Lesson Design and Implementation							
Row	**RTOP**	**Manual Description**	**0**	**1**	**2**	**3**	**4**
1	The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	A cornerstone of reformed teaching is taking into consideration the prior knowledge that students bring with them. The term "respected" is pivotal in this item. It suggests an attitude of curiosity on the teacher's part, an active solicitation of student ideas, and an understanding that much of what a student brings to the mathematics or science classroom is strongly shaped and conditioned by their everyday experiences.	No evidence	Teacher asks students to write or describe their previous knowledge of a topic before starting instruction.	In addition to asking for previous knowledge, class time is spent discussing student ideas and how they relate to the current or previous activity.	The teacher actively solicits student ideas and discussion of these ideas takes place throughout the lesson, but lesson direction is teacher determined.	The teacher actively solicits student ideas and builds the lesson from their starting point. The direction of the lesson is shaped by student ideas.
2	The lesson was designed to engage students as members of a learning community	Much knowledge is socially constructed. The setting within which this occurs has been called a "learning community." The use of the term community in the phrase "the scientific community" (a "self-governing" body) is similar to the way it is intended in this item. Students participate actively, their participation is integral to the actions of the community, and knowledge is negotiated within the community. It is important to remember that a group of learners does not necessarily constitute a "learning community."	No evidence	Interaction is limited to student-teacher interactions. No ideas or understanding of concepts developed between students.	Students interact with each other in groups (may be hands-on but not minds-on) or good student-teacher interaction and development of ideas. No conceptual understanding.	Students interact with each other to construct some ideas but some conceptual understanding is developed through these interactions. Good teacher-student interaction and development of ideas. Group construction of knowledge	Students interact with each other to construct understanding of concepts. Student-student interaction, group to group as well as whole group interaction to reach (or prior to) final consensus.
3	In this lesson, student exploration preceded formal presentation	Reformed teaching allows students to build complex abstract knowledge from simpler, more concrete experience. This suggests that any formal presentation of content should be preceded by student exploration. This does not imply the converse...that all exploration should be followed by a formal presentation	No evidence	Students engage in exploration through teacher-led discussion or questioning with no activity and no negotiation of meaning between students.	Students engage in exploration through discussion, questioning, or activity prior to a formal presentation but teacher tells content to students before they discover it for themselves No negotiation of meaning occurs between students. Students rely on teacher for meaning.	Students engage in exploration through discussion, questioning, or activity prior to a formal presentation, some negotiation of meaning occurs between students, however, teacher tells before final consensus. (discussion)	Students engage in exploration through discussion, questioning, or activity prior to a formal presentation. Students negotiate meaning through the entire community of learners
4	This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	Divergent thinking is an important part of mathematical and scientific reasoning. A lesson that meets this criterion would not insist on only one method of experimentation or one approach to solving a problem. A teacher who valued alternative modes of thinking would respect and actively solicit a variety of approaches, and understand that there may be more than one answer to a question.	No evidence	The teacher asks for student to share at least one other approach to the investigation, but this approach is not valued (condemned or does not receive further discussion)	The teacher encourages a variety of approaches to the problem, but then asks students to consider only his/her direction.	The teacher actively solicits a variety of approaches to the problem and shows respect to the suggestions by considering their feasibility. Students are not allowed to pursue their ideas through further discussion or action.	The teacher actively solicits a variety of approaches to the problem and shows respect to the suggestions by considering their feasibility. Students are encouraged to pursue their own investigation directions through discussion or action.
5	The focus and direction of the lesson was often determined by ideas originating with students	If students are members of a true learning community, and if divergence of thinking is valued, then the direction that a lesson takes cannot always be predicted in advance. Thus, planning and executing a lesson may include contingencies for building upon the unexpected. A lesson that met this criterion might not end up where it appeared to be heading at the beginning.	No evidence	Very teacher-directed lesson. The instructor answers questions that the students raise, but the teacher does not let the questions change the direction of the lesson.	Somewhat teacher directed. The instructor answers questions that the students raise that may take the lesson in another direction. Discussion is allowed to follow the students' ideas.	Somewhat student-directed. Students are allowed to direct their own participation in small groups or during a segment of the lesson.	Student-directed lesson. Student ideas set the focus and direction of the entire lesson.

Content--Propositional Knowledge							
Row	**RTOP**	**Manual Description**	**0**	**1**	**2**	**3**	**4**
6	The lesson involved fundamental concepts of the subject	The emphasis on "fundamental" concepts indicates that there were some significant scientific or mathematical ideas at the heart of the lesson. For example, a lesson on the multiplication algorithm can be anchored in the distributive property. A lesson on energy could focus on the distinction between heat and temperature.	No evidence	Most of the lesson not based on grade level appropriate, state or national standards.	Lesson is standards-based, but not presented at an appropriate level for the class being taught.	Lesson standards-based, taught at the appropriate level, significant scientific ideas not the main focus.	Lesson based on grade level appropriate standards, the scientific ideas covered are central to scientific knowledge.
7	The lesson promoted strongly coherent conceptual understanding	The word "coherent" is used to emphasize the strong inter-relatedness of mathematical and/or scientific thinking. Concepts do not stand on their own two feet. They are increasingly more meaningful as they become integrally related to and constitutive of other concepts.	No evidence .	Lesson promoted few concepts as integrally related to and constitutive of other concepts. Lesson presented concepts as un-connected pieces of knowledge.	Lesson promoted some concepts as integrally related to and constitutive of other concepts. Lesson presented concepts as mostly disconnected or loosely connected.	Lesson promoted most concepts as integrally related to and constitutive of other concepts. Lesson presented concepts as mostly connected.	Lesson promoted all concepts as integrally related to and constitutive of other concepts. Lesson presented concepts as strongly connected.
8	The teacher had a solid grasp of the subject matter content inherent in the lesson	This indicates that a teacher could sense the potential significance of ideas as they occurred in the lesson, even when articulated vaguely by students. A solid grasp would be indicated by an eagerness to pursue student's thoughts even if seemingly unrelated at the moment. The grade-level at which the lesson was directed should be taken into consideration when evaluating this item.	No evidence . Many content errors. Teacher did not allow students to present and/or elaborate on potentially relevant ideas. Lesson was completely teacher-driven.	Some content errors. Teacher seemed uncomfortable allowing students to elaborate on ideas that were potentially relevant to the content or failed to recognize the potential significance of student ideas. Lesson was largely teacher-driven with few if any deviations based on student thoughts.	Some content errors. Teacher allowed students to elaborate on ideas that were potentially significant to the content. Teacher was willing to pursue students' thoughts if relevant.	No major content errors. Teacher allowed students to elaborate on ideas that were potentially significant to the content. Teacher was willing to pursue students' thoughts even if seemingly unrelated at the moment.	No content errors. Teacher drew attention to student ideas that were potentially significant to the content, even when students articulated those ideas vaguely. Teacher seemed eager to pursue student's thoughts even if seemingly unrelated at the moment.
9	Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so	Conceptual understanding can be facilitated when relationships or patterns are represented in abstract or symbolic ways. Not moving toward abstraction can leave students overwhelmed with trees when a forest might help them locate themselves.	No evidence .	The teacher did not use any drawings or props, and gave only verbal concrete examples of scientific theory. (The lesson provides opportunity for the teacher to use drawings, etc.)	The teacher used drawings, props, and concrete examples, but did not help students to build scientific theory from phenomenon.	The teacher used drawings, props, and concrete examples and used these examples to build the scientific theory from the phenomenon. (implicit)	The teacher used drawings, props, and concrete examples and used these examples to build the scientific theory from the phenomenon. (explicit)
10	Connections with other content disciplines and/or real world phenomena were explored and valued	Connecting mathematical and scientific content across the disciplines and with real world applications tends to generalize it and make it more coherent. A physics lesson on electricity might connect with the role of electricity in biological systems, or with the wiring systems of a house. A mathematics lesson on proportionality might connect with the nature of light, and refer to the relationship between the height of an object and the length of its shadow.	No evidence .	The teacher only presented examples from content disciplines and/or everyday life applications of the scientific theory.	The teacher uses applications and circumstances from everyday life, and students discuss these connections without exploration.	The teacher uses applications and circumstances from everyday life, and students work with everyday phenomena to implicitly develop conceptual understanding.	The teacher uses applications and circumstances from everyday life and students work with everyday phenomena to explicitly develop conceptual understanding.

Procedural Knowledge							
Row	**RTOP**	**Manual Description**	**0**	**1**	**2**	**3**	**4**
11	Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives) to represent phenomena.	Multiple forms of representation allow students to use a variety of mental processes to articulate their ideas, analyze information and to critique their ideas. A "variety" implies that at least two different means were used. Variety also occurs within a given means. For example, several different kinds of graphs could be used, not just one kind.	No evidence.	Students used one approach to articulate ideas, but no analysis of information took place.	Students used at least one means to articulate their ideas and analyze their information. Some experimentation and data collection.	Students used at least two different means or two varieties of means to articulate ideas, analyze information. Little or no critical analysis of ideas.	Students used at least two different means or two varieties of means to articulate ideas, analyze information, and critique their idea.
12	Students made predictions, estimations, and/or hypotheses and devised means for testing them (collecting and analyzing data) Conjecture evident.	This item does not distinguish among predictions, hypotheses and estimations. All three terms are used so that the RTOP can be descriptive of both mathematical thinking and scientific reasoning. Another word that might be used in this context is "conjectures". The idea is that students explicitly state what they think is going to happen before collecting data.	No evidence. Teacher gives students information needed to solve problem.	Students were given a hypothesis to test or discuss. Step by step process. No prediction. (Cookbook activity).	Students made predictions, but these predictions were followed up by classroom discussion and teacher directed explanations Methodology provided.	The students stated what they expected the outcomes of the activity were going to be, and devised a means to test the prediction and collect data. Hypotheses vague. Some teacher guidance	The students explicitly stated what they expected the outcomes of the activity were going to be, and devised a means to test the prediction and collect data.
13	Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	This item implies that students were not only actively doing things, but that they were also actively thinking about how what they were doing could clarify the next steps in their investigation.	No evidence.	Student participation was limited to classroom discussions.	Students were actively engaged in activity (may be more hands-on than minds-on). Students followed the procedures provided by the teacher.	Students were actively engaged in thought-provoking activity at some point during the lesson. Students critically assessed how the procedures could clarify the next steps in their investigation at some point during the lesson.	Students were actively engaged in thought-provoking activity throughout the lesson. Students often critically assessed how the procedures could clarify the next steps in their investigation.
14	Students were reflective about their learning.	Active reflection is a meta-cognitive activity that facilitates learning. It is sometimes referred to as "thinking about thinking." Teachers can facilitate reflection by providing time and suggesting strategies for students to evaluate their thoughts throughout a lesson. A review conducted by the teacher may not be reflective if it does not induce students to re-examine or re-assess their thinking.	No evidence.	Teacher asks no questions that facilitate reflection.	Teacher questions are mostly recitation/ knowledge level, and do not facilitate reflection.	Teacher's questions stimulate reflective and critical analysis of student knowledge. Students do not exhibit any independent reflection exhibited by their questions.	Teacher's questions stimulate reflective and critical analysis of student knowledge. Students ask questions that are reflective, demonstrating that they are thinking about their learning.
15	Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	At the heart of mathematical and scientific endeavors is rigorous debate. In a lesson, this would be achieved by allowing a variety of ideas to be presented, but insisting that challenge and negotiation also occur. Achieving intellectual rigor by following a narrow, often prescribed path of reasoning, to the exclusion of alternatives, would result in a low score on this item. Accepting a variety of proposals without accompanying evidence and argument would also result in a low score.	No evidence.	No competing ideas presented. Scientific argumentation was not modeled or encouraged. Students were asked if they reached the correct conclusion, with explanation following by the instructor. Students do not present (report) findings.	At least two competing ideas were presented. Students reported their data, explained their conclusions, but received no critical questioning or challenge from the instructor.	The instructor asked students to provide evidence to support their conclusions, and that students explain how they reached their conclusion. Challenge and negotiation of conclusions was not encouraged. Findings presented by groups and discussed.	A variety of ideas was presented by the students and whole class or cross-group critique occurred. The instructor encouraged challenge and negotiation, and the instructor asked students for evidence to support their ideas. The instructor modeled scientific argumentation.

Classroom Culture							
Row	**RTOP**	**Manual Description**	**0**	**1**	**2**	**3**	**4**
16	Students were involved in the communication of their ideas to others using a variety of means and media.	The intent of this item is to reflect the communicative richness of a lesson that encouraged students to contribute to the discourse and to do so in more than a single mode (making presentations, brainstorming, critiquing, listening, making videos, group work, etc.). Notice the difference between this item and item 11. Item 11 refers to representations. This item refers to active communication.	No evidence. Students did not share ideas. Alternative articulation not encouraged.	Communication between student and teacher consists of responses to teacher prompts. No variation, only one medium used.	Students explored ideas by following teacher prompts. More than a single mode may be used (e.g., presentations, brainstorming, critiquing, listening, making videos, group work). Teacher guides development of a rationale.	Students negotiated meaning and explored alternative ideas in more than a single mode (e.g., presentations, brainstorming, critiquing, listening, making videos, group work). Student rationale presented without discussion/debate of ideas.	Students negotiated meaning and explored alternative ideas in more than a single mode (e.g., presentations, brainstorming, critiquing, listening, making videos, group work). Rationale presented with discussion/debate of ideas.
17	The Teacher's questions triggered divergent modes of thinking.	This item suggests that teacher questions should help to open up conceptual space rather than confining it within predetermined boundaries. In its simplest form, teacher questioning triggers divergent modes of thinking by framing problems for which there may be more than one correct answer or framing phenomena that can have more than one valid interpretation.	No evidence. Teacher gives information rather than asking question.	Teacher questions frame the conceptual space within predetermined boundaries. All or nearly all questions frame problems/ phenomena in ways that allow only one correct answer or valid interpretation/ explanation. Teacher mostly giving information.	Teacher questions do not clearly open up the conceptual space. Most questions frame problems/ phenomena in ways that allow only one correct answer or valid interpretation/ explanation. Teacher giving some information.	Teacher questions mostly open up the conceptual space. Most questions frame problems/ phenomena in ways that allow more than one correct answer or valid interpretation/ explanation. Teacher giving little information.	Teacher questions fully open up the conceptual space. All questions frame problems/ phenomena in ways that allow more than one correct answer or valid interpretation. Teacher giving very little information.
18	There was a high proportion of student talk and a significant amount of it occurred between and among students.	A lesson where a teacher does most of the talking is not reformed. This item reflects the need to increase both the amount of student talk and of talk among students. A "high proportion" means that at any point in time it was as likely that a student would be talking as that the teacher would be. A "significant amount" suggests that critical portions of the lesson were developed through discourse among students.	No evidence. No talk among students. Answering questions is not scored.	Teacher talk is significantly greater than student discussion. Lesson is mostly teacher talk.	Students engaged in discussion, but teacher contributes significantly.	Student discussion is significantly greater than teacher talk	Lesson consists mostly of talk between and among students. Critical portions of the lesson were developed through student discourse.
19	Student questions and comments often determined the focus and direction of classroom discourse.	This item implies not only that the flow of the lesson was often influenced or shaped by student contributions, but that once a direction was in place, students were crucial in sustaining and enhancing the momentum.	No evidence. Teacher determines direction of lesson.	Student questions are limited to whole class instruction and are all directed to the teacher. Teacher answers student questions, however, teacher determines direction of lesson.	Student questions in groups or in whole class instruction are all directed to the teacher. Teacher answers student questions, however, teacher determines direction of lesson.	Students discuss in groups and with the instructor. Encouraged to ask questions. Teacher answers questions not central to idea and students determine focus and direction of discourse.	Discussion includes group-to-group; student ideas are elicited at beginning of class and determine focus and direction of discourse.
20	There was a climate of respect for what others had to say.	Respecting what others have to say is more than listening politely. Respect also indicates that what others had to say was actually heard and carefully considered. A reformed lesson would encourage and allow every member of the community to present their ideas and express their opinions without fear of censure or ridicule.	No evidence	Teacher only acknowledges student remarks, but does not encourage elaboration.	Teacher actively encourages student remarks, however, elaboration is not encouraged and ideas are not explored freely.	Within groups, students share ideas and share ideas with the instructor; most ideas explored freely.	Ideas are shared and considered between groups and with the entire class. Students allowed to explore ideas freely.

Student-Teacher Relationships							
Row	**RTOP**	**Manual Description**	**0**	**1**	**2**	**3**	**4**
21	Active participation of students was encouraged and valued.	This implies more than just a classroom full of active students. It also connotes their having a voice in how that activity is to occur. Simply following directions in an active manner does not meet the intent of this item. Active participation implies agenda-setting as well as "minds-on" and "hands-on".	No evidence	Students answer questions, but provide no direction to questioning and do not contribute to development of description or explanation. Students simply follow directions (hands-on only)	Minimal minds-on. Teacher gives information. Students encouraged to answer and ask questions; teacher describes and explains.	Minds-on activity. Students actively participate in describing and explaining.	Students actively participate in describing and explaining. Student questions and remarks frame final description or explanation. Students have voice in how activity occurs.
22	Students were encouraged to generate conjectures, alternative solution strategies, and/or different ways of interpreting evidence.	Reformed teaching shifts the balance of responsibility for mathematical of scientific thought from the teacher to the students. A reformed teacher actively encourages this transition. For example, in a mathematics lesson, the teacher might encourage students to find more than one way to solve a problem. This encouragement would be highly rated if the whole lesson was devoted to discussing and critiquing these alternate solution strategies.	No evidence	Students are encouraged to find the "right" answer.	Students are encouraged to think of different ways to solve a problem, however, emphasis is placed on "right" answer.	Students are encouraged to think of other ways to solve problems and to critique strategies. Discussion is primarily within groups.	The balance of responsibility for thought is shifted from teacher to student. Whole class discussion is evident. Critique of alternative solutions is evident.
23	In general, the teacher was patient with students.	Patience is not the same thing as tolerating unexpected or unwanted student behavior. Rather there is an anticipation that, when given a chance to play itself out, unanticipated behavior can lead to rich learning opportunities. A long "wait time" is a necessary but not sufficient condition for rating highly on this item.	No evidence. Lesson involves no questions or activities for which wait time can occur.	Teacher provides insufficient wait time to allow students to think/ reflect/ work before answering or drawing conclusions. Teacher generally seems impatient with students.	Teacher provides sufficient wait time to allow students to think/reflect/work before answering or drawing conclusions. The wait time is not clearly intended to allow unanticipated behaviors to play themselves out and lead to rich learning opportunities.	Teacher provides sufficient wait time for the implicit purpose of allowing unanticipated behaviors to play themselves out and lead to rich learning opportunities.	Teacher provides sufficient wait time for the explicit purpose of allowing unanticipated behaviors to play themselves out and lead to rich learning opportunities.
24	The teacher acted as a resource person, working to support and enhance student investigations.	A reformed teacher is not there to tell students what to do and how to do it. Much of the initiative is to come from students, and because students have different ideas, the teacher's support is carefully crafted to the idiosyncrasies of student thinking. The metaphor, "guide on the side" is in accord with this item.	No evidence. No student investigation.	Teacher tells students how to complete the activity. Questions direct students to "right" answer. Teacher initiated activity and questioning.	Teacher answers questions. Student initiative tolerated but not encouraged.	Teacher does not "tell" students what to do. Teacher encourages student inquiry, but may be answering questions rather than asking probing questions.	Teacher does not "tell" students what to do. Initiative comes from student. Teacher encourages inquiry through probing questions.

25	The metaphor "teacher as listener" was very characteristic of this classroom.	This metaphor describes a teacher who is often found helping students use what they know to construct further understanding. The teacher may indeed talk a lot, but such talk is carefully crafted around understandings reached by actively listening to what students are saying. "Teacher as listener" would be fully in place if "student as listener" was reciprocally engendered.	No evidence. Teacher gives information. Limited interactions between student and teachers. Students give no input in the lesson.	The teacher largely gives information with minimal checks for understanding. Teacher talk is directive. Teacher asks few questions, and questioning is largely focused on a right answer. Neither teacher nor students are engaged in active listening.	The teacher helps students construct understanding, but the understanding is not clearly built from student pre-understandings. Teacher talk is mostly directive, answering questions. Teacher questioning is largely focused on a right-answer (e.g., funneling). Teacher and students are not clearly engaging in active listening.	The teacher helps students construct understanding, but not consistently from student pre-understandings. Teacher talk is not clearly crafted around understandings reached by actively listening to what students are saying. Either teacher or students are not actively listening.	The teacher helps students use what they know to construct further understanding. Teacher talk is carefully crafted around understandings reached by actively listening to what students are saying. Teacher and students are both actively listening.

Notes: