coaching a soccer team makes a useful contrast between learning content and achieving skills for independent learning. Let's say these two teachers were soccer coaches and coached their teams in ways similar to the scaffolded instruction used in their classrooms. They would present problems in defense that required certain physical skills. Students would practice these skills in the selected problems, perhaps rotating through different positions such as goalie and defender. However, they would not be coached in how to size up different defensive problems as they occur in a game. Further the problems they were presented would not have been selected nor adjusted for improving skills. Rather, they would be selected for their relevance to specific problems deemed important for "learning" soccer. Students would learn how to set up plays but only under the guidance of the coach and not with the goal that they were responsible for learning how to "solve soccer problems" on their own.

Instructional scaffolding was focused on using inquiry skills and not on learning the skills themselves nor how and when to employ those sills in scientific problems. Put another way, the teachers paid more attention to using inquiry as a method for teaching science than teaching how to do inquiry. Elements of inquiry were used as a means for teaching science principles or facts but neither the elements of inquiry themselves nor the thinking necessary to engage in inquiry were the subject of instruction.

Suggestions for Further Research

Both teachers were successful in eliciting and maintaining a high degree of student attention, participation, and cognitive involvement. A feature of instruction that was effective in both classrooms were specific teaching routines that fostered student behavior that supported student participation in inquiry-oriented procedures (see Figure 4). Could routines effective in fostering behaviors that supported participation in activities be applied to the support of thinking skills important for engaging in inquiry?

Palincsar and Brown (1984) showed that "reciprocal teaching", a form of instructional routine, was effective in fostering comprehension and comprehension-monitoring in seventh-grade students reading science texts. They focused on development of a set of skills shown to be in common across many reading comprehension studies. These skills were summarizing, clarifying, stating questions answerable from the text, and predicting the content of the next portion of text. Are these skills useful in promoting cognitive skills for engaging in inquiry? What other cognitive skills are important for engaging middle school students in the meaning and purpose of inquiry? Are these skills developmentally appropriate for early adolescent children? What instructional routines are effective in communicating instructional goals of fostering cognitive and metacognitive behaviors the support inquiry? How can instruction be designed to develop cognitive skills, calibrate the difficulty of tasks, and gradually reduce instructional support to promote independent inquiry at the middle school level?

A fruitful direction for further research in support of reform-based instruction is to examine the nature and function of instructional routines that target cognitive and metacognitive skills that are predicted to support learning science through inquiry.

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