Honing teachers' behind the scenes work:

Pragmatic ideas from best practices

Herb Fynewever, Charles Henderson, Stephen Barry, Sandra Erwin, Scott Hanson, Michael Huber, Mary Z. Lindow, and Kathy Mirakovits.

Abstract

During the 2006-2007 academic year, six high school teachers and two university faculty met monthly to identify best practices for four types of unobservable instructional activities. For each, we summarize best practices and describe how they have been adapted by team members. Survey data provides a snapshot of how typical teachers feel they are doing in each area.

Introduction

Often teaching is thought of as something that can be observed, with good teaching described in terms of what an observer might see happening during a class session. This viewpoint is evident in many of the calls for inquiry-based instruction that focus on what a teacher can do to help the students be more active learners during class time. For example, how a teacher might facilitate a class discussion to help students propose possible explanations for a phenomena that can then be tested experimentally. There is considerably less focus on the many things that teachers do "behind the scenes" to help their students learn.

In this paper, we describe the results of a project where six high school teachers and two university faculty worked throughout an academic year to find and distill best practices for teachers' unobservable educational choices in four areas: homework construction, test item writing, formative assessment, and supporting students in metacognition. We surveyed the literature and reflected on the research results in light of our own experiences as teachers. We individually wrote draft "quality indicators" to summarize the guidelines implicit in the research as they might inform our own teaching. We then brought artifacts from our own practice that we know have been (or have *not been*) successful to see how the research base can be summarized to evaluate these pieces. The complete list of quality indicators can be found in Table 1. It should be noted that there are a few items that are often or even usually observable. Although this was not the focus of our project, we did include these items because they figure prominently in these four areas that are *mostly* made up of unobservable practice.

We invite readers now to self-assess their own instructional practices. Think of a particular class that you teach and rate yourself on a scale of 1: "very little" to 5: "very much" for each of the 40 quality indicators. When you are finished, calculate your total score for each of the four major areas.

Although each of the quality indicators is well-supported by educational research, some of the instructional activities described are more common in actual practice than others. To get an understanding of how common each area is in practice, we asked all of the science teachers at three schools in Michigan to use the quality indicators to self-assess the unobservable educational choices that they make. A total of 22 teachers participated in the self-assessment. Average self-ratings in each area by these teachers are (in descending order): homework construction (average rating of 39 (out of 50)), test item writing (average rating of 35 (out of

50)), supporting students in metacognition (average rating of 31 (out of 50)), and formative assessment (average rating of 29 (out of 50)).

Follow-up ideas

What should you do if your scores in a particular area or for particular items are low? Below we give some more information about each area of focus together with references and some examples of teacher practice. We hope that these concrete examples, together with literature suggestions of best practices, are helpful to teachers looking for ideas on how to shore up areas of weakness.

Homework assignments

Spending time learning through homework is very important for American students (Cooper, Valentine 01). For example, it is recommended that, on average, high school students have 1-2 hours of homework per course each week (Cooper 94). It is important that this time be used in synchrony with the in-class work. In practice, though, teachers who move towards more inquiry-oriented instructional styles sometimes retain their former homework practices of rote-oriented worksheets. Many of the reforming principles that have worked for learning in classrooms can also be applied as a guide for science teachers in designing learning activities for outside of class.

As an example of high quality homework assignments, see Figure 1, which shows questions given as homework in an International Baccalaureate Chemistry course. This assignment is representative of the quality indicators especially in that it focuses on "content likely to be in the standards" (Item 1) even while it "involves application of learned material to new situations" (Item 8). Although this was one of our groups highest scoring homework artifacts, it still only scored marginally well (3.71 out of 5) for "Assignments emphasize higher-order thinking" (Item 2) and less well (2.86 out of 5) for "Assignments emphasize inquiry" (Item 3). This highlights how homework assignments lag behind classroom lessons in conforming to these best practices.

Figure 1: Homework assignment from an International Baccalaureate Chemistry class

a. Electrolysis can be used to obtain chlorine from molten sodium chloride. Write an equation for the reaction occurring at each electrode and describe the two different ways in which electricity is conducted when the cell is in operation.

b. In one experiment involving the electrolysis of molten sodium chloride, 0.1 mol of chlorine was formed. Deduce, giving a reason, the amount of sodium formed at the same time.

c. In another experiment involving the electrolysis of molten sodium chloride, the time of the electrolysis was halved and the current increased from 1 amp to 5 amp, compared to the experiment in (b). Deduce the amount of chlorine formed, showing your work.

d. If dilute aqueous sodium chloride is electrolyzed, a different product is obtained at each electrode. Identify the product formed at each electrode and write an equation showing its formation.

Test Questions

Tests are an important opportunity to gather data on what students are learning and to reveal that data to the student and the instructor (Ennever 06). But while teachers may have students learn through inquiry-oriented in-class activities, they might still create tests focused on rote memorization. This sends mixed messages to the students and diminishes the importance they give to the in-class activities. By realigning test items to be more consistent with the nature of a reformed classroom we as teachers can reinforce the type of deep learning that we value.

As an example of high quality test questions, see Figure 2 which shows a series of four questions taken from a 9th grade Physical Science course. This artifact does well with several of the quality indicators. It goes beyond rote memorization, requiring deep thinking and the use of models and abstractions (Item 13). The test includes everyday phenomena, likely to be within the student experience (Items 15). A couple of the items shown require the students to justify their ideas (Item 17) and to synthesize their knowledge (Item 18). Note that, even though this was the highest scoring artifact submitted by our group, it still scored poorly (1.57 out of 5) for Item 14 "Test requires students to analyze alternative positions/explanations." Although this important component of inquiry is easily incorporated into classroom lessons that encourage students to critique each other's ideas it is less likely to be included in our testing.

Figure 2: Test items from a 9th Grade Physical Science class

1. Sketch a two-dimensional model of a water molecule. Show the polarity of the molecule.
2. Show in a picture salt particles completely dissolved in a beaker of water.
3. Ethanol evaporates more quickly at room temperature than water. How could you explain this fact using what you know about particle interactions?
4. Substance A dissolves in water, but Substance B does not. What would explain the differences between Substance A and Substance B?

Formative Assessment

As teachers we are often frustrated when students are more interested in the grade that they are getting than they are curious about the science they should be learning. Yet, we might be reinforcing these attitudes by using "points" lost or gained as the primary motivator to get our students to work. The use of formative assessment (a.k.a. "assessment for learning") can begin to change this environment for the better. With formative assessment the focus shifts from quantitative grades to a more narrative style of feedback. Teachers who have been able to make the radical shift away from any numerical scores (on homework, for example) have seen how it increases students' interest in the content and even increases their quantitatively measured test scores (Black et al. 04).

To gauge the use of formative assessment in our group we wrote open-ended descriptions of our practice which aligned (or did not align) with the quality indicators which we had settled on. Figure 3 contains an excerpt from the practices of a biology teacher. These practices take

advantage of some aspects of formative assessment through the use of rubrics and peer assessment up front. The teacher admits, however, that the labor-intensive nature of accepting revised work prevents her from doing so.

Figure 3: Teacher comments regarding formative assessment in a sophomore biology class

"Students are given rubrics for their lab notebook, formal lab reports, and any special projects I might assign. The expectation is that the student will assess their own work based on the criteria contained in the rubric. At the sophomore level, students have the opportunity to peer edit their formal lab reports in class. After peer editing, the students are typically given at least two days to make revisions on the lab report before submitting it for my evaluation.

Occasionally I allow several students to submit revised formal lab reports or have them complete an incomplete lab notebook. With 90 to 100 sophomores, it is difficult to accept more than a few revisions."

Metacognitive Support

Research shows that experts (teachers and scientists) are very proficient in metacognitive activities, such as self-assessment, self-explanation, monitoring, or revising in order to productively engage in inquiry (White, Frederiksen 05). Although we might assume that our students will pick up these skills "along the way," as teachers we can greatly boost and accelerate this process by explicitly training and supporting our students in metacognition (Carillo et al. 05). This training can take place as classroom lessons but it can also be integrated into assignments and other elements of course structure.

As an example of instruction that incorporates metacognitive support, see Figure 4 in which a high school physics teacher describes how she incorporates metacognition into an interdisciplinary forensic science class. One element of metacognition in this example is the modeling that the teacher does. By explicitly coaching the students to think carefully, rather than to jump to conclusions, the students are learning how to use the caution and logic required by science. Another focus is on elaboration and organizational strategies that the students use to extract and preserve important information from shared resources. Overall, the teacher warns that, in her experience, instruction in metacognition is most effective if it is not "overbearing."

Figure 4: Teacher comments regarding metacognition in a Forensic Science class

"Teaching study skills is effective if you are not overbearing with the insistence on teaching/using those skills. Modeling, using, suggesting ways to tackle material seems to be the most effective. The best example I can think of in this class is probably during the crime scene assessment. I try to direct students in ways to open themselves up to all possible reasons for what they observe—to think with an open mind, not to jump to conclusions too soon. Another study skill we use is outlining a chapter in the book and expanding on important ideas. Students do not have their own book, but share a classroom set, so they have to learn to take good notes and outline a chapter, as it is their only personnel copy of the material."

Teacher perceived successes and remaining barriers

In addition to rating themselves on the quality indicators, we asked the 22 teachers to reflect on those quality indicators for which they gave themselves a low score. We asked them whether they felt that these quality indicators were important. In some cases they did not, but in most cases teachers felt that the quality indicators were important. In these cases they were invited to provide a reason for the discrepancy between their belief in the importance of the item and their low self-rating. Five types of reasons came up regularly (listed in order of the number of times each occurred): not sure how to do, teacher time constraints, class time constraints, had not considered previously, students not capable. Table 2 gives an example of each of these reasons.

The reasons given point to the many obstacles that teachers face when considering a new instructional activity and also to the difficulty they have balancing multiple demands. Although the obstacles are real and, in many cases, significant we believe that it is productive for teachers to be aware of gaps between their desired instructional practices and their actual instructional practices. Although it is probably never possible to close the gap completely, it is possible to make the gap increasingly smaller. This is good for the teacher's self-image as well as the success of their students.

Herb Fynewever (herb.fynewever@wmich.edu) is an Assistant Professor of Chemical Education, and Charles Henderson (charles.henderson@wmich.edu) is an Assistant Professor of Physics Education both at Western Michigan University in Kalamazoo, Michigan; Scott Hanson (scott.hanson@bcmsc.k12.mi.us) teaches chemistry and Mary Z. Lindow (mary.lindow@bcmsc.k12.mi.us) teaches biology both at the Battle Creek Mathematics and Science Center in Battle Creek, Michigan; Stephen Barry (barrys@harpercreek.net) and Sandra Erwin (erwins@harpercreek.net) both teach chemistry and physical science at Harper Creek High School in Battle Creek, Michigan; Mike Huber (MHuber@PortagePS.org) teaches chemistry and Kathy Mirakovits (kmirakovits@portageps.org) teaches physics and forensic science, both at Portage Northern High School in Portage, Michigan.

Acknowledgements

The authors would like to acknowledge the Michigan Spaces Grants Consortium for providing funding in support of this work.

References

Black, P., Harrison, C., Lee, C., Marshall, B., and Wiliam, D. 2004. Working inside the black box: Assessment for learning in the classroom. *Phi Delta Kappan* 86(1): 8-21.

Carillo, L., Lee, C., and Rickey, D. 2005. Enhancing science teaching by doing MORE: A frame work to guide chemistry students' thinking in the laboratory. *The Science Teacher* 72(10): 60-64.

Cooper, H. and Valentine, J.C. 2001. Using research to answer practical questions about homework. *Educational Psychologist* 36(3): 143-153.

Cooper, H. (1994) Homework research and policy: A review of the literature, *Center for Applied Research and Educational Improvement Research/Practice Newsletter*, 2(2)*:* http://www.education.umn.edu/CAREI/Reports/Rpractice/Summer94/homework.html

Ennever, F. 2006. More than multiple-choice. *The Science Teacher* 73(10): 54-56.

White, B. and Frederickson, J. 2005. A theoretical framework and approach for fostering metacognitive development, *Educational Psychologist* 40(4): 211-223.

Table 1: Quality Indicators						
	Homework construction	***very little***				***very much***
1	The content of the homework is important (i.e. likely to be in the standards).	1	2	3	4	5
2	Assignments emphasize higher-order thinking (e.g. integration of ideas – not rote memorization).	1	2	3	4	5
3	Assignments emphasize inquiry (e.g. evaluate evidence, provide explanation).	1	2	3	4	5
4	Instructions for completing homework are stated clearly.	1	2	3	4	5
5	The homework matches the students' developmental level.	1	2	3	4	5
6	There is a clear purpose for the homework (i.e. the teacher can explain how it fits into the course).	1	2	3	4	5
7	The total amount of homework per week is appropriate. (NOTE: total refers to sum over all classes for one student) • Grades seven to nine – three to five 45-75 minute assignments • Grades ten to twelve – four to five 75-120 minute assignments	1	2	3	4	5
8	Assignments involve some application of learned material to new situations.	1	2	3	4	5
9	Students are held accountable for completing the homework assignment.	1	2	3	4	5
10	A high percentage of students generally complete the homework assignments.	1 <20%	2 50%	3 70%	4 90%	5 >90%
	Homework subtotal (out of 50) (Add score from items 1-10.)					
	Test items	***very little***				***very much***
11	Test items do not require sophisticated knowledge that goes beyond the content required by the standards (i.e. knowledge of content required by standards is sufficient).	1	2	3	4	5
12	Test items are valid, i.e. they measure what they claim to measure. • Test questions cannot be answered by general knowledge alone (logic, test wiseness) • Test items should not be confusing.	1	2	3	4	5
13	Test is characterized by items that focus on higher-order thinking. • Deep thinking is required, not just rote	1	2	3	4	5

	memorization. • Test requires use of models or abstractions as appropriate.					
14	Test items require students to analyze alternative positions/explanations.	1	2	3	4	5
15	Test items include application to everyday phenomena that is likely to be within student experience.	1	2	3	4	5
16	Test requires extraction of relevant information from complex situations.	1	2	3	4	5
17	Test requires the justification of ideas.	1	2	3	4	5
18	Test requires reflection on and synthesis of knowledge.	1	2	3	4	5
19	Test includes application of benchmark ideas to new situations (i.e. transfer).	1	2	3	4	5
20	Test reflects teacher understanding of common student difficulties, e.g. engages common student misconceptions.	1	2	3	4	5
	Test items subtotal (out of 50) (Add score from items 11-20.)					
	Formative assessment practices	***very little***				***very much***
21	Teachers collects and acts on student self-assessments.	1	2	3	4	5
22	Comment-only grading is used on some assignments (no numerical score is given).	1	2	3	4	5
23	Teacher comments on written work give guidance for how students can improve their work.	1	2	3	4	5
24	Students are given opportunity to revise their work in light of teacher or peer feedback.	1	2	3	4	5
25	Students are engaged in written tasks that effectively reveal their understanding.	1	2	3	4	5
26	Students are given time to brainstorm ideas in pairs or small groups in preparation for whole-class discussion.	1	2	3	4	5
27	Students engage in peer assessment.	1	2	3	4	5
28	Students are trained in and engage in self-assessment.	1	2	3	4	5
29	Lesson plans are changed when teacher acquires new knowledge of student learning needs.	1	2	3	4	5
30	Grading rubrics are shared with students to assess students in self-assessment while they are completing assignments.	1	2	3	4	5

	Formative assessment subtotal (out of 50) (Add score from items 21-30.)					
	Metacognitive support	***very little***				***very much***
31	Teacher's lesson plans or syllabus explicitly include plans to teach metacognitive processes.	1	2	3	4	5
32	The use of metacognitive knowledge is explicitly assessed.	1	2	3	4	5
33	Students are encouraged to assess the strengths and weaknesses of their work.	1	2	3	4	5
34	Students are required to explain their thought processes on assignments.	1	2	3	4	5
35	Assignments include questions that require students to reflect on the big picture behind the lesson.	1	2	3	4	5
36	Students are required to reflect on questions they want to ask the teacher.	1	2	3	4	5
37	Students are required to explicitly plan their problem solving process.	1	2	3	4	5
38	Teacher models/encourages *elaboration* strategies for processing material. This could include the use of mnemonics, summarizing, paraphrasing, selecting main ideas from texts.	1	2	3	4	5
39	Teacher models/encourages *organizational* strategies for processing of material when appropriate. This could include the use of outlining, concept mapping, note taking.	1	2	3	4	5
40	Teacher models how they use a particular strategy in solving problems. E.g. by thinking out loud during problem solving.	1	2	3	4	5
	Metacognitive support subtotal (out of 50) (Add score from items 31-40.)					

Table 2: Examples of reasons given by teachers to explain why they gave themselves low scores on quality indicators that they think are important

Reason Category	**Example**
not sure how to do	Quality Indicator: "#46 – Students are required to explicitly plan their problem solving process." Reason for Low Self-Rating: "I want students to focus on this, but sometimes I don't have the ideas on how to implement it."
teacher time constraints	Quality Indicator: "#27 – Students are given the opportunity to revise their work in light of teacher or peer feedback." Reason for Low Self-Rating: "Just a practicality issue -- would take time to read all the revisions."

class time constraints	Quality Indicator: "#32 – Students engage in peer assessment." Reason for Low Self-Rating: "Time to complete curriculum is a key factor -- peer assessment requires more time,"
had not considered previously	Quality Indicator: "#25 – Comment-only grading is used on some assignments (no numerical score is given)." Reason for Low Self-Rating: "Not something I had thought of prior. Definitely want to initiate this -- see much merit."
students not capable	Quality Indicator: "#19 – Test requires the justification of ideas." Reason for Low Self-Rating: "Students have difficult acquiring basic concepts let alone higher level skills."