**III. LESSON DESIGN AND IMPLEMENTATION**

**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.

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| 4 | Most students are engaged in discussion of prior knowledge and it is explicit that preconceptions are explored. Most students are engaged in small group and whole group discussions.  |
| 3 | Students apply prior knowledge in whole group discussion. Teacher solicits examples and or discussion of problems and some students respond.  |
| 2 | Teacher asks students to recall and a few students respond. There is some discussion in the whole group. |
| 1 | The teacher refers to previous student experiences or reminds students of previous learning.  |
| 0 | The teacher makes no reference to prior knowledge. |

**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.”

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| 4 | All students in the small group contribute to the construction of ideas and theory building. Whole class discussion also occurs with many students actively participating. |
| 3 | Some students in the small group contribute to the construction of ideas and theory building and/or there may be some whole class discussion with a few students participating. |
| 2 | There is some student-to-student interaction and discussion but little or no construction of ideas or theory building. |
| 1 | The lesson employs only large group discussion with little evidence of community. Primarily the teacher addresses the class and some students respond. |
| 0 | This lesson is completely teacher-centered, lecture only. |

**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.

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| 4 | The teacher presents no formal content prior to student exploration. |
| 3 | The teacher introduces formal content prior to student investigation. |
| 2 | The teacher presents the results of the student investigation prior to student exploration. |
| 1 | The teacher instruction of formal content occurs prior to student investigation. |
| 0 | No student exploration is seen. |

**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.

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| 4 | The teacher solicits multiple approaches to solve the problem and class discussion occurs in small and large groups. Students may evaluate responses and discuss their relative merits. |
| 3 | The teacher solicits multiple approaches to solve the problem in small group or large group. Students may compare approaches, make generalizations |
| 2 | The teacher may suggest multiple approaches, and the students utilize at least two approaches to solve the problem individually or with a small group. Students may use information to solve problems, identify connections and/or relationships but alternative approaches are not an integral part of the lesson.  |
| 1 | The student investigation is teacher directed. Activity is “cookbook” and/or has one solution to a problem. Students may restate or paraphrase information.  |
| 0 | The students do no investigation or problem solving. Activity may include memorizing information and does not indicate understanding the material. |

**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.

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| 4 | The teacher presents a general problem and students originate ideas/approaches/strategies which focus the direction of the lesson. It could involve either activity or discussion.  |
| 3 | Teacher determines focus of lesson but students generate ideas and questions which significantly change the direction of the lesson. Teacher may or may not tie student discussion back to original lesson plan. A large portion of the lesson is determined by student input. |
| 2 | Teacher determines focus of lesson and although student ideas are explored in some depth the end result is still as planned.  |
| 1 | Teacher determines focus of lesson which proceeds as planned; although some student ideas may be explored at a superficial level it does not change the direction of the lesson. Student input is largely procedural. |
| 0 | The lesson is teacher demonstration/lecture.  |

**IV. CONTENT: Propositional Knowledge**

**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.

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| 4 | The lesson is driven by a fundamental scientific or mathematical content concept. Concepts are taken from the appropriate benchmarks in the Arizona Content Standards. Concepts are explored in depth and it is clearly the heart of the lesson. |
| 3 | The lesson includes a fundamental scientific or mathematical concept to average depth. Concepts are taken from the appropriate benchmarks in the Arizona Content Standards. Concepts are explored to an average depth. |
| 2 | The lesson includes a fundamental scientific or mathematical content concept with little or no depth. Concepts are taken from the appropriate benchmarks in the Arizona Content Standards. Concepts are minimally explored.  |
| 1 | The lesson is based on a procedural algorithm, not a fundamental scientific or mathematical concept. |
| 0 | The lesson has no scientific or mathematical concept at its heart. |

**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.

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| 4 | The teacher directs small and/or large group discussion/concept building to center on the major math or science concepts of the unit. Students are highly engaged in creating conceptual meaning from the lesson.  |
| 3 | The teacher solicits description of the phenomena from the students small and/or large group discussions and teacher makes connections between related concepts. |
| 2 | The students have no opportunity for group discussion although teacher-student dialogue occurs. It is clear that this lesson presents a piece of a larger picture where concepts are likely to be connected. |
| 1 | The lesson follows a logical progression, but no effort is made to make students aware of the progression or to allow students to organize the structure themselves. The lesson has potential for conceptual development and may be a piece of a larger picture. Students may have little or no opportunity for discussion. |
| 0 | The concepts have no interrelatedness; each is isolated from the others. The concept is unclear. The lesson may be covering a piece of a concept but there is no effort to make it understood that this is part of a larger understanding.  |

**8) The teacher had a solid grasp of the subject matter content inherent in the lesson. *In practice, the teacher is secure in content and is skilled at pursuing student thoughts and questions (PCK).***

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.

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| 4 | The teacher senses the potential significance of an idea vaguely articulated by a student and pursues the student’s thoughts even if seemingly unrelated at the moment.  |
| 3 | The teacher senses the potential significance of an idea vaguely articulated by a student, but does not pursue the student’s thoughts.  |
| 2 | The teacher does not recognize the potential significance of an idea vaguely articulated by a student. |
| 1 | The teacher makes a factual error in content. |
| 0 | The teacher makes a factual error in content that when pointed out s/he does not acknowledge. |

**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.

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| 4 | The students represent the phenomenon or problem in a symbolic way, and students develop theory through discussion. |
| 3 | The students represent the phenomenon or problem in a symbolic way, and teacher develops theory through discussion. |
| 2 | The students represent the phenomenon or problem in a symbolic way, or teacher develops theory through discussion. |
| 1 | The teacher represents the phenomenon or problem in a symbolic way or teacher explains the theory. |
| 0 | No abstract or symbolic representations of the phenomenon or problem are demonstrated and no real theory is developed. |

**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.

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| 4 | The lesson is connected to a familiar context, and a real world example, application or connection to another discipline is valued and explored extensively. Students are highly engaged in making connections. |
| 3 | The lesson is connected to a familiar context, and at least one real world example, application or connection to another discipline is discussed. Students are moderately engaged in making connections.  |
| 2 | The lesson is based on familiar context but there is no significant exploration. Any connections observed may be weak or superficial. Student engagement in making connections is minimal.  |
| 1 | The lesson is based on a familiar context, but the connection is weak and largely irrelevant to the lesson. Teacher may ignore student proffered connections. |
| 0 | The lesson is not connected to or based on a familiar context. |

**IV. CONTENT: Procedural Knowledge**

**11) Students used a variety of means (models, drawings, graphs, symbols, concrete materials, manipulatives, etc.) 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.

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| 4 | The students represent the phenomenon in at least 3 different ways. Teacher encourages students to make multiple representations and student representations are integral to the class. Students are highly engaged in the articulating their ideas, analyzing information and/or critiquing their ideas |
| 3 | The students represent the phenomenon in at least 2 different ways and are moderately engaged in at least two of the following: articulate their ideas and/or analyze information and/or critique their ideas |
| 2 | The students represent the phenomenon in one or two ways but students minimally articulated their ideas and/or analyze information and/or critique their ideas |
| 1 | The students represent the phenomena in only one way and students do not articulate, analyze or critique their ideas.  |
| 0 | The teacher represents the phenomenon and/or students do an activity which does not significantly engage mental processes.  |

**12) Students made predictions, estimations and/or hypotheses and devised a means for testing them.**

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. In mathematics, these terms may have a somewhat different meaning which would involve analyzing situations, and engaging in systematic reasoning and proof. Exploring, justifying, and using mathematical conjectures are common to all content areas and, with different levels of rigor, all grade levels.

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| 4 | The students explicitly make and explain their prediction, estimation and/or hypothesis. Students devise a means for testing their prediction, estimation and/or hypothesis. In mathematics, students may offer up possible solution strategies and demonstrate reasoning on individual problems. Students determine what are relevant strategies or tools for the solution, and what would be valid and reasonable possible solutions.. |
| 3 | The students explicitly make their prediction, estimation and/or hypothesis. Students devise a means for testing their prediction, estimation and/or hypothesis with input from teacher. In mathematics, students may offer up possible solutions and demonstrate reasoning on individual problems. The teacher guides student discussions, determines what are relevant strategies or tools for the solution and what would be valid and reasonable possible solutions.. |
| 2 | The students make at least one prediction, estimation and/or hypothesis, but teacher devises/guides a means for testing the student’s prediction, estimation and/or hypothesis. In mathematics, students may offer up possible solutions on individual problems. The teacher tests the hypothesis or solutions. |
| 1 | Students may informally play around with materials or ideas. Teachers may demonstrate solutions and reasoning processes. May overhear one instance of prediction, estimation, hypothesizing by students but not further explored in class. |
| 0 | Not seen today / not part of assignment |

**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.

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| 4 | The teacher asks the students to reflect upon the procedure. Students critically assess the validity of their procedures. Ideas are shared with the whole group as well as small groups. |
| 3 | Students were actively engaged in thought provoking activity in small groups, critically assess what they are doing, and try to determine the best procedure. Ideas are not shared with whole group.  |
| 2 | The majority of students are actively engaged in a thought-provoking activity, but do not assess the validity of the procedure, or how it could be improved. Students may ask questions, talk through problems, try to figure out how to do something. |
| 1 | Many students are actively engaged, but the activity is not thought-provoking and students do not assess their procedures. Some students may not be involved in assignment. |
| 0 | The majority of students are passively engaged in the lesson. |

**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.

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| 4 | The students discuss questions such as “How do we know this?” “How can we be sure?” “What does this tell us about what we know?” within their small and large group. |
| 3 | The students discuss questions such as “How do we know this?” “How can we be sure?” “What does this tell us about what we know?” only within their small group.  |
| 2 | There is evidence that some students are thinking about their thinking |
| 1 | The teacher asks a question to prompt students to consider how they think about their learning, but no discussion occurs. |
| 0 | There is no evidence of student reflection. |

**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.

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| 4 | There is critical discussion of the ideas within the small groups and/or cross-group and/or whole group (we expect to see at least two forums for discussion and debate).  |
| 3 | There is critical discussion of the ideas within small or large groups. |
| 2 | Most students articulate at least one one idea. One or two competing ideas may be offered. |
| 1 | Some students articulate one idea, but no competing ideas are offered. |
| 0 | The students articulate no ideas related to the activity. |

**V. CLASSROOM CULTURE: *Communicative Interactions***

**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.

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| 4 | Most/all students share their ideas with their classmates using at least three modes of communication in small and large groups. |
| 3 | Most students share information using at least two means of communication in large or small groups. Students clearly listen to each other.  |
| 2 | Some students may communicate ideas within small groups using one or two means of communication. It is noted that many students are not engaged in communicating ideas. |
| 1 | Little communication among students. Students may share procedural information but not ideas. |
| 0 | The students mainly work alone and do not communicate ideas with others |

**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.

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| 4 | The teacher asks many open-ended questions which open up the conceptual space. Students offer multiple explanations and/or explore connected areas within the large and small groups. Many different answers are possible and various interpretations may be explored. |
| 3 | The teacher asks some genuinely open-ended questions that focus the lesson. Students are encouraged to respond. Teacher may also propose explanations, but does not discount student's ideas.  |
| 2 | The teacher asks at least one open-ended or divergent question. It is a genuine open ended question. Teacher may encourage students to trying out different strategies and encourage them to explore. There is time for expression of student ideas.  |
| 1 | The teacher asks at least one open-ended question, but it is clear the teacher is looking for a specific answer. |
| 0 | The teacher asks no open-ended questions. Questions are fact-based only. |

**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.

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| 4 | This lesson is mostly student talk with critical portions of the lesson developed through student-to-student discourse. |
| 3 | A larger portion of the talk is student-to-student; however critical portions of the lesson are not developed through this discourse. |
| 2 | The proportion of student-to-student talk to teacher-to-student talk is about equal. |
| 1 | There is minimal student-to-student dialog. |
| 0 | There is no talk amongst students. Student-instructor dialog (answering questions) is not scored for this item. |

**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.

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| 4 | The students discuss in their groups, between groups, with the teacher and with the large group. This discourse is central to the development of the description and development of understanding of the phenomenon. |
| 3 | The students discuss in their groups and with the teacher. This discourse is central to the development of the description of the phenomenon. |
| 2 | The students discuss in their small groups, but the discourse is not central to the development of the description of the phenomenon. |
| 1 | The students discuss with the teacher, however student input only slightly influences the focus or direction of the discourse. |
| 0 | The teacher determines the direction of the lesson with no student input. |

**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.

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| 4 | All students are comfortable representing their ideas and expressing their opinions without fear of censure or ridicule. All teacher interactions encourage students to listen to each other respectfully and present their ideas in small and large groups |
| 3 | Most students are comfortable representing their ideas and expressing their opinions without fear of censure or ridicule. Teacher interactions usually encourage students to listen to each other respectfully and present their ideas in small and large groups |
| 2 | Some students are comfortable representing their ideas and expressing their opinions without fear of censure or ridicule. Teacher interactions seldom encourage students to listen to each other respectfully and present their ideas in small and large groups |
| 1 | There is some student interaction. Teacher interaction does not encourage students to listen to each other respectfully and present their ideas in small and large groups |
| 0 | There is little or no student interaction. If the students interact, negative comments may occur. |

**V. CLASSROOM CULTURE: *Student/Teacher Relationships***

**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”.

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| 4 | The students describe the phenomenon and play a significant role in constructing and validating the final explanation of the phenomenon. |
| 3 | The students describe the phenomenon but do not play an adequate role in constructing and validating the final explanation. (Some building of explanation) |
| 2 | The students describe the phenomenon but do not participate in constructing or validating the final explanation of the phenomenon. (No building of explanation) |
| 1 | The teacher’s questioning strategy involves student participation, but is not closely tied to concept building. |
| 0 | Student participation was not encouraged and valued. |

**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.

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| 4 | Teacher actively encourages students to generate conjectures, alternative solution strategies, and/or different ways of interpreting evidence within small groups and brings back for discussion with the large group. |
| 3 | Teacher generally encourages students to generate conjectures, alternative solution strategies, and/or different ways of interpreting evidence within small groups; it is not discussed with the large group. |
| 2 | The teacher accepts multiple strategies, conjectures or ways of interpreting evidence but makes no effort to solicit multiple ways. |
| 1 | The teacher has only one path to the correct answer that is acceptable. |
| 0 | The teacher provides all conjectures, solution strategies and ways of interpreting evidence. |

**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 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.

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| 4 | The teacher provides sufficient wait time and ample opportunity for students to explore and/or respond on their own terms.  |
| 3 | The teacher provides sufficient wait time, but does not capitalize on all opportunities to allow students to explore and/or respond on their own terms. |
| 2 | The teacher tends to provide sufficient wait time before accepting student responses but may or may not follow through on student response. |
| 1 | The teacher seldom provides sufficient wait time before accepting student responses and may or may not follow through on student responses. |
| 0 | The teacher provides no wait time. |

**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.

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| 4 | The teacher uses student investigations or questions to direct the inquiry process. |
| 3 | The teacher answers questions instead of directing inquiry. |
| 2 | The student investigations are teacher prescribed (cookbook). |
| 1 | The teacher demonstrates the phenomenon followed by large group discussion. |
| 0 | The class is lecture based. |

**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.

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| 4 | The teacher listens to the students and does not dominate group interactions. The teacher asks questions to help the student construct their own understanding.  |
| 3 | The teacher listens to the students, the students listen to the teacher (reciprocity) but the teacher was too directive. The teacher gives too many answers instead of asking questions to help the student construct their own understanding.  |
| 2 | Some attempts are made by the teacher to listen to the students: The teacher attempts at least two of the following: checking for understanding and/or checking for initial student knowledge and/or incorporating student ideas into the lesson and/or assessing final student understanding of the material. |
| 1 | One attempt is made by the teacher to listen to the students: this may be seen by the lack of checking for understanding, or checking for initial student knowledge or incorporating student ideas into the lesson or assessing final student understanding of the material. |
| 0 | There is no attempt by the teacher to listen to the students: this may be seen by the lack of checking for understanding, or checking for initial student knowledge or incorporating student ideas into the lesson or assessing final student understanding of the material. |