

EQUIPping Teachers



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Inquiry

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Inquiry

Developing
Inquiry

Preinquiry

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A protocol to guide and improve inquiry-based instruction

— Jeff Marshall, Robert Horton, and Chris White —

Many teachers have uttered the following statement, or at least something similar: “I do not know exactly how to define inquiry, but I know it when I see it.” This intuitive understanding may work for onlookers, but something greater is needed from those who lead instruction in our classrooms. For many years, publications such as the *National Science Education Standards* (NRC 1996) and *The Science Teacher (TST)* have encouraged teachers to focus science classes more heavily on inquiry-based instructional practice. The

challenge becomes more than just increasing the amount of time spent on inquiry—we also need to improve the quality of inquiry within science classrooms.

One way to improve our teaching practice is to use a benchmark assessment to obtain a solid point of reference that honestly reflects what we do in the classroom, and then to design a developmental plan to raise the level of performance. Electronic Quality of Inquiry Protocol (EQUIP) is helpful in providing both a benchmark and a guide to improving the quality of inquiry implemented in our classrooms.

EQUIP overview

A survey completed in 2007 found that K–12 math and science teachers reported spending an average 39% of their time on inquiry-based instruction (Marshall, Horton, and Smart In Press). Further observations suggested that the inquiry being implemented was often of poor quality. However, our research team had difficulty verifying this claim without a valid measure of inquiry instruction. To address this need, we created EQUIP. Two years of development and testing have resulted in a reliable, valid measurement tool to assess inquiry instruction.

Good teachers should use many different instructional methods throughout the day, week, and year. Consequently, EQUIP is not designed for all situations; it specifically focuses on the factors associated with the quality of inquiry-based instruction, not with other methods used in the classroom. The development of the protocol was supported by several existing instruments (Horizon

Research 2002; Llewellyn 2005, 2007; Sampson 2004; Sawada et al. 2000).

EQUIP considers five specific factors (see “Factors and indicators breakdown,” p. 53) that support inquiry-based teaching and learning:

- ◆ Time Usage
- ◆ Instruction
- ◆ Discourse
- ◆ Assessment
- ◆ Curriculum

Indicators associated with each factor are first evaluated, and then a holistic score for each factor is determined based on the level of inquiry (see “Factors and indicators breakdown”). Although not necessarily the mean of the independent indicator scores, the holistic scores reflect the essence of the lesson relative to that component.

Once the benchmark measurement has been

FIGURE 1

Sample to illustrate Time Usage Factors (with index of terms below).

Time (min.)	Activity Focus	Organizational Structure	Student Attention	Cognitive Levels	Notes
0–5	Proficient Inquiry (Level 3)	Whole class	Medium	Receipt of Knowledge	Instructions/challenge were provided.
5–10	Proficient Inquiry (Level 3)	Small group	High	Create	Students brainstormed their designs.
10–15	Developing Inquiry (Level 2)	Small group	High	Lower Order	Teacher provided a visual to show students how to build vehicle.

Activity Focus (facilitated by teacher):

- ◆ Noninstructional time
- ◆ Preinquiry
- ◆ Developing Inquiry
- ◆ Proficient Inquiry
- ◆ Exemplary Inquiry

Organizational Structure:

- ◆ Whole class
- ◆ Small group
- ◆ Individual work

Student Attention:

- ◆ Low—20% or less are attending to or engaged in the lesson.
- ◆ Medium—50% of students are attending to or engaged in the lesson.

- ◆ High—80% or more are attending to or engaged in the lesson.

Cognitive Levels (displayed by students):

- ◆ Other (e.g., classroom disruption, noninstructional portion of lesson)
- ◆ Receipt of Knowledge
- ◆ Lower Order (i.e., recall, remember, understand, and activities focus on completion exercises)
- ◆ Apply (i.e., demonstrate, modify, compare, and activities focus on problem solving)
- ◆ Analyze/evaluate (i.e., evidence, verify, analyze, justify, interpret)
- ◆ Create or transfer (i.e., combine, construct, formulate, develop)

established, teachers or teams are then able to chart growth and target areas where improvement is desired. This helps to move from the “I know it when I see it” view to an understanding of the specific aspects of a lesson that make inquiry effective. This knowledge can provide a foundation for developing a plan that will ultimately improve inquiry-based instruction and student learning.

There are several ways to use the EQUIP instrument:

- ◆ Teachers can use it to reflect upon a lesson (most convenient but least valuable and most subjective).
- ◆ Teachers can videotape a lesson and then go back and complete the protocol either alone or with peers during a replay of the lesson.

- ◆ Teachers can complete the instrument while observing another’s class.
- ◆ An instructional coach or curriculum coordinator can use it to guide conversations with a teacher or team of teachers.

Providing a benchmark

To begin, the EQUIP instrument is used to review the objectives and standards for a given lesson to make sure they are clear, explicit, and well aligned with the instructional plan. Then, analysis is initiated within each of the five factors to determine the level of inquiry demonstrated—from Preinquiry (Level 1) to Develop-

FIGURE 2

Instruction Factors associated with inquiry-based instruction.

Construct measured	Preinquiry (Level 1)	Developing Inquiry (Level 2)	Proficient Inquiry (Level 3)	Exemplary Inquiry (Level 4)
Instructional Strategies	Teacher predominantly lectured to cover content.	Teacher frequently lectured and/or used demonstrations to explain content. Activities were verification only .	Teacher occasionally lectured , but students were engaged in activities that helped develop conceptual understanding.	Teacher occasionally lectured, but students were engaged in investigations that promoted strong conceptual understanding .
Order of Instruction	Teacher explained concepts. Students either did not explore concepts or did so only after explanation.	Teacher asked students to explore concept before receiving explanation . Teacher explained.	Teacher asked students to explore before explanation . Teacher and students explained .	Teacher asked students to explore concept before explanation occurred. Though perhaps prompted by the teacher, students provided the explanation .
Teacher Role	Teacher was center of lesson; rarely acted as facilitator.	Teacher was center of lesson; occasionally acted as facilitator .	Teacher frequently acted as facilitator.	Teacher consistently and effectively acted as facilitator.
Student Role	Students were consistently passive as learners (taking notes, practicing on their own).	Students were active to a small extent as learners (highly engaged for very brief moments or to a small extent throughout lesson).	Students were active as learners (involved in discussions, investigations, or activities, but not consistently and clearly focused).	Students were consistently and effectively active as learners (highly engaged at multiple points during lesson and clearly focused on the task).
Knowledge Acquisition	Student learning focused solely on mastery of facts, information, and rote processes.	Student learning focused on mastery of facts and process skills without much focus on understanding of content.	Student learning required application of concepts and process skills in new situations.	Student learning required depth of understanding to be demonstrated relating to content and process skills.

ing Inquiry (Level 2) to Proficient Inquiry (Level 3) to Exemplary Inquiry (Level 4)—for a specific lesson on a given day and time.

The descriptive rubric is meant to provide a benchmark to challenge teachers to think individually or collectively about how to improve the quality of inquiry-based instructional practice. If a teacher's goal is a high-level inquiry experience, for example, then Level 3 or Level 4 inquiry is desirable. Teachers should avoid becoming defensive about the ratings; it is important to understand why a score falls into a specific level and what can be done to advance the lesson to a higher level in the future.

In the next sections, each of the five factors is dis-

cussed in more depth as we illustrate the application of EQUIP. (**Note:** The complete EQUIP instrument [Marshall et al. 2008] can be freely downloaded from http://iim-web.clemson.edu/?page_id=166.) The example we use is from a physical science lesson framed by the essential question: “What factors affect the motion of an object?” To address this question, the teacher provided teams of three or four students with mousetrap racer kits and challenged them to create the fastest mousetrap racer to reach 5 m while incorporating a braking mechanism to stop it before it reached 6 m. This competition incorporated process skills (e.g., asking good scientific questions, collecting meaningful data,

FIGURE 3

Discourse Factors associated with inquiry-based instruction.

Construct measured	Preinquiry (Level 1)	Developing Inquiry (Level 2)	Proficient Inquiry (Level 3)	Exemplary Inquiry (Level 4)
Questioning Level	Questioning rarely challenged students above the remembering level.	Questioning rarely challenged students above the understanding level .	Questioning challenged students up to application or analysis levels .	Questioning challenged students at various levels, including at the analysis level or higher; level was varied to scaffold learning .
Complexity of Questions	Questions focused on one correct answer; typically short-answer responses.	Questions focused mostly on one correct answer ; some open-response opportunities.	Questions challenged students to explain, reason, and/or justify .	Questions required students to explain, reason, and/or justify. Students were expected to critique others' responses .
Questioning Ecology	Teacher lectured or engaged students in oral questioning that did not lead to discussion.	Teacher occasionally attempted to engage students in discussions or investigations but was not successful.	Teacher successfully engaged students in open-ended questions, discussions, and/or investigations.	Teacher consistently and effectively engaged students in open-ended questions, discussions, investigations, and/or reflections.
Communication Pattern	Communication was controlled and directed by teacher and followed a didactic pattern.	Communication was typically controlled and directed by teacher with occasional input from other students; mostly didactic pattern.	Communication was often conversational with some student questions guiding the discussion.	Communication was consistently conversational with student questions often guiding the discussion .
Classroom Interactions	Teacher accepted answers, correcting when necessary, but rarely followed up with further probing.	Teacher or another student occasionally followed up student response with further low-level probe.	Teacher or another student often followed up response with engaging probe that required student to justify reasoning or evidence .	Teacher consistently and effectively facilitated rich classroom dialogue where evidence, assumptions, and reasoning were challenged by teacher or other students.

analyzing results) and conceptual ideas (e.g., speed, motion, force, conservation of energy) from science, math, and engineering disciplines.

Time Usage Factor

In EQUIP, Time Usage is assessed by several indicators at 5-minute intervals (Figure 1, p. 47; see also “Factors and indicators breakdown,” p. 53). (Note: The complete Time Usage instrument [Marshall et al. 2008] can be freely downloaded from http://iim-web.clemson.edu/?page_id=166.) Coding the indicators allows pat-

terns and trends in instruction to be seen, and thus provides a mapping of strengths and challenges.

During the first time segment in our example, the teacher provided the mousetrap racer kit challenge to the class. As this was a very appropriate use of time—the instructions were complete enough for students to understand the task at hand, but open enough to encourage creativity and depth of thought—we rated the Activity Focus’ inquiry at Level 3 (Figure 1). However, the quality of the inquiry dropped to Level 2 at the 10- to 15-minute segment as students went

FIGURE 4

Assessment Factors associated with inquiry-based instruction.

Construct measured	Preinquiry (Level 1)	Developing Inquiry (Level 2)	Proficient Inquiry (Level 3)	Exemplary Inquiry (Level 4)
Prior Knowledge	Teacher did not assess students' prior knowledge.	Teacher assessed students' prior knowledge but did not modify instruction based on this knowledge.	Teacher assessed students' prior knowledge and then partially modified instruction based on this knowledge.	Teacher assessed students' prior knowledge and then modified instruction based on this knowledge.
Conceptual Development	Teacher encouraged learning by memorization and repetition.	Teacher encouraged product- or answer-focused learning activities that lacked critical thinking .	Teacher encouraged process-focused learning activities that required critical thinking .	Teacher encouraged process-focused learning activities that involved critical thinking that connected learning with other concepts .
Student Reflection	Teacher did not explicitly encourage students to reflect on their own learning.	Teacher explicitly encouraged students to reflect on their learning but only at a minimal knowledge level .	Teacher explicitly encouraged students to reflect on their learning at an understanding level .	Teacher consistently encouraged students to reflect on their learning at multiple times throughout the lesson; encouraged students to think at higher levels .
Assessment Type	Formal and informal assessments measured only factual, discrete knowledge.	Formal and informal assessments measured mostly factual, discrete knowledge .	Formal and informal assessments used both factual, discrete knowledge and authentic measures .	Formal and informal assessment methods consistently and effectively used authentic measures .
Role of Assessing	Teacher solicited predetermined answers from students requiring little explanation or justification.	Teacher solicited information from students to assess understanding .	Teacher solicited explanations from students to assess understanding and then adjusted instruction accordingly .	Teacher frequently and effectively assessed student understanding and adjusted instruction accordingly; challenged evidence and claims made; encouraged curiosity and openness .

from problem solving to listening to a lecture on how to build their racer.

In regard to Student Attention, after an initial period when several students were off task, almost all students became involved in solving the mousetrap vehicle challenge. During this same 15-minute period, the Cognitive Level (Figure 1) changed from Receipt of Knowledge (when the teacher provided instructions) to Create (when students brainstormed ideas on their racers), to Lower Order (when students were following the teacher's directions on how to assemble their racer). Overall, the quality of inquiry would have been significantly better had the teacher allowed students more time to explore and then follow through on their own ideas.

For the remaining four factors, all indicators are assessed at the end of the class. A descriptive rubric is used to differentiate the various levels of inquiry regarding these indicators.

Instruction Factor

Figure 2 (p. 48) shows the five indicators that comprise the Instruction Factor (see also "Factors and indicators breakdown"). Two of these indicators—Instructional

Strategies and Order of Instruction—are described using the mousetrap challenge example.

In the class being analyzed, the teacher provided the vehicle assembly instructions for students before they had sufficient time to think through their own creation; she also stopped and lectured about the terminology associated with motion. Therefore, the Instructional Strategies indicator earned a Level 2 inquiry rating (Figure 2). Had the teacher provided more opportunities for input of student ideas throughout the investigation, then the quality of the inquiry would have been at least Level 3.

However, the teacher did achieve a Level 3 inquiry rating for Order of Instruction because the lesson engaged students in exploring concepts before the teacher explained them, and students were involved in explaining their conceptual ideas to the teacher and their peers.

Discourse Factor

Discourse measures the classroom climate and interactions relating to inquiry instruction and learning (Figure 3, p. 49; see also "Factors and indicators breakdown"). Two of the indicators associated with this factor—

FIGURE 5

Curriculum Factors associated with inquiry-based instruction.

Construct measured	Preinquiry (Level 1)	Developing Inquiry (Level 2)	Proficient Inquiry (Level 3)	Exemplary Inquiry (Level 4)
Content Depth	Lesson provided only superficial coverage of content.	Lesson provided some depth of content but made no connections to the big picture.	Lesson provided depth of content with some significant connection to the big picture.	Lesson provided depth of content with significant, clear, and explicit connections to the big picture.
Learner Centrality	Lesson did not engage learner in activities or investigations.	Lesson provided prescribed activities with anticipated results.	Lesson allowed for some flexibility during investigation for student-designed exploration.	Lesson provided flexibility for students to design and carry out their own investigations.
Standards	Lesson was solely content-focused; no inquiry present.	Lesson was content-focused with minimal opportunities provided for inquiry.	Lesson used inquiry to address content.	Lesson consistently and effectively united learning of content with inquiry.
Organizing and Recording Information	Students organized and recorded information in prescriptive ways.	Students had only minor input as to how to organize and record information.	Students regularly organized and recorded information in nonprescriptive ways.	Students organized and recorded information in nonprescriptive ways that allowed them to effectively communicate their learning.

Questioning Level and Classroom Interactions—are described here using the example class.

As the lesson progressed, the teacher provided challenging, higher-level questions (e.g., “How did your results compare with those from other groups?”) while students presented their findings, resulting in a Level 3 inquiry rating for Questioning Level.

However, once students responded to the higher-level questions, the quality of the interactions dropped as the teacher followed up responses with only low-level probes (e.g., “How did you find the second point on the graph?”). This accounts for the Level 2 inquiry rating for Classroom Interactions (Figure 3, p. 49). The teacher could raise this score by following up student responses with more thought-provoking questions, such as, “Why was the slope calculated by group 2 larger than the slope calculated by group 1? What does that slope tell us?”

Assessment Factor

Five indicators are used to measure Assessment Factors relating to instructional practice (Figure 4, p. 50; see also “Factors and indicators breakdown”). Two of the indicators—Prior Knowledge and Conceptual Development—are described in the context of the mousetrap challenge.

Because the lesson did not attempt to assess or take into consideration the prior knowledge students possessed, the teacher earned a Level 1 inquiry rating for Prior Knowledge (Figure 4). A short pretest, a K-W-L (What I *know*, What I *want* to know, What I *learned*) chart, or even a discussion concerning what students already knew may have revealed strengths or misconceptions regarding motion that should have been addressed.

The teacher also fell short on Conceptual Development. When diagnostic and formative assessments are implemented throughout the lesson, student learning increases (Black and Wiliam 1998). By making the lesson more prescribed than necessary, critical thinking was minimized. This resulted in a Level 2 inquiry rating for this indicator (Figure 4). When students are challenged to defend their solutions to scientific questions, a Level 3 or 4 inquiry rating is appropriate.

Curriculum Factor

Finally, EQUIP assists teachers in measuring four indicators associated with various curriculum issues related to inquiry instruction (Figure 5, p. 51; see also “Factors and indicators breakdown”). Two of these indicators—Standards and Organizing and Recording Information—are discussed using the example class.

The Standards addressed by the lesson example included both inquiry-process skill development (e.g., communicating findings) and content standards (e.g., speed versus time graph, conservation of energy), thus earning a Level 3 rating.

Organizing and Recording Information was scored at Level 2 because the teacher provided little opportunity for students to determine how the data should be collected and organized (Figure 5). Because the teacher provided data sheets with the headings and axes already labeled, she deprived students of a rich opportunity to think about how to collect, organize, and convey meaning from the data. This opportunity would have challenged students to think more deeply and more critically about the concepts being investigated (e.g., “How many trials are needed? Is speed the independent or dependent variable, and why?”). Had the teacher provided this opportunity, the rating for this indicator would have risen to a Level 3 or 4.

Organizing and Recording Information is one of several areas in which teachers can provide students with different levels of scaffolding—thus differentiating instruction. The goal is to challenge all students to the highest level while not overly frustrating anyone. For instance, one student with a learning disability may need the structure that a graphic organizer provides; an English language learner (ELL) may need more visuals to help decode the language barriers. Ideally, students will eventually progress to a level where less direct assistance is needed. Thus, lifelong learning is encouraged and developed. To earn a Level 4 on this and other indicators, teachers should consider the various needs of *all* students in their class.

Improving quality of inquiry teaching

After each of the indicators associated with the five factors has been assessed, an overall rating is determined for each. Again, this holistic rating is not necessarily the mean of the indicators, but rather it should capture the essence of the lesson.

Once the instrument has been completed and the current state of inquiry instruction is established, the next step is to improve the quality of inquiry. Establishing the benchmark may bring about some changes because specific aspects of instructional practice are brought to the teacher’s attention. The goal is to be more intentional and explicit by developing an action plan of next steps. It is normal to want to improve everything that ails our instruction all at once. However, such a course of action often leads to frustration and undue anxiety; effective change is usually incremental.

Our recommendation is for teachers to focus on one specific indicator that they wish to improve upon during the next lesson or unit of study. Once the desired growth has been achieved, then it is time to tackle another indicator. After five indicators relating to inquiry instruction have been improved—perhaps one from each of the factors—the teacher should strive to maintain that level of performance before undertaking more improvements. If teachers work with others and note common areas for

growth, it may make sense to work on certain indicators together. This shared approach provides a support structure to exchange thoughts and ideas.

If current practice falls largely in Level 1 inquiry, then it makes sense to begin by reading about inquiry and constructivist forms of teaching to look for examples and models of inquiry-based instruction. *TST* consistently features examples and models that help teachers acclimate to an inquiry-based instructional approach. Also, many professional development institutes provide opportunities for teachers to experience inquiry learning firsthand.

Generally, a Level 2 inquiry performance suggests that a teacher is familiar with getting students engaged and active, but that students are largely involved in more prescriptive forms of inquiry. Additionally, instruction is still heavily teacher-focused.

By Level 3, a teacher has demonstrated a student-centered inquiry learning environment that actively engages students in investigations, questioning, and explanations. The role of the teacher remains vital, but he or she now functions more as a facilitator who scaffolds learning experiences than as a giver of facts and knowledge.

Conclusion

It is not expected that any one lesson would merit a Level 4 for all indicators or factors. We have yet to see such a lesson, and we have seen some amazing ones. The point is not to make every instructional moment a Level 3 or higher; rather, the goal is to make teachers more intentional about their practice. Teachers who are more aware of what high-quality inquiry practice entails will be more likely to implement it successfully when it is the desired instructional approach.

We hope that EQUIP will provide teachers with a concrete way to reflect on their own teaching practice as they strive to lead inquiry-based, project-based, and problem-based learning experiences in their classrooms. Inquiry instruction is challenging to implement well, but when done effectively, learning is clearly evident with all students and at all ability levels. ■

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Factors and indicators breakdown.

Time Usage:

- Activity Codes
- Organization Codes
- Student Attention to Lesson Codes
- Cognitive Codes
- Inquiry Instruction Component Codes
- Assessment Codes

Instruction:

- Instructional Strategies
- Order of Instruction
- Teacher Role
- Student Role
- Knowledge Acquisition

Discourse:

- Questioning Level
- Complexity of Questions
- Questioning Ecology
- Communication Pattern
- Classroom Interactions

Assessment:

- Prior Knowledge
- Conceptual Development
- Student Reflection
- Assessment Type
- Role of Assessing

Curriculum:

- Content Depth
- Learner Centrality
- Standards
- Organizing and Recording Information