EDUCATIONAL SERVICE DISTRICT 112

THE SUSTAINABLE CLASSROOM PROJECT

High School Case Study: Ann

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About Ann

Ann has been teaching mathematics for 12 years. She currently teaches grades 10-12 in a town of about 5,000 people north of Vancouver, WA off the I-5 freeway. Ann has an undergraduate degree from the University of Portland and a Master's Degree in Education with an emphasis in Educational Technology.

Ann has a strong history as an educational innovator and school leader. Currently, she is the Mathematics Department Chairperson and a Team Leader for the School District Math Committee. She has served on a variety of district committees, attended state and regional math conferences and trainings, and taught web page development to colleagues. She is a member of a local group of teachers who meet after school weekly to study best practices in assessment. This voluntary group has had considerable impact on the ways that teachers assess teaching and learning in high school.

In the four years prior to becoming a participant in the Sustainable Classroom Project, Ann acquired local school district funds and grants such as TELDEC (Technology and the Essential Learnings: Developing Effective Classrooms), TLP (Teacher Leadership Project) and Title II to equip her classroom with ten computers, a network printer, digital camera, camcorder, document camera, and projector. Because of the Title II grant that Ann wrote, all mathematics teachers in the high school received document cameras and projectors.

In her classroom, Ann makes substantial use of technological resources to enhance teaching and student learning on a daily basis. The equipment is used for manipulative and problem-solving simulations, presentations using specific mathematics software and PowerPoint, guided Internet searches, viewing of online java simulations of mathematical concepts, classroom brainstorming, creation of project rubrics, and display of student work. All computers in her classroom have MS Office, IE, Excel, iMovie, Geometer's Sketchpad, Graphing Calculator, TI Connect, Zap-A-Graph, and Green Globs. Her teaching computer also has Macromedia Dreamweaver for website production and Inspiration software.

The technology resources are used by students to investigate how mathematics can be used in the real world to investigate and solve problems. Students collect data from sources in the community, e.g. measurements and diagrams of local creeks to calculate flow rate/volume of water flow to analyze media reports of area drought, periodically taking the temperature of a dead horse for prediction of time of death as used in forensics, etc.

Specialized programs such as Geometer's Sketchpad, Graphing Calculator, TI Connect, Zap-A-Graph, and Green Globs are used for both teacher demonstration and student investigations. The Internet is used for research, to complete WebQuests and tutorials, take online quizzes, and prepare for standardized tests, i.e. Washington Assessments of Student Learning (WASL), SAT's, and Advanced Placement Calculus Exam. As well, students use computers for accessing Ann's classroom website, viewing grades, creating multimedia presentations, and creating mathematical movies that demonstrate major concepts studied and mastery of course content.

Ann's Classroom

Introduction

Ann said she applied for the Sustainable Classroom Project because she is "… committed to improving student learning and achievement in [her] classroom, and [she believes] that the technology, training and support provided by this grant represents an …opportunity to do that." She wrote, "At the heart of it all, this grant is about using effective teaching strategies, but I believe that amazing things can happen for students when interactive technologies are used in conjunction with research-based practices."

Currently Ann teaches Algebra II, Pre-calculus and AP Calculus to approximately 105 students in grades 10-12. Her classes contain slightly more female than male and are evenly divided by age of student. Her average class size is 21 students. In terms of socio-economic status, Ann described her students as middle class whose parents work at a variety of jobs, many commuting to Vancouver, WA or Portland, OR.

The Book Study

Chapter 1: Beginning the Study

As the project began, Ann looked forward to learning research-based instructional strategies and working with colleagues from around her area. She wrote in her first journal entry:

> *I'm very excited to try out the research-based strategies presented in this book. They look very promising based on the initial presentation of the research and I'm looking forward to learning more about them and trying them out in my own classroom. I like the fact that all the teachers involved in this grant will have the chance to communicate about the strategies throughout this process; that way, if something doesn't go the way we expect, other teachers can share their experiences and give suggestions. I think this will make the implementation of these strategies more successful.*

Instructional Strategy 1: Similarities and Differences

Unit Topic: Algebra II – Linear Equations
Technology Used: Interactive whiteboard and tablet, document camera

Some of the information in *Chapter 2: Similarities and Differences* was familiar to Ann, while other material was new. Ann indicated that she regularly used comparing and classifying activities in her mathematics classes. "My students know that I use these strategies," she wrote, "I make their use very explicit."

She expanded upon this idea:

> *Reading about these strategies was kind of like a pat on the back, an affirmation that my use of these strategies is appropriate and desirable. My goal this year is to strengthen my use of these strategies and to combine them with the use of technology.*

On the other hand, although sometimes used, metaphors and analogies were less purposeful. Ann wrote:

> *I think that it is natural to use metaphors with a student in any subject who may struggle with a concept, but I don't think that I use it with the class at large on an intentional level. It's something that seems to develop and "happen" rather than something that I intentionally plan. I need to look for ways to consciously use this strategy with my students.*

The external evaluator was invited to visit the class. She wrote the following observation.

Observation #1:

The goal for Ann's experimental lesson was for her Algebra II students to be able to solve systems of linear equations by a variety of methods and be able to choose the most appropriate strategies for solving them.

Ann started the lesson by explaining what the students would be doing during the class period and showing evaluation questions on the interactive whiteboard. (Ann and the students used a wireless tablet to interact with the interactive whiteboard throughout the lesson.) Then she handed out a printed worksheet containing math problems and instructed students to work in pairs to decide which of three problem-solving methods they thought would be best to solve each problem – graphing, linear combinations, or substitution. Problems were displayed on the interactive whiteboard and manipulated with the wireless tablet.

When the students had completed the assignment, they were asked to use the wireless tablet to drag problems to the category they thought was the best problem-solving method. Students had different ideas about the best method and freely expressed agreement and disagreement with categories. Ann asked if there was a "right" answer. Students agreed that there often was not.

Ann asked students to look at the problems and decide in pairs which ones were "most graphable." When they completed the assignment, she asked students to explain which ones they chose and to explain why. Ann moved problems around with the wireless tablet as students selected them.

Students were told to turn the worksheet over and look at a three-way Venn diagram. They were assigned to put equations into appropriate categories of the Venn (three methods above). Students explained where they placed the equations and why. Finally, a practice quiz consisting of a story problem was distributed and students were asked to solve it individually. Using the document camera, Ann wrote student answers to questions as students described how they solved the problems and suggested tips on how to think through story problems.

Students used the wireless response system to evaluate the lesson:

- 88% of the students in Ann's class indicated that they absolutely or mostly understood the lesson ideas;
- 71% indicated that the instructional strategy absolutely or mostly helped them understand the ideas;
- 76% thought the technology absolutely or mostly helped them understand the lesson ideas; and
- 93% liked the way they learned the lesson.

Overall, Ann felt good about the way the strategy worked with the lesson. She analyzed the lesson in her journal:

> *The strategy worked well for the ideas and concepts I was trying to get across to my students. I did find that THEY had different ideas about the effectiveness than I did. All students were able to choose an appropriate problem-solving method and support their choice after this lesson, but not all students felt that this lesson helped that. It is possible that some students had already noticed patterns on their own before this, so they found it less effective.*

INSTRUCTIONAL STRATEGY 2: SUMMARIZING AND NOTE-TAKING

Unit Topic: Pre Calculus – Trigonometric Identities
Technology Used: Interactive whiteboard and wireless tablet, document camera, wireless response system

Ann was eager to use strategies from *Chapter 3: Summarizing and Note-Taking* in her math classes since note taking was a regular activity for students. She wrote:

> *I especially like the idea that they are a "work in progress" and I am going to focus on activities that encourage and require students to review and revise their notes on a regular basis. At my school, we use 2-column notes, but we could possibly add a third column that we purposely leave blank until after we've discussed the assignment or in preparation for an assessment.*

Ann developed the experimental lesson for a Pre Calculus class on Trigonometric Identities. Her goal was that her students would know quotient, reciprocal, and Pythagorean properties and be able to use them to transform trigonometric expressions and prove identities. The instructional materials used in the lesson were: teacher-prepared notes of properties, interactive whiteboard, wireless tablet, document camera, projector, and wireless response system. Ann led a class discussion using the interactive whiteboard and wireless tablet to work through the teacher-prepared notes on properties and examples of identities/transformations. The students participated in the class discussion, took notes of the examples Ann provided and completed a practice assignment. After they had completed and discussed the practice assignment using the document camera to display their work, the students used the wireless response system to take an in-class quiz on the material covered.

In evaluating the lesson using the wireless response system:

- 80% of Ann's students indicated that they absolutely or mostly understood the ideas in the lesson;
- 79% responded that the instructional strategy used in the lesson helped them absolutely or mostly understand the lesson ideas;
- 84% said they believed the technology absolutely or mostly helped them understand the lesson ideas; and
- 65% absolutely or mostly liked how they learned the lesson.

In her evaluation of the lesson, Ann addressed her rationale for how she set up the notes and an outcome generated by the new format:

> *The notes I gave were "partially prepared;" I wanted something that helped students with the format and recording the important information, but ... still, required their attention and participation to make them complete.*
>
> *One difficulty when students begin proofs is that they can be overwhelmed even knowing where to start. In the teacher-prepared notes, I gave examples of different proofs that required a variety of strategies to complete. The proofs already had steps completed, so students just had to determine what had been done and give mathematical reasons for each step that was done. This moved the focus from "what do I do?" to "why is that step valid?"*

She summarized: "I was very happy with this strategy, and most students were too. I will definitely use it again!"

INSTRUCTIONAL STRATEGY 3: REINFORCING EFFORT AND PROVIDING RECOGNITION

Unit Topic: Graphing Parabolas
Technology Used: Interactive whiteboard, wireless tablet, document camera, wireless response system

Ann said she enjoyed reading *Chapter 4: Reinforcing Effort and Providing Recognition* and thinking about ways she could do a better job in both areas. As she thought it through, she brainstormed a couple of ideas. She wrote:

> *This has actually been a goal that some of my colleagues...share. We've been discussing ways to provide recognition to students, especially those that aren't necessarily the top-of-the-class honor roll students. I liked the idea of a "personal best" honor roll for students who show improvement. We also plan to give rewards for a "Flash of Brilliance," which might be a great solution to a math problem on an assessment, or it could be a really insightful question asked during a lesson.*

Ann's goal for the experimental lesson was that her students would be able to graph parabolas in standard, vertex, and intercept forms. As well, she wanted them to understand that effort contributes to success. Ann used the interactive whiteboard, document camera, and wireless response system to facilitate the lesson. She began with guiding a class discussion, and providing notes and sample problems on graphing parabolas. Students took notes, participated in the discussion and completed a practice assignment. Then, Ann told a personal story that provided anecdotal evidence that increased effort contributed to higher achievement. Finally, using the wireless response system, she gave a quiz in which she asked students, first to solve the problem over the current topic, second to rate their level of understanding of the problem, and finally, to rate their effort in learning the material.

In her assessment of the lesson, Ann wrote, "The [wireless response system] was a great way to have students self-assess their own achievement and effort levels....I think it showed them a connection between their effort and their level of achievement."

INSTRUCTIONAL STRATEGY 4: HOMEWORK AND PRACTICE

Unit Topic: Mathematics – Homework
Technology Used: Interactive whiteboard

Ann was happy to read in *Chapter 5: Homework and Practice* that research supported the practice of giving homework at the grade levels she taught. She was particularly interested in the information about homework comments since she had started a new policy this school year of not grading daily homework, but providing feedback from herself or other students in the classroom. As a result of reading the chapter, she resolved to have students give each other feedback on a more regular basis.

Since the chapter activities came at the end of the first semester, Ann planned the lesson collaboratively with her students to design a new "homework sheet" similar to the homework squares idea presented in the chapter. The sheet would combine ideas from the current chapter with ones from the last chapter on effort and achievement. Students were asked to assess their progress in meeting the objectives of the current unit. Then, using the interactive whiteboard, Ann shared a draft of the homework coversheet she had developed and led a discussion/editing session as she and the students talked through it. Finally, she asked students to fill out the new homework sheet for the current unit they were studying and hand it in.

> *In thinking about the process, Ann wrote, "I think it will be a good tool....When I introduced the idea to students, they were pretty positive about it. They seemed to think that it would help them organize themselves better."*

Student evaluation of the lesson indicated that:

- 81% understood the lesson ideas;
- 76% believed the instructional strategy helped them understand the ideas;
- 90% thought the technology helped them understand the lesson ideas; and
- 95% liked how they learned the lesson.

INSTRUCTIONAL STRATEGY 5: NONLINGUISTIC REPRESENTATIONS

Unit Topic: Pre Calculus – Harmonic Analysis
Technology Used: Interactive whiteboard and wireless tablet, document camera, wireless response system

Ann was excited to try some of the techniques that were discussed in *Chapter 6: Nonlinguistic Representations.* She said she already made substantial use of pictures and physical models in the classroom to help students make sense of complex, abstract mathematical concepts, but had not made a great effort to develop graphic organizers. She wrote:

> *I think graphic organizers would be an easy practice to include more often and would fit in with what we already do. I think I often organize information in a note-like structure, maybe because that is already familiar to high school students, but I think organizing it graphically would also be great. We usually go over material more than once, so it would be easy to do both.*

The lesson Ann planned for the nonlinguistic instructional strategy was on harmonic analysis. Her goal was that students would be able to recognize equations with variable axis or variable amplitude and know how to write their equations. Ann used an exploration activity from the textbook, graphing calculators, interactive whiteboard, document camera, and a teacher-created graphic organizer.

The outside evaluator observed the lesson and noted the following:

Observation #2:

The class was made up of 23 students who sat in pairs or alone at small tables. An interactive whiteboard, document camera, set of graphing calculators, and the wireless response remotes, as well as note pads, were used during the lesson.

Ann displayed the attendance chart on the interactive whiteboard and students checked in with the wireless response systems as they entered the classroom.
She began the lesson with a formative quiz that was displayed on the interactive whiteboard. Students used notepads to work the problems, and then clicked in their responses using the wireless response system. As Ann moved from one question to another, she gave immediate feedback by showing the correct answer, then using the wireless tablet to demonstrate on the interactive whiteboard how to correctly solve the problem. The students asked questions, observed the solution, and then wrote notes. When the wireless tablet had a technical glitch, Ann seamlessly switched to a paper notepad and the document camera. Students were instructed to get out their graphing calculators when they were needed to solve problems.

Ann began the lesson on sinusoids by showing a large visual display of representative problems on the interactive whiteboard. She wrote notes for solving beside each visual box using different colors for specific elements. She worked the problems on the wireless tablet as she talked through the problems. The students took notes and asked questions throughout the presentation. Ann put a graphing calculator on the document camera to show students what the answer to the problem looked like visually.

To begin the lesson on Harmonic Analysis, Ann displayed a teacher-developed graphic organizer on the interactive whiteboard and used different colors to represent the key parts of variable axis and variable amplitude equations – function, amplitude, and period – as she filled in the chart.

Some students indicated that although they understood the parts of the equations, the graphic organizer confused them. Ann asked students how many already understood and how many thought the graphic organizer helped. Students were divided in opinion.

Ann provided visual examples using the document camera. Students were engaged and asked questions.

Student evaluation of the lesson indicated that:

- 57% of the students said they absolutely or mostly understood the lesson ideas;
- 43% believed the instructional strategy absolutely or mostly helped them understand the ideas;
- 52% believed the technology helped them understand the lesson ideas; and
- 48% mostly liked how they learned the lesson.

Ann reflected on the effectiveness of the lesson and her students' reactions to it:

> *Well, this unit's lesson was interesting....Harmonic analysis involves writing the equation for a graph that is a combination of two or more sinusoids (sine or cosine equations). There are several things to consider in this process, and even after working on it for a couple of days there were still a few students having trouble with it. I thought that presenting the same information in a different format, using a graphic organizer, might help those students. Student reactions to the graphic organizer were mixed; it seemed that more girls than boys liked the strategy. Since the lesson, I've noticed several female students referring to the graphic organizer to help themselves with the process but haven't noticed any male students doing the same on their own.*

In analyzing student responses, she theorized:

> *I think part of the reaction that some students had to this strategy is because I don't use them often, and they don't always handle change well, even when it's good for them. It will be interesting to see how they react to it when I use it more frequently.*

INSTRUCTIONAL STRATEGY 6: COOPERATIVE LEARNING

Unit Topic: Mathematics – Story Problems
Technology Used: Interactive whiteboard, wireless tablet, wireless response system

"Cooperative learning is a strategy that I truly believe in." Ann journaled as she began *Chapter 7: Cooperative Learning*. She went on to write:

> *One challenge I have run into when using cooperative learning is how to group students. I generally try to create heterogeneous groups for most tasks, and the research supports this. I do worry during certain tasks though that a student may just try to "ride the coat tails" of others. If the group task is to create a product, it is important to me that all students contribute to the final product. I know that roles can be assigned, but I also know that a high-achieving student in the group will tend to pick up the slack if another student doesn't, and I don't want that to happen.*

The experimental cooperative learning lesson Ann developed was on graphs of polynomial functions. The goal she set for the lesson was that given the equation, students would be able to identify the basic behavior of the graph, including the number of turns, number of roots/zeros, and the end behavior. Graphing calculators, teacher-prepared notes, an exploration worksheet, the document camera, interactive whiteboard software, wireless response system, and teacher-created online quizzes (Hot Potatoes) were used to teach the lesson.

To begin the study of polynomial graphs, Ann introduced basic vocabulary terms to the class and students filled in their teacher-prepared notes during the discussion of the terms. Next, students completed the exploration activity in cooperative groups. The exploration asked students to analyze numerous graphs of polynomial functions on their graphing calculator and then make conjectures about how features of polynomial graphs (especially the number of turns and end behavior) relate to the equation of the polynomial.

After completing the exploration, the class discussed their results and completed a class graphic organizer that summarized the relationships between graph features and the equation. Finally, in cooperative groups, the students completed a Hot Potatoes quiz (see sample: http://uk1.hotpotatoes.net/ex/13740/QVXPHQUT.php). Each group

used the whiteboard or wireless tablet to complete the quiz. Then, to assure that all students were accountable for the quiz and not just the group at the whiteboard, the rest of the class used the wireless response system to indicate whether they agreed or disagreed with the match-up. After voting, Ann or the group at the whiteboard clicked the button on the quiz to see if the group had been correct or not.

When the students evaluated the lesson,

- 83% believed they absolutely or mostly learned the key ideas in the lesson;
- 88% thought the instructional strategy absolutely or mostly helped them learn the lesson ideas;
- 94% thought the technology absolutely or mostly helped them understand the lesson ideas; and
- 88% absolutely or mostly liked the way they learned the lesson.

INSTRUCTIONAL STRATEGY 7: SETTING OBJECTIVES AND PROVIDING FEEDBACK

Unit Topic: Algebra 2 – Solving Polynomial Functions by Factoring
Technology Used: Interactive whiteboard, wireless tablet, document camera, wireless response system

Ann was familiar with the ideas in *Chapter 8: Setting Objectives and Providing Feedback.* She wrote, "I have already done a lot of work in these areas through my participation in an assessment group at my school. I was part of a team that attended a summer institute by Rick Stiggins, and our team has continued for the past two years by providing inservices in our school district and through weekly book study." However, the idea of student contracts interested her. She reflected:

> *One idea that was new to me as I read this chapter though was the use of contracts. I know teachers that have used them, but I haven't used them in my classes. The example they gave didn't really sound like a contract to me though, it sounded more like a rubric that I might use in my class. When I use rubrics to assess, the rubric specifies what needs to be done to meet standard or exceed standard. So, maybe it is like a contract because students can certainly decide for themselves what grade they are going to go for. I think I could easily turn the rubric into a contract for a particular unit of study.*

The goal for Ann's experimental lesson was that students would learn how to factor polynomials with a degree greater than two, including sum/difference of cubes, quadratic forms of degree 4 or greater, and cubic polynomials that require factor by grouping. They would also learn to use factoring to find all real roots of such polynomials. To get feedback on their progress toward mastering the skills, they would set sub-goals for themselves and analyze their own progress.

The outside observer attended the class period when Ann tested the lesson and recounted what happened:

> **Observation #3:**
>
> To assist students in reaching the goals, Ann created a note sheet for students with the objectives, markers for student reflection on their progress, and practice items. The interactive whiteboard, wireless response system, document camera, and projector were used to facilitate the lesson.
>
> As students entered the classroom, they picked up wireless response system units and checked into class. Patti began the class session with an online (Hot Potatoes) review quiz on polynomial operations and factoring with students using their wireless response system to select answers. She wrote a question (problem) on her wireless tablet, and then randomly displayed a student's name to give the response. All students worked the problems on scratch paper and the randomly selected student chose to use the wireless tablet to demonstrate the solution or talk the teacher through it. The other students used their wireless response units to agree or disagree with the response. Students were selected to give reasons for their agreement or disagreement. If the response was incorrect, Ann explained why. The final question was from the material for the current day's lesson. Students were very enthusiastic and involved in the activity and discussions. The

discussions were very easy going, with give and take between Ann and the students. At times, they applauded a response and they were disappointed when the quiz ended.

To begin the day's lesson, Ann handed out the teacher created note sheet, and then displayed a three-column chart on the interactive whiteboard – factor by grouping, sum/difference of cubes/quadratic forms. Six equations were listed under the chart. After sharing lesson goals with the students, she used the interactive whiteboard to lead a discussion on finding real zeros by factoring. Students were asked to sort equations into the appropriate area of the chart. The students worked on the problems individually, deciding what type of factoring worked with each equation. Ann asked students which of the three columns each equation should be moved into and moved it to where a selected student suggested. Other students were asked to agree or disagree. When students disagreed, Ann asked them for explanations and moved equations to their suggested areas.

After all six equations had been discussed, Ann directed students' attention to each area and talked through the rationales that applied to each grouping and how students could know that an equation went in a particular category. Then students were asked to turn over their note sheet and solve three more problems. Ann circulated throughout the classroom and assisted students as needed; students assisted each other with questions, as well. When all were finished, Ann went through each question with the whole class using a 3-step process – write equation on the wireless tablet, talk through solving it on the wireless tablet, and ask students if they understood. The students talked through each step with her and asked many clarifying questions.

Finally, Ann assigned students their homework - to fill out the front side of the note sheet. They were to tell what they knew under each listed objective and what they still needed to practice, and then turn in the sheet the next day.

Ann analyzed the lesson:

Using the ideas from this unit, I created an activity to help students self-assess themselves and set some personal goals. They completed a worksheet that involved three types of factoring problems. After completing it, we discussed the worksheet and then students assessed their progress toward the objectives for this chapter of study. I shared my specific objectives and had them rate their progress, and I also encouraged them to change them and set their own personal objectives. It worked reasonably well I think, and will probably work better when this practice is incorporated as a regular part of the class. I need to have them do this more often!

In the student evaluation of the lesson:

- 80% thought they absolutely or mostly learned the lesson ideas;
- 60% thought the instructional strategy helped them learn the ideas;
- 70% thought the technology helped them learn the lesson ideas; and
- 70% liked the way they learned the lesson.

INSTRUCTIONAL STRATEGY 8: GENERATING AND TESTING HYPOTHESES

Unit Topic: Algebra 2 – Graphs of functions involving radicals or rational exponents
Technology Used: Interactive whiteboard, document camera, wireless response system

Ann found the ideas in *Chapter 8: Generating and Testing Hypotheses* to be familiar and the research interesting. She journaled:

I tend to use quite a few inductive investigations as I find that students learn the material better when they "discover" it. It worried me a bit though when I read on page 105 that the effect sizes for inductive techniques were smaller than for deductive techniques, but when I looked at the data

> *on page 106 I noticed that the average effect sizes for deductive techniques ranged from .02 to .83, so I'm not sure how accurate that conclusion is. Personally, I have gotten great results from this technique in the past as long as it is very structured. When I use inductive investigations, I always ask very specific questions that require them to make a hypothesis related to the critical information, so it is very guided. Sometimes I provide sentence stems, or I ask very specific questions that require the student to explain their reasoning. Then I include another situation/problem where the students can test their hypotheses to see if their hypothesis is confirmed or not.*

The goal of the lesson Ann planned was that students should be able to sketch the graph of a function involving radicals or rational exponents (1/2 power or 1/3 power) and should be able to write the equation of these functions when given the graph. As well, students should be able to state the domain and range of these functions.

To teach the lesson, Ann introduced the lesson vocabulary and guided students through completion of teacher-prepared notes. After the students went through the teacher-prepared notes they participated in a class discussion and individually completed the practice assignment. Then, they participated in creating a graphic organizer on graphing techniques. For the exploration activity, students wrote potential equations for graphs (formulated hypotheses) and used graphing calculators to check their results (tested hypotheses). Finally, Ann gave an in-class quiz on the topic using the wireless response system.

Ann analyzed her lesson:

> *After reading this chapter, I realized that I am very comfortable using inductive techniques for generating hypotheses but that I don't think I use deductive techniques as much. So, I left my comfort zone and tried using more of a deductive approach. I think it worked very well and I would definitely use it again. On Day 1 of the lesson, I used teacher-created notes and direct instruction to teach students how to graph square root and cube-root functions from an equation. Then on Day 2, students had to use this information to write the equation of a function when given its graph. After they wrote the equation, they used the graphing calculator to test it and see if they were correct. If they were wrong, they had to figure out what their error was and generate a new hypothesis, then test it. Some students wanted me to tell them if their equation was correct or not, and my response was, "Did you test it?"*

In an overall analysis, Ann wrote*:* "One or two students didn't like this strategy, and when I asked why they said they would rather that I just tell them if their answers were correct. Overall, it was very successful and I will definitely use it again."

Student evaluations of the lesson indicated that:

- 73% believed they absolutely or mostly learned the key ideas in the lesson;
- 80% thought the instructional strategy absolutely or mostly helped them learn the ideas;
- 100% believed the technology absolutely or mostly helped them learn the lesson ideas; and
- 80% absolutely or mostly liked the way they learned the lesson.

INSTRUCTIONAL STRATEGY 9: CUES, QUESTIONS AND ADVANCE ORGANIZERS

Unit Topic: Algebra 2 – Exponential and logarithmic functions
Technology Used: Interactive whiteboard, document camera, wireless response system

Ann was familiar with most of the techniques found in *Chapter 10: Cues, Questions and Advance Organizers,* but she noted a few new ideas. She wrote:

> *I think we all use cues and questions regularly, and it shouldn't be a surprise to anybody that higher level questions increase learning more than lower level questions, that wait time is a good*

> *instructional technique, or that advance questions and organizers are a good way to prepare students for learning. However, I was surprised that several studies show that maybe they are incorrectly used because they may focus on "interesting" information rather than the critical information. It is something that I don't think I do, but also something that hadn't really occurred to me either, so I am going to try to look at my own practice to see if this is a problem that I am simply unaware of and to see if I could improve on this. I also liked their expanded definition of wait time and think that I could improve on this practice, especially increasing the time after student responses before I respond.*

Ann continued to analyze her practice:

> *Out of all the examples of advance organizers, I tend to use graphic advance organizers the most. I am comfortable using them and they lend themselves well to my subject matter (math). I have used skimming when previewing a unit, but it doesn't work well or have much meaning for students when kids are looking at advanced mathematical content that they have no experience with yet. I haven't used narrative advance organizers but think that they could be a great way to introduce an overlying problem to be solved during a new unit; the problem would have to be an authentic problem that would interest students, and we could continue to refer to it throughout the unit.*

The goals Ann planned for her experimental lesson were that students would be able to rewrite logarithmic expressions in exponential form and they would be able to evaluate logarithmic expressions without a calculator. She described her lesson in her second journal:

> *Since I wanted to use prior knowledge that students had about exponents to teach logarithms, I tried to focus on creating cues and questions that would help me to that for this lesson....I began with an opening quiz which served two purposes: it made them focus on prior knowledge about exponents, and it put them in the right frame of mind for the upcoming information. Then we made a brief graphic organizer for the upcoming chapter on exponential and logarithmic functions. We'll continue to add to it during the unit as we learn more about these topics and how they are related. Then we tied the opening quiz and the information from the graphic organizer together to help us learn to evaluate logarithms. After some discussion and practice problems, students divided into groups and did the line-up activity; each member of the group was given a different problem to evaluate, then the group was to line up in order from least to greatest based on their answers. The class...used the [wireless response system] to vote on whether or not they agreed with the lineup order. When students had questions about particular problems, we used the whiteboard to discuss the problem and show how it could be solved.*

Ann evaluated, "I felt that it was pretty successful....Most students said they understood the material and enjoyed the lesson, which I think is a huge success when high school seniors only have 15 days left and are getting a bit antsy."

Student evaluation of the lesson indicated that:

- 76% believed they had learned the lesson ideas absolutely or mostly;
- 97% thought the instructional strategy absolutely or mostly had helped them learn the ideas;
- 90% thought the technology absolutely or mostly helped them learn the ideas; and,
- 93% absolutely or mostly liked the way they learned the lesson.

Chapters Eleven and Twelve: Completing the Study

The final two chapters in the book study had the effect of further energizing Ann. She used strategies suggested in Chapter 11 to finish her Pre-Calculus class with a surge. She journaled:

> *One thing I liked was their suggestion for teaching vocabulary. I've used a similar method in the past but I think in a less formal way. My Pre Calculus class just began an introduction to Calculus unit and we began by learning about limits. I created a glossary with three columns labeled "verbally," "graphically," and "algebraically." First, we discussed the terms, and then the students complete the glossary table. In the "verbally" column, the students describe each term in their own words. In the "graphically" column, students create a nonlinguistic representation of the term. In the "algebraically" column, students give examples of formulas and/or equations that are related to this concept. This glossary was part of the teacher-created notes that we used for this lesson.*
>
> *The other strategy that I tried with my students was a discovery-based lesson (also for my Pre-Calculus class). In this lesson, students were given several examples to work through and then asked to write a rule for finding limits of various types of functions.*

In analyzing the strategies, Ann noted:

> *Feedback was very positive and students seemed to understand the lesson very well. I heard a great comment from my [teacher assistant] who was in my Calculus class this year when she saw the vocabulary instruction, teacher-created notes, and discovery activity in this lesson; she said, "I wish we had learned limits this way." Having already learned this content earlier this year, she thought that this lesson was improved by the vocabulary instruction and teacher-created notes. I was definitely happy to hear that!*

Chapter 12's focus on the implementation of research-based strategies caused Ann to reflect on one that was particularly troublesome, and to identify a solution for the coming school year. She wrote:

> *One thing that I still struggle with is having students write their own learning goals. I find that students aren't able to do this unless they have at least some familiarity with the subject matter, so how do I have a student who has never taken Calculus write meaningful goals about it? After some discussion on the discussion board, I do think that this is a long process, one that may not be able to occur at the beginning of a unit but rather during and after. I find the same thing with vocabulary development: students write better descriptions in their own words if I have them wait until they have some familiarity with the terms through our discussion and lesson than if I had them complete this immediately when first introducing the new terms.*
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> *I like the idea of having students review their goals and progress regularly, and so I have set up a blog...that I plan to begin using next school year. Students will be able to complete journal entries on any computer at school, at the public library, or from home, and I will be able to view them and comment any time without carrying around piles of papers or notebooks. I plan to use this resource in a variety of ways including student self-assessment, discussing concepts from class, exploring and extending concepts, and applying knowledge.*

Summing up her experience in the Sustainable Classroom Project, Ann wrote:

> *All in all, participating in this grant was one of the most profound experiences I have had as a teacher. It has changed the way I teach, energized me as a teacher, and fostered enthusiasm in my classroom. I feel like I have a better-equipped teacher toolbox now, and I am excited for a new school year to implement all the new information I've learned from the beginning of the school year. I think I was a good teacher before, but I am definitely a better teacher now.*

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