Middle School Mathematics

Excerpts from
The Knowledge Loom: Educators Sharing and Learning Together
Web site
(http://knowledgeloom.org)

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The Knowledge Loom: Educators Sharing and Learning Together

http://knowledgeloom.org

The attached document is a user−generated download of selected content found on The Knowledge Loom Web site. Content on The Knowledge Loom is always being updated and changed. **Check online for the most current information.**

What is The Knowledge Loom?

The Knowledge Loom is an online professional development resource featuring specially organized spotlights on high−priority education issues, including:

- a list of promising practices (including an explanation of each practice and a summary of the research or theories that support the practice)
- stories about the practices in action in actual education settings
- lists of related resources found on other web sites.

The site is designed to help educators facilitate decision−making, planning, and benchmarking for improved teaching and learning through collaborative activities.

Are there other resources on The Knowledge Loom?

In addition to printable content, the site features interactive tools that allow users to share information and knowledge, read what panels of practitioners have to say about selected topics, ask questions of content experts, and print custom documents like this one. A companion guidebook, *Using The Knowledge Loom: Ideas and Tools for Collaborative Professional Development* (http://knowledgeloom.org/guidebook), can be downloaded. It offers activities and graphic organizers to support collaborative inquiry about what works in teaching and learning in support of school improvement.

What spotlight topics are currently available?

- Adolescent Literacy in the Content Areas
- Culturally Responsive Teaching
- Elementary Literacy
- Good Models of Teaching with Technology
- Leadership Principles in Technology
- Middle School Mathematics
- Principal as Instructional Leader
- Redesigning High Schools to Personalize Learning
- School, Family, and Community Partnerships
- Successful Professional Development
- Teaching for Artistic Behavior: Choice−Based Art

Overview of Spotlight: Middle School Mathematics

This overview provides an outline of all content components of this spotlight that are published on The Knowledge Loom Web site. The creator of this document may have printed only selected content from this spotlight. View complete content online (http://knowledgeloom.org/).

As part of its mission to improve K−12 mathematics and science teaching and learning, the Eisenhower National Clearinghouse (ENC) collects information and resources on promising practices in Middle School Mathematics. Drawing from standards as stated in **Principles and Standards for School Mathematics** (PSSM, 2000) from the National Council of Teachers of Mathematics (NCTM), ENC has identified the following areas as essential to enhanced teaching and learning:

Practices

Each practice includes an explanation, a summary of each story that exemplifies the practice, a research summary (review of the literature), a reference list of the literature, and a short list of related Web resources (URLs and full annotations provided online or in the Related Web Resources section if it has been printed).

- Integrating Technology into Middle School Mathematics
- Inquiry and Problem Solving in Middle School Mathematics
- Effective Professional Development for Middle School Mathematics
- Assessment That Informs Practice in Middle School Mathematics

Stories

The Stories correspond to the summaries printed as part of each practice published on The Knowledge Loom. These are detailed examples of how the practices look in action in educational settings.

Central Middle School
East Woods School
Hampshire Regional High School
South Hadley Middle School

Related Web Resources: 25

This is an annotated list of resources found on other Web sites that relate to the spotlight topic on The Knowledge Loom.

Eisenhower National Clearinghouse

Practices

This section presents the Knowledge Loom practices for the spotlight you selected.

Each practice includes an explanation, a summary of each story that exemplifies the practice, a research summary (review of the literature), a reference list of the literature, and a short list of related Web resources (URLs and full annotations provided online or in the Related Web Resources section of this document).

For an overview of additional content presented on The Knowledge Loom Web site that may not have been selected for this print document, see the Overview of Spotlight located earlier in the document.

Integrating Technology into Middle School Mathematics

The Technology Principle from the **Principles and Standards from School Mathematics** (PSSM) states that "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student learning" (NCTM, 2000, p. 24). Corollary ideas emphasize that technology is not an end in itself but rather a means to the ultimate goal of improved learning and effective mathematics teaching.

The resources that ENC has identified for integrating technology into the classroom support the following three ideas as stated in **PSSM**:

- Technology enhances mathematics learning.

  Calculators, computers, and software provide students with the opportunity to visually explore abstract concepts and representations. Such tools also provide feedback that can foster understanding and the opportunity for teachers to tailor the instruction to fit students' diverse needs. Technology also lends itself to in−depth exploration of concepts.
- Technology supports effective mathematics teaching.

  Teachers can improve student learning by choosing mathematical tasks that are supported by available technologies, such as graphing and computing. Virtual manipulatives, representations, and simulations allow for advanced student collaborations and wide collection of data.
- Technology influences what mathematics is taught.

  The availability and ease−of−use of technological tools allow for earlier introduction of topics and more in−depth exploration of concepts. Access to real−world data and the computer's facility with "number crunching" free students for fuller investigations and modeling of mathematics.

Questions to Think About:

As the use of technology becomes more complex and more pervasive in education, the issues surrounding its effective use in mathematics teaching and learning become more pressing. The temptation exists to use technology as a panacea for what is perceived as lacking in classroom instruction, leading some educators to fear that teachers will be replaced. Certainly the role of the teacher is changing as classrooms become more inundated with educational technology. Also, the proliferation of technological tools available −− such as powerful graphing calculators, computers, and related software −− for teachers to use can lead to confusion as to which resources are best for a given purpose and student population.

Some questions to consider:

- How do educators identify exemplary educational technology, such as Internet sites and software?
- When does the use of technology support the development of a particular topic?
- How can teachers determine which technological resource is most appropriate for their classroom and curriculum?
- How can technology use improve gender equity and educational opportunity for students?

- In what ways can technology improve teacher learning and practice?

Another Consideration:

The most effective use of technology is as a complement to hands−on classroom learning, not as a replacement or surrogate for teacher−student interaction.

It takes time, effort, and patience for teachers to learn how to effectively incorporate technology into their classroom instruction. The learning curve for some teachers is particularly steep and as technological innovations continue to proliferate, that curve is just going to get steeper. Professional development and ongoing support, training, and maintenance are necessary components to ensure successful incorporation of educational technology into classroom instruction.

Answer This Question: How can teachers best be supported as they endeavor to effectively integrate technology into their instructional practices so as to meet the NCTM standard of enhancing students' mathematical learning?

Story Summaries

East Woods School

- Software enables fifth−grade students to go beyond visual identification of shapes
- Provides meaningful tasks that consistently challenge students to examine their current thinking
- Students must make necessary abstractions from the current situation and then change their thinking
- Students' geometric thinking rises to a higher level of sophistication.

Geometry curriculum taught in high school requires students to construct formal proofs within an axiomatic system. However, such students are often unable to successfully accomplish these proofs because their experiences have not provided the necessary opportunities to progress to this level of sophistication.

When−fifth graders are challenged to learn more than just identifying the shapes visually, they begin to build the necessary foundation that will allow them to construct formal proofs in geometry. The **Shape Maker** computer program provides meaningful tasks that consistently challenge students to examine their current thinking. They must make necessary abstractions from the current situation and then change their thinking to accommodate their new conjectures. As a result, the students' geometric thinking rises to a higher level of sophistication. Here, a fifth−grade teacher describes how she and a colleague used software to teach geometric reasoning to fifth graders.

Research Summary

Overview of Technology Integration in Middle School Math

This overview was originally published in **ENC Focus: A Magazine for Classroom Innovators**, vol. 6, no.3, 1999. It addresses the issue of how teachers can take initiative in becoming effective

technology users. For additional information, see http://enc.org/topics/edtech/context/

Technology in the Classroom: Asking the Right Questions

by Lynne Schrum,
President International Society for Technology in Education

When it comes to using educational technology in the classroom, I think it is important to ask the right questions, and I am not sure that we have done that in the past. We have wanted technology to be a magic bullet or a wand that we could wave over children to make them have perfect test scores.

Of course, nothing is that easy. We have to ask some difficult questions:

- What do we know about appropriate ways to enhance student learning with technology?
- How can technology change the nature of teaching and learning?

We are starting to see some answers, I believe. We are seeing new ways of interacting that change the curriculum. We are not just thinking about static content that fits inside a textbook. We are really thinking about a process of learning that includes all kinds of materials that students will discover on their own, that we as the designers of lessons haven't necessarily defined ahead of time.

Students Learn to Ask Their Own Questions

To use educational technology effectively, teachers must create the vehicle that will encourage students to think about what they need to learn and to ask their own questions. This sounds like such an easy thing to change, but it is really very difficult. I hear a number of teachers say that they would really like to be able to change the way they teach; they would like to do project−based, multi−disciplinary lessons because the real world is not broken down into academic disciplines.

But these same teachers say that they and their students are held accountable for getting through the curriculum before May. They have to cover an incredibly broad pool of material, and that lends itself to facts and formulas and tests. Faced with these conflicting pressures, how can teachers encourage students to ask −− and investigate −− their own questions?

Technology lends itself to exploration. But before we can use it effectively, we need to value exploration as real teaching and real learning. We need to recognize that if students are writing about what they are learning, if they are investigating and asking questions, if they are doing it in an authentic context, then clearly they are learning how to read and write and think. The biggest difference, the one that might scare us, is that when students explore there is no one right answer.

Now, that does not mean that we all just run around doing what we want and end up who knows where. Activities must be carefully guided and structured, but having the technology available in a ubiquitous manner makes the difference. By that I mean that technology is the means not the end. Technology merely provides the tools to be used for authentic learning.

One of the things that we do know is that when students have technology available, they tend to move faster than we expected. So we have sixth and seventh graders doing complex systems analysis. The possibilities are endless. Students who really are excelling in a particular area can take courses online or through distance education. They can continue to learn even if their community has limited resources.

From my background in special education, I know that we must also think about equity for the student who won't be taking the most advanced courses. Technology has the potential to build on whatever skills a student possesses. When students' own interests drive the learning process, we find that they work longer and harder, they are more engaged in their learning, they are asking questions at whatever level they happen to be.

Teachers Become Life−Long Learners

To use technology for this sort of authentic learning, we have to educate teachers. We must start in preservice teacher education programs and encourage those people to come into teaching who like the ambiguity, or at least can live with it. Prospective teachers need to be helped to recognize that their jobs are not to pour content knowledge and dates and facts and figures into students' heads.

Professional development for practitioners needs to model the ideal of life−long learning. When teachers recognize that they will never stop learning, they will live that ideal, and they will model it for their students.

Technology allows all sorts of possibilities for continuing education for teachers, but first they must be comfortable using it. What we know doesn't work is somebody standing at the front demonstrating how to use a computer, and then everyone goes home. We know that becoming comfortable with technology takes an intense amount of time and that educators need to have the computers at school and, typically, at home if they are truly to become users.

Teachers are very creative, very intelligent people, who quickly see the power of technology. Once they use it for their own professional lives −− for keeping records, for typing documents, and for their own learning −− they come up with all kinds of ways that technology can enhance what they are doing with students.

We also know that it is not enough to bring in technology either top down or bottom up−−enthusiasm has to come from both directions. You have to have teachers who are eager and interested. You have to have administrators who value learning about technology as an important piece of what teachers do. All parties must recognize teachers' accomplishments in the use of technology and accept even their mistakes as an important part of the learning process.

It has become clear that educational technology is not a passing fad. Its potential is overwhelming, and we need to do it right.

When computer technology first came to schools in the 1980s, we educators stepped back and let the vendors, the software designers, and others decide what we needed and what we should buy. Now we as educators must take the pedagogical high road and demand good software and hardware.

We need to make sure that the technology we use in our classrooms is structurally sound and thoughtful and free of gender and racial bias. We really need to take the lead in using technology in a way that meets all of our students' needs.

Web Sites of Interest:

- **Principles and Standards for School Mathematics** can be accessed online at http://standards.nctm.org/
- Illuminations − http://Illuminations.nctm.org/index2.html
- ENC Online − http://enc.org − Eisenhower National Clearinghouse offers excellent resources

including:

- Middle school mathematics teachers will find a wide variety of professional development resources, curriculum materials, Internet sites, and other tools to enhance their teaching and learning. ENC's Digital Dozen, (http://enc.org/weblinks/dd/) a monthly selection of 13 math and science related web sites, is one place teachers will find an assortment of Internet resources to use in their classroom or for their own professional growth.
- Educators can also search for resources on assessment through ENC's collection of more than 17,000 math and science educational materials (to browse the collection, go to http://enc.org/resources/browse/ for subject categories).
- A section of ENC Online specifically devoted to the topic of educational technology can be found at http://www.enc.org/topics/edtech/ and contains all the material that was published in the issue of **ENC Focus** entitled "Integrating Technology in the Classroom." Look specifically at the selection of curriculum and professional development resources chosen on this topic by ENC's Math and Science Content Specialists. The complete list of materials as published in the print version of the magazine can be seen at http://www.enc.org/topics/edtech/selections/
- Educators can also search for technology resources through ENC's collection of more than 17,000 math and science educational materials (to browse the collection, go to http://enc.org/resources/browse/ for subject categories).

- International Society for Technology in Education − http://www.iste.org/

  This site features a variety of resources to support technology integration, including lessons, units, and standards.
- The Math Forum − http://forum.swarthmore.edu/

  This online community of teachers, parents, and other stakeholders interested in mathematics education includes resources such as Ask Dr. Math, the Teacher2Teacher question and answer service, and web−based discussion areas. Of particular interest is the Web Units section at http://forum.swarthmore.edu/web.units.html which contains lessons, papers, and projects that deal specifically with using the Internet in the classroom.
- The Glass Wall − http://www.terc.edu/mathequity/gw/html/gwhome.html

  For educators looking to incorporate computer games and other software into mathematics instruction, this site addresses how students can gain mathematical content from games. Reviews of popular educational software can help educators make purchasing decisions.
- **Technology &Learning** − An additional place to look for software reviews is the online version of the educational technology magazine **Technology &Learning**. At http://www.techlearning.com/review.html educators can enter search criteria and look for titles that have received awards, read comparative reviews, and find contact information for the software vendor.

Related Web Resources

Educational Technology (0)
Educational Technology Resources (0)
Graphing Calculators in the Mathematics Classroom (0)
PBS Mathline Grades 6−8 (0)

Synergy Learning (0)

Effective Professional Development for Middle School Mathematics

In order for teachers to be effective instructors, they must have both a solid foundation in content knowledge and a thorough understanding of good pedagogy. They must be models of learning and continue to grow in their own professional skills, mathematical understanding, and teaching practice. Therefore, it is essential that educators experience ongoing, meaningful opportunities to grow and develop their skills, to reflect on their practice, and deepen their content knowledge.

The availability and quality of professional growth opportunities directly impact teachers' ability to meet the requirements of the Teaching Principle in **Principles and Standards for School Mathematices** (PSSM): "Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well" (p.16).

The resources that ENC has identified for providing effective professional development opportunities support the following three ideas as stated in **PSSM**:

- Teachers must have a deep knowledge and understanding of the mathematics content they teach.

  It would seem to be self−evident that in order to teach others, one must have knowledge of the material to be taught. And yet in many schools and classrooms, teachers are being asked to teach out of their area of expertise and so lack the confidence that comes with depth of knowledge. Teachers should have regular and ongoing opportunities to interact with and understand the content material and curriculum they teach.
- Teachers need to have a firm understanding of their students as learners and doers of mathematics.

  Students have different needs and blossom under different pedagogical strategies. Teachers need to be aware of assessment techniques, instructional methods, and other currents in pedagogy so as to best meet the varied educational needs of their students.
- Teachers need to have ample opportunity to reflect on and modify their practices.

  The traditional model of a one−day professional development workshop does not offer teachers the environment they need for reflection on their practices. And it is through continual self−assessment and reflection that teachers come to understand and modify their classroom behavior so as to enhance the mathematical teaching and learning of their students.

Questions to Think About:

Professional development opportunities are as varied as are districts and teachers. Financial constraints, time considerations, and other resource limitations influence the kinds of opportunities that are available.

Some questions to consider:

- What should the goal of professional development be?
- What constitutes effective professional development?
- How can one measure whether or not a given professional development program has been successful?

- What sort of follow−up should there be after any given professional development opportunity?
- What core values need to be in place before a systemic emphasis on professional development can have an influence on growth opportunities for teachers?

Another Consideration:

Professional development is most effective when it is ongoing, reflective, and integral to a teacher's professional experience. The opportunity to learn new ideas and skills must be matched by the opportunity to apply those ideas in the classroom, and that process can be difficult, time−consuming, and even threatening for both teachers and students who are confronting new ways of doing and thinking about mathematics.

Answer This Question: What role can and should teachers play in the design and implementation of their own professional development, especially when it could necessitate some drastic changes in their pedagogical practices?

Story Summaries

Hampshire Regional High School

- Teacher creates an environment in which it is safe to take risks
- Whole−class discussions follow reading and exercises
- Writing assignment helps to organize thoughts further and fuel a more in−depth discussion

This teacher of an advanced algebra class of eighth− and ninth−graders has begun to focus on creating a new kind of learning environment −− by providing wait time, learning to accept necessary periods of silence, and slowing down the pace of over−anxious students. A recent assignment involved reading a short lesson and doing a set of exercises on direct variation. After a lively discussion of the homework problems, it became clear the students still did not have a handle on the concept even though they had managed the exercises quite well. The teacher then asked the students to write a paragraph describing direct variation.

The next day, they had a fruitful discussion in which they came to a fuller understanding of the concept together. After reading the students' paragraphs, the teacher realized that the writing exercise had merely helped students to organize their thoughts and at least begin to make connections. It was the combination of their paragraphs and the interactive classroom that created the opportunity to discover as much as they did in their discussion.

Research Summary

Overview of Professional Development in Middle School Math

The article "Teacher Change" by Michael Fullan and Andy Hargreaves from the Ontario Institute for Studies in Education of The University of Toronto was originally published in August 1998 as part of ENC's professional development package called **Teacher Change: Improving K−12 Mathematics**. It can be accessed online, along with additional supporting materials, such as cases and narratives that

illustrate the principles described in the article. See:

http://www.enc.org/focus/change/document.shtm?input=CDS−000389−389_toc

(Note: Use "back" button and click on "References" to access the reference list for this article.)

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Web Sites of Interest:

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- Illuminations − http://Illuminations.nctm.org/index2.html
- ENC Online − http://enc.org − Eisenhower National Clearinghouse offers excellent resources including:

- Middle school mathematics teachers will find a wide variety of professional development resources, curriculum materials, Internet sites, and other tools to enhance their teaching and learning. ENC's Digital Dozen, (http://enc.org/weblinks/dd/) a monthly selection of 13 math and science related web sites, is one place teachers will find an assortment of Internet resources to use in their classroom or for their own professional growth.
- A section on teacher change and professional development can be accessed at http://enc.org/resources/browse/ It contains all the materials that were originally published as ENC's professional development package to help educators and professional developers facilitate discussion and reflection on improving K−12 mathematics and science.
- Yet another portion of ENC Online is specifically devoted to professional development. At http://www.enc.org/weblinks/pd/ teachers will find a rich assortment of web sites designed to improve their pedagogical knowledge and practice.
- ENC Online also features the text from one of its booklets, entitled **Ideas that Work: Mathematics Professional Development**, at http://www.enc.org/professional/learn/ideas/math/ Here educators will find 15 strategies that outline effective professional development and examples of programs that embody those strategies, along with contact information for program administrators.

Related Web Resources

Help in Making Change: SummerMath for Teachers Serves as a Model (0)
Synergy Learning (0)

Inquiry and Problem Solving in Middle School Mathematics

The Problem Solving Standard from **Principles and Standards for School Mathematics** (PSSM) stresses that problem solving is integral to mathematics learning (p. 52). Consequently, Grades 6−8 instructional programs should:

- build new mathematical knowledge through problem solving;
- solve problems that arise in mathematics and in other contexts;
- apply and adapt a variety of appropriate strategies to solve problems; and
- monitor and reflect on the process of mathematical problem solving

Problem solving is a vehicle for deepening student understanding and appreciation of mathematics. As students work through good, thoughtful problems, they draw on skills and techniques from other contexts, building on the mathematical knowledge and understanding they have already acquired. As stated in PSSM, "The essence of problem solving is knowing what to do when confronted with unfamiliar problems" (p. 259).

Three guiding principles can be gleaned from PSSM's discussion of the role of problem solving in middle school mathematics:

- Problems should be carefully selected to be relevant to students' everyday experience and to important mathematical ideas in the curriculum.
- Teachers can encourage effective problem solving and inquiry through modeling, encouraging collaboration, and questioning.
- Students and teachers should reflect on their own experience with problem solving with an eye for how they might modify, expand, or clarify the process.

Questions to Think About:

- What does good problem solving look like?
- What tools are available to help teachers incorporate a problem−solving approach into their instruction?
- How can teachers support the growth of their students as problem solvers?
- How should instruction be structured to encourage the integration of truly open−ended problem solving?
- What are some sources of good problems for middle school mathematics instruction?

Another Consideration:

Establishing the use of open−ended problem solving in classroom settings requires flexibility on the part of the teacher and willingness to cope with potentially "messy" learning: heightened noise, increased bustle and movement in the room, and some level of student frustration as the problem defies easy solutions. The reward of using such a technique, however, includes greater student understanding and empowerment as they take ownership of their own mathematical learning and thinking. When solving real and engaging problems, students are challenged to apply their knowledge, make new connections, and explore creative solutions. In essence, problem solving is learning in action.

Answer This Question: How can teachers be best supported as they endeavor to effectively integrate

a problem−solving approach into their instructional practices?

Story Summaries

South Hadley Middle School

- "Petals Around the Rose" problem gives students data and an answer, but neither a formal question nor explicit conditions.
- Students begin making judgments about right and wrong solutions without depending on teacher for verification.
- Students generate a list of conditions and try to make the problem simpler.
- Students collaborate to solve the problem.

Petals Around the Rose, a game of dice, offers a change of pace, a non−traditional problem that engages students in light−hearted activity. At the same time, it requires them to use several important strategies, including "guess and check," listing known facts, and drawing samples/diagrams. As described here, the game was played with a heterogeneous mix of 25 seventh−grade students. It shows how the students were able, together, to develop a feeling of success and power and a positive view of problem solving.

Research Summary

Overview of Inquiry/Problem Solving in Middle School Math

Although the following article, initially published in **ENC Focus: A Magazine for Classroom Innovators** (vol. 6, no .2, 1999), deals explicitly with inquiry as it applies to science instruction, the principles expressed in the article can be applied to mathematics teaching and learning, as well. Along with additional supporting resources, it can be accessed online at:

http://www.enc.org/focus/inquiry/document.shtm?input=FOC−000708−index

To read a story about how a middle school math teacher changed her teaching practice over time, see "Teaching Students to Swim in Any Pond" at:

http://www.enc.org/professional/learn/change/practice/cases/document.shtm?input=CDS−000374−374

Inquiry in the Everyday World of Schools

by Ronald D. Anderson, University of Colorado

Inquiry is a word with a long−standing place of honor in science education circles. It was the label for many of the new approaches to teaching promoted in the NSF−funded curriculum materials of the 1950s and 60s. It has a central place in the current National Science Education Standards (NSES). It is the favored word for describing the essence of good science teaching; seemingly, everyone uses it and there seems to be little disagreement about it.

But is everyone talking about the same thing when they use the word inquiry? If we got precise about its meaning, would we still be agreeing with each other? What does it look like in the classroom? What are the results?

A close look at the NSES shows inquiry is used in at least three different senses:

- scientific inquiry,
- inquiry learning, and
- inquiry teaching.

Scientific inquiry refers to the means scientists use to study nature and formulate explanations of what they observe. It deals with how science proceeds and can be considered independently of educational processes.

Inquiry learning refers to the active processes in which students are engaged as they pursue increased understanding of science. The writers of the NSES obviously see some relationship between scientific inquiry and inquiry learning. It is thought that student learning in a school context should reflect the nature of inquiry in the world of science. While the word "constructivism" is not used in the NSES −− possibly because its meaning varies significantly among its users −− inquiry sometimes appears to be used in the NSES in a similar way. In fact, many scholars who study human learning would argue that significant learning demands an active process for which the label of constructivism, or inquiry learning, would be appropriate. In other words, inquiry is the essence of learning.

Inquiry teaching as used in the NSES has no precise operational definition, although, however it is understood, it seems to be something that promotes inquiry learning. This lack of clarity as to what inquiry teaching entails is at the heart of many teachers' struggles to put the NSES into practice. This same lack of clarity is found in the extensive body of research studies on inquiry teaching; it is defined differently by different researchers, and often in terms that are not easy to use in talking about the everyday activities of a teacher in the classroom.

In the interest of being able to communicate in concrete terms, the rubric in the box to the right may be of help. It was developed in connection with case studies of schools from across the country that were judged to be successful in putting into practice reforms such as those advocated in the NSES and the 1989 NCTM standards for mathematics (Anderson, 1996).

Understanding what is entailed in inquiry teaching, and inquiry learning, requires close attention to three tangible aspects of the classroom−−the role of teacher, the role of students, and the nature of student work−−described in the rubric. The specifics listed in the rubric were observed in actual classrooms and are offered here as a beginning point for personal reflection on our own teaching.

Research has some important insights to offer as assistance in this personal reflection. Review of a large number of research studies supports the following generalizations:

1. When inquiry teaching actually is put into practice, it works; i.e., student learning is enhanced.
2. It is possible to put inquiry teaching into practice, but it is a demanding task, and it is not clear how widespread one can expect it to become.
3. The barriers and dilemmas experienced in putting inquiry teaching into practice are closely related to teachers' basic values and beliefs about teaching and learning.
4. Teachers need and deserve a great deal of assistance in putting inquiry teaching into practice (Anderson, 1998).

Sources of information are available about how to put new forms of teaching and learning into practice (e.g., Anderson &Pratt, 1995). In addition, it is hoped that the work of such groups as the Center for Science, Mathematics and Engineering Education at the National Research Council will soon provide significant additional help in putting inquiry teaching and inquiry learning into practice in schools. It is the right direction to go, but getting there will be a big challenge.

(Note: Use "back" button and click on "References" to access the reference list for this article.)

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Web Sites of Interest:

- **Principles and Standards for School Mathematics** can be accessed online at http://standards.nctm.org/
- Illuminations − http://Illuminations.nctm.org/index2.html
- ENC Online − http://enc.org − Eisenhower National Clearinghouse offers excellent resources including:

    - Middle school mathematics teachers will find a wide variety of professional development resources, curriculum materials, Internet sites, and other tools to enhance their teaching and learning. ENC's Digital Dozen, (http://enc.org/weblinks/dd/) a monthly selection of 13 math and science related web sites, is one place teachers will find an assortment of Internet resources to use in their classroom or for their own professional growth.
    - To perform an advanced search for Internet resources on problem solving, teachers should go to http://www.enc.org/resources/search/advanced/ and type in "mathematics" as one subject, "problem solving" as another, and "Internet resource" as media type, with the grade levels selected that they teach.
    - For resources specifically related to inquiry and problem solving, teachers should look at http://www.enc.org/topics/inquiry/ which contains the content of the issue of **ENC Focus** on this topic. Educators will find classroom stories, articles, and a selection of curriculum resources on the topic of problem solving selected by ENC's content specialists.

Related Web Resources

Curricula for Teaching Fractions (0)
Mathematics Projects that Foster a Critical Look at Our World (0)
MathNerds (0)

Real World Math &Science (0)

Assessment That Informs Practice in Middle School Mathematics

The Assessment Principle from the **Principles and Standards from School Mathematics** (PSSM) states that "Assessment should support the learning of important mathematics and furnish useful information to both teachers and students" (NCTM, 2000, p. 22). Assessment should be ongoing, integral to mathematics instruction, and instrumental in shaping teacher practice.

The resources that ENC has identified for making meaningful, reflective assessment an integral part of mathematics instruction support the following two ideas as stated in the **Principles and Standards from School Mathematics**:

- Assessment should enhance mathematics learning.

  The kinds of tasks that teachers use in assessments demonstrate to students the sort of mathematical knowledge and performance they value, so it's important that the assessment tasks reflect significant mathematical ideas. Worthwhile tasks appeal to students and deal with problems that seem relevant to them. Also, when alternative assessments such as journaling and student interviews are used, students learn through the process of articulating their ideas.
- Assessment can be valuable in making instructional decisions.

  When teachers are continually engaged in the process of measuring student progress, they can better support their students learning of specific mathematical goals. Solid knowledge of where students are mathematically informs instructional decisions such as when to review, when to spend more time on a difficult concept, and how to adapt tasks for both struggling and advanced students.

Questions to Think About:

Effective assessment is much more than quizzes and tests, although such formal assessments do have their place in good classroom instruction. Ideally, assessment is ongoing, reflective, and responsive to individual student needs and abilities. Tools such as self−assessments, informal assessments, and standardized testing can all factor into the total learning environment. Such a proliferation of assessment opportunities and styles, however, can also lead to confusion for educators, parents, and students alike as they seek to understand the role of assessment and how it can be implemented in the mathematics classroom.

- What does good assessment look like?
- How can teachers know which type of assessment (i.e., formal quizzes vs. portfolio assessment) is most appropriate for a given student and/or mathematics topic?
- How can standardized assessments such as state−mandated proficiency tests be used as tools for enhanced student learning?
- How can teachers incorporate the use of informal assessments such as journals and educational technology tools?

Story Summaries

Central Middle School

- Implementing portfolios and student−led conferences is a gradual process
- Self−evaluation is a skill that must be taught
- Building portfolios invites students to communicate with teachers, peers, and parents while increasing confidence and self−esteem

Here, a teacher describes what happened after she decided to use student portfolios: in this case, it is a collection of student work or artifacts that is self−evaluated and reflects the learner's skills and thinking. Initially, she assumed students would be able to reflect on and evaluate their own work with little effort. She quickly learned that self−evaluation is a skill that must be taught. To help them get started, she developed guidelines for reflection.

The teacher found that a good way for students to showcase their work was to conduct student−led parent conferences. Unlike teacher−parent conferences, the teacher is at these meetings only to support and encourage the child. The students are the ones who describe their work, acknowledging their growth and learning. After the parent conference, the portfolio is taken home for further review. The students and teacher develop questions they would like parents to respond to regarding portfolios and conferences. Parents include their answers in a follow−up letter addressed to the child.

Research Summary

Overview of Assessment in Middle School Math

This overview was originally published in **ENC Focus: A Magazine for Classroom Innovators**, vol. 7 no. 2, "Assessment That Informs Practice," and can be found online at:

http://www.enc.org/focus/assessment/document.shtm?input=FOC−001558−index

Standardized Test Scores and Alternative Assessments: Different Pieces of the Same Puzzle

by William E. Loadman and Anne Marie Thomas, The Ohio State University

Far−reaching policies are often based on the results of state−imposed standardized testing programs. Concerned individuals, both in the educational community and beyond, have questioned this. The usefulness of these tests in terms of actual student assessment has been debated. The testing programs and their scores have been blamed for disrupting normal classroom learning and assessment. Often the tests are viewed as being one dimensional, biased, and simply not useful for classroom teachers (Haney &Madeus, 1989; Mehrens and Kaminski, 1989; Cattrel , 1991; Cooley, 1991; Darling−Hammond, 1991; Jaeger, 1991; Smith &Rottenberg, 1991; Stake, 1991; Lanese,1992; Mehrens, 1992; Popham, 1992; Herman &Golan, 1993).

Alternative assessment strategies, such as teacher observation, personal communication, and student performances, demonstrations, and portfolios, have been offered by experts as having greater

usefulness for evaluating students and informing classroom instruction (Dorr−Bremme &Herman, 1986; Stiggins, 1994; Brookhart, 1999). In addition, the contentious atmosphere surrounding standardized testing has resulted in a backlash against that format and in favor of alternative or "authentic" strategies (Stiggins, 1994).

We would like to suggest to classroom teachers that standardized test scores and alternative student assessments both have an important place in our classrooms. Both offer different pieces of information about a given student. Teachers who are comfortable with both types of assessment have the ability to assess student knowledge, skills, and abilities more comprehensively.

Understanding Different Types of Assessment

Both standardized testing and alternative assessment strategies are designed to assess student learning, but the purposes behind these two types of assessment frequently differ. Large−scale, high−stakes standardized tests do gather information about individual student performance, but most of these assessments are primarily designed to inform decision makers about performance on the school, district, and/or state level. On the other hand, alternative assessment strategies are more frequently used to provide information about individual students.

Beyond understanding the basic purposes of each type of assessment, teachers need to take into account two other important considerations.

The first consideration is a question of values. Assessment, whether reflected in a standardized test score or in a teacher−written description of a student performance, is based in subjective human value. People have different values. These differing values often lead to different evaluation criteria, which ultimately result in different final assessments.

The second consideration is the underlying reference model. There are three prominent models used in education:

1. The norm−referenced model, in which individual student performance is compared with a norm group;
2. The criterion−referenced model, in which individual student performance is compared to a standard or criterion; and
3. The growth model, in which individual student performance is assessed by examining student growth on a concept, knowledge base, or skill between two points in time.

Lack of understanding of which model is being used in interpreting student achievement often confuses the debate over the merits of various assessment strategies.

Each of these considerations is pertinent for both standardized test scores and the interpretation of alternative assessments.

What Standardized Test Scores Can Tell Us

Standardized test scores properly obtained through a valid and reliable instrument and used appropriately can offer a wealth of information. For example, to evaluate mathematics achievement in algebra, students could be asked to solve 15 different algebra problems. The criterion might be set that seventh graders should be able to solve 12 out of the 15 correctly to meet the standard for achievement in algebra. The same test might also be referenced normatively. Perhaps the school district average for algebra achievement among seventh graders was solving eight problems. Finally,

if these standardized test measures on algebra were gathered over time or across grade levels, the assessment of growth is possible.

We illustrate the possibilities by looking at one student, Ashley, who solved nine out of the 15 problems correctly. In a similar assessment taken when she was in sixth grade, Ashley solved five out of ten algebra problems. Given the reference points, the teacher has valuable information about Ashley. She did not meet the criterion, but she did perform better than the district average, and it appears that she has grown from the previous academic year. All three pieces of information should be shared with Ashley and her parents so that the fact that she did not meet the criterion is not interpreted as academic failure.

The reference points also provide information on the level of achievement in the district. The fact that the norm for the district was below the criterion achievement level certainly is a cause for concern. Perhaps there is some curricular misalignment. The match between the district algebra curriculum and the algebra items on the exam should be examined before teachers make any drastic changes in classroom instruction. If there is a match, delivery of the material could be modified for the next year. A mismatch would suggest that district leadership should review both the curriculum and the test.

What Alternative Assessments Can Tell Us

Alternative assessment formats, such as teacher observation, personal communication, and student performances, demonstrations, and portfolios, offer students and teachers a forum where the knowledge or skill to be assessed is grounded in the kind of work people actually do in the real world (Wiggins, 1989). Moreover, the varied formats offer additional and, in many instances, more comfortable ways for students to demonstrate what they know and are able to do.

For example, if we turn to Ashley again, it could be that she has algebra knowledge and skills that were untapped by the paper−and−pencil format of the standardized test. Alternative algebra assessments could allow for that discovery. Perhaps an algebra game would show that Ashley can solve 14 out of the 15 problems correctly. Or direct communication with the teacher might result in Ashley getting all 15 correct.

Formats such as personal communication or teacher observation also offer teachers information on their curricula and their instruction. A teacher might believe she has covered all the terminology necessary for the students to demonstrate algebra skills. However, during a student demonstration, she realizes that the term "variable" had not been clear during the instruction.

Given the opportunity, students can become actively involved in assessment of their own performance and of the curriculum and instruction. For example, students might communicate that the instruction contradicted items on the test.

Pieces of information such as these would not have been available through a paper−and−pencil standardized test. Alternative assessments have been criticized as not being objective enough and not being generalizable, but they offer a new dimension as well as the opportunity for successful performance by students who may be disadvantaged by standardized tests.

What Does This Mean for Teachers?

Multiple methods and perspectives must go into the assessment of students by classroom teachers. Use of all assessment tools available, including standardized test scores, is imperative. We as educators have the responsibility to build reliable portraits of individual student achievement and to

use that information to shape both curriculum and instruction.

(Note: Use "back" button and click on "References" to access the reference list for this article.)

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Web Sites of Interest:

- **Principles and Standards for School Mathematics** can be accessed online at http://standards.nctm.org/
- Illuminations − http://Illuminations.nctm.org/index2.html
- ENC Online − http://enc.org − Eisenhower National Clearinghouse offers excellent resources including:
    - Middle school mathematics teachers will find a wide variety of professional development resources, curriculum materials, Internet sites, and other tools to enhance their teaching and learning. ENC's Digital Dozen, (http://enc.org/weblinks/dd/) a monthly selection of 13 math and science related web sites, is one place teachers will find an assortment of Internet resources to use in their classroom or for their own professional growth.
    - Educators can also search for resources on assessment through ENC's collection of more than 17,000 math and science educational materials (to browse the collection, go to http://enc.org/resources/browse/ for subject categories).
    - A section of ENC Online specifically devoted to the topic of assessment can be found at http://www.enc.org/topics/assessment/. By clicking on "Selected Resources," teachers can find a selection of professional development resources, curriculum materials, and Internet sites on assessment.
- Dr. Helen Barrett's Favorite Links and Alternative Assessment &Electronic Portfolios: http://electronicportfolios.org/portfolios/bookmarks.html

Related Web Resources

Assessment − Eisenhower National Clearinghouse (0)

Stories

This section presents Knowledge Loom stories about classrooms, schools, or districts that exemplify one or more of the practices in the spotlight.

Each story contains a full feature article and a set of facts about how the practice was put into action. Each story lists the practices it exemplifies and the name of the content provider.

For an overview of additional content presented on The Knowledge Loom Web site that may not have been selected for this print document, see the Spotlight Map located earlier in the documentt.

East Woods School

East Woods School

Hudson, OH

School Type: Public

School Setting: Suburban

Level: K−8

School Design: Traditional

Content Presented By:
Eisenhower National Clearinghouse

The following is an adaptation of a story written by Linda S. Hallenbeck, a fifth−grade teacher from Hudson, Ohio. It originally appeared in **ENC Focus: A Magazine for Classroom Innovators** (vol. 6, no. 3, 1999), entitled "Integrating Technology in the Classroom." The full article, in its original form, can be found at:

http://www.enc.org/focus/edtech/document.shtm?input=FOC−000700−index

The Shape of Things to Come

Computers can be a powerful tool to enhance learning in geometry. However, trying new curriculum materials and learning computer applications at the same time can be overwhelming for teachers. I have found that collaboration with fellow mathematics teachers can ease the process. The result is learning not only for the students, but also for the teachers.

Recently, I was involved in such a collaboration with another fifth−grade teacher of mathematics, Maria Regan. We selected the computer−based curriculum **Shape Makers: Developing Geometric Reasoning with the Geometer's Sketchpad**, by Michael T. Battista (1998). This research−based text consists of computer tasks which, used in combination with rich classroom discourse, help to develop students' thinking about geometric shapes and the characteristics or properties of specific shapes. Computers, calculators, paper and pencil, and classroom discussion are used to aid the students' thinking about properties of quadrilaterals and their classification.

Geometry curriculum taught in high school requires students to construct formal proofs within an axiomatic system. However, such students are often unable to successfully accomplish these proofs because their experience has not provided the necessary opportunities to progress to this level of sophistication. Research has shown that fifth−grade students' thinking can progress from identifying shapes visually to property identification; some are able to interrelate these properties and construct class−inclusion relationships, as well.

When fifth−graders are challenged to learn more than just identifying the shapes visually, they begin to build the necessary foundation that will allow them to construct formal proofs in geometry. The **Shape Maker** computer program provides meaningful tasks that consistently challenge students to examine their current thinking. This perturbation causes students to attempt to bring about resolution to the mental conflict. They must make necessary abstractions from the current situation and then

change their thinking to accommodate their new conjectures. As a result, the students' geometric thinking rises to a higher level of sophistication.

Maria and I worked together to develop skills to encourage this type of exploration. Using a program like **Shape Makers**, the teacher's role becomes that of posing questions, offering students support when needed −− but always asking for students to justify their geometric conjectures. Much of the class time is spent with the students working in pairs at their computers. At the same time, the teacher travels from pair to pair, asking questions and constantly challenging students to explain their thinking.

Classroom discussion is also an integral component of this style of learning. The class must formulate a consensus that is mathematically sound, yet agreeable to all. For instance, one partnership of students may have conjectured that they believe a kite always has at least one line of symmetry that will always bisect the angles, while others may not agree. In this situation, the teams who disagree may go to a computer to support their argument. One team will try to show why the conjecture is not workable, while another group sets out to manipulate the program to create various kites, identifying the line of symmetry to demonstrate the validity of their conjecture.

Another class discussion that is sure to take place is that a square meets all the criteria of a rectangle, so it is a rectangle. Since many fifth graders believe that squares and rectangles are two different, unrelated classifications of quadrilaterals and that squares are not rectangles, students may debate this issue in great length. The result is that they learn much about properties and the interrelationship of properties in quadrilaterals.

Fifth−grade students are active learners who enjoy working with computers. Maria and I also found that our students gained autonomy when making conjectures and justifying those conjectures to each other. Our computer−aided geometry unit was a wonderful learning experience for more than one hundred students. However, the two teachers were equally enriched.

Demographics

This information will be added soon.

Background

While computers can be a powerful tool to enhance learning in geometry, trying new curriculum materials and learning computer applications at the same time can also be overwhelming for teachers. I have found that collaboration with fellow mathematics teachers can ease the process. Recently I was involved in such a collaboration with another fifth−grade teacher. I had previously used computers to teach a two−dimensional geometry unit, but had no colleague with whom to discuss classroom discourse and students' learning and thought processes. My colleague, Maria Regan, was eager to try something new.

We saw our endeavor as a chance for both of us to benefit. Maria saw this as another opportunity to learn more about children's geometric reasoning while also learning a new computer program. I anticipated that the discussions we would have about our students' development would give me more insight into my students' thinking and thus improve my teaching.

Design &Implementation

Maria and I selected the computer−based curriculum *Shape Makers: Developing Geometric*

Reasoning with the Geometer's Sketchpad, by Michael T. Battista (1998). We began by meeting for a concentrated period of time on a Sunday afternoon to experiment and delve into the computer program. This allowed us a large block of time with no interruptions, as well as a day in which we had not already used all of our brainpower teaching our students. We also decided we would talk before and after shcool, as needed and as our time allowed.

This research−based text consists of computer tasks which, along with rich classroom discourse, develop students' thinking about geometric shapes and the characteristics or properties of specific shapes. Computers, calculators, paper and pencil, and classroom discussion are used to aid the students' thinking about properties of quadrilaterals and their classification.

Maria and I worked together to develop skills to encourage this type of exploration. Using this program, the role of the teacher becomes one of posing questions, offering students support when needed, but always asking for students to justify their geometric conjectures. Much of the time in class is spent with the students working in pairs at their computers as the teacher travels from pair to pair asking questions and constantly challenging students to explain their thinking.

Classroom discussion is also an integral component of this style of learning. The class must formulate a consensus that is mathematically sound, yet agreeable to all. For instance, one partnership of students may have conjectured that they believe a kite always has at least one line of symmetry that will always bisect the angles, while others may not agree. In this situation, the teams who disagree may go to a computer to support their argument. One team will try to show why the conjecture is not workable, while another group sets out to manipulate the program to create various kites, identifying the line of symmetry to demonstrate validity of their conjecture.

Results

The *Shape Makers*computer program provides meaningful tasks that consistently challenge students to examine their current thinking. This perturbation causes students to attempt to bring about resolution to the mental conflict. They must make necessary abstractions from the current situation and then change their thinking to accommodate their new conjectures. As a result, the students' geometric thinking rises to a higher level of sophistication.

One class discussion that is sure to take place is that since a square meets all the criterion of a rectangle, it is a rectangle. Since many fifth−graders believe that squares and rectangles are two different, unrelated classifications of quadrilaterals and that squares are not rectangles, students may debate this issue in great length. The result is they learn much about properties and the interrelationship of properties in quadrilaterals.

Replication Details

Maria and I spent many lunch periods, as well as before−and after−school meetings, in discussion and sharing ideas. Some meetings were very short, while others were lengthy discussions of students' thinking and learning, and the implications of the students' learning for us, their teachers.

This experience has confirmed for both of us that a mentoring relationship is truly a two−way street. Both the mentor and the mentee benefit from the rich dialog, the sharing of ideas, and the enhancement of professional development that has a fovaorble impact on children. We look forward to sharing with others what we have learned through our joint growth process.

Costs and Funding

The cost of the computer−based curriculum *Shape Makers: Developing Geometric Reasoning with the Geometer's Sketchpad*, by Micheal T. Battista (1998).

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Rating Criteria

This information will be added soon.

This story exemplifies the following practices:
Integrating Technology into Middle School Mathematics

Hampshire Regional High School

Hampshire Regional High School

Westhampton, MA

School Type: Public

School Setting:

Level:

School Design: Traditional

Content Presented By:

Eisenhower National Clearinghouse

The following is an adaptation of a story by Jan Schott, a mathematics teacher at Hampshire Regional High School in Westhampton, Massachusetts. It was originally featured in a professional development package that ENC produced on the topic of Teacher Change. The full story, in its original form, can be found on ENC Online at:

http://www.enc.org/focus/change/document.shtm?input=CDS−000381−381

Making Change in Junior High/Middle School Mathematics: Breaking the Lecture Mold in Algebra Class

(**Editor's note:** Jan Schott has participated in numerous SummerMath for Teachers Institutes and graduate courses at Mount Holyoke College. She also took part in the Southeastern Consortium for Minorities in Engineering at the University of Florida.)

For several years I have been working on making my classroom more interactive as the students construct their own learning and ideas. My previous definition of teaching can be simply summed up as follows: Pour information into the students' brains with clear, concise explanations and lectures while simultaneously stopping the leaks. I realized that I needed to do less preaching and teaching. Instead I have been urging my students to explore their ideas and voice their thoughts. I have been working on encouraging them to be mathematicians.

I have found that by working together in small groups and in whole class discussions, students discover mathematics for themselves. One of my goals is to establish a safe environment −− which does not imply that all ideas that are offered are correct or that they are taken to be correct. Contributions are not immediately judged by either the teacher or students but are respectfully discussed and critically analyzed.

I am especially focusing my attention on providing wait time, learning to accept necessary periods of silence, and slowing down the pace of over−anxious students. Sometimes, when the students are engaged in a vigorous discussion, I simply record what I hear without interrupting the flow. When we are working on exercises with specific solutions, I ask for all the different answers the students have developed and record all of them on the board.

Then we have a discussion about how they reached these solutions, how we could determine if the solutions are correct, and if any of the solutions are, in fact, equivalent. Lively discussions result as

students argue their points of view and listen to others defend theirs. Looking at the board, students struggle to make connections between the ideas of one student and those of another.

In one of my classes, an advanced algebra class of eighth− and ninth−graders, a recent assignment involved reading a short lesson from the text −− **Elementary Algebra** by Harold Jacobs −− and doing a set of exercises on direct variation. This book is not a typical algebra text; there are not a lot of drill problems with the same set of directions. Rather, it offers short, very readable lessons on the topic and then reinforces and further develops these concepts in the problem set.

The concept of direct variation is introduced using a chart that compares the height of an object to the length of its shadow at a given time of the day. The standard formula for direct variation is $y = ax$, in which a is the constant of variation. If the height of the object is doubled, the length of the shadow is also doubled. These are the main points of the short lesson.

After a very lively discussion of the homework problems on direct variation, I posed the question, "What is direct variation? How would you describe direct variation?" The silence that followed was unusual, and when they finally spoke, the students could only voice their confusion.

I was surprised at this turn of events. The students did not have a handle on direct variation and all the subtle and not−so−subtle interconnected thoughts. The excellent book presentation had not been any better at teaching direct variation to these students than my lecturing had taught it to classes in the past. Yet these students had managed the exercises very well, and they had had a very lively discussion of the problem set. I realized the class needed a second chance to create their own meaning. They knew more than they realized but just hadn't put the pieces together.

Many associates at my school and in the mathematics education courses I had taken had talked about using writing in math classes. Some assigned journals in which the students wrote about what they were learning, what was causing difficulty, and what they did not yet understand. Teachers would then respond to the student journals with thoughts, questions, and encouragement. Several had mentioned use of essays on math tests to determine whether students had a firm understanding of a particular concept.

For homework that night, I asked my students to write a paragraph describing direct variation. The next day we had a fruitful discussion in which we determined together that the slope is defined as the change in the y coordinate over the change in the x coordinate, or the rise over the run.

Later that day, I had a chance to read the students' paragraphs. It was obvious that the exercise of writing had helped them organize their thoughts and at least begin to make connections. The writing had fueled the fire of our discussion. However, their paragraphs revealed that they had not made all the connections. In fact, many were not clear and/or complete in their definition and also, evidently, in their understanding. It was the combination of their paragraphs and the interactive classroom that created the opportunity to discover as much as they did in their discussion. Great inquiring minds met in that classroom with kernels of ideas that germinated and sprouted in the discussion.

Demographics

This information will be added soon.

Background

This information will be added soon.

Design &Implementation

This information will be added soon.

Results

This information will be added soon.

Replication Details

This information will be added soon.

Costs and Funding

This information will be added soon.

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Rating Criteria

This information will be added soon.

This story exemplifies the following practices:
Effective Professional Development for Middle School Mathematics

South Hadley Middle School

South Hadley Middle School

South Hadley, MA

School Type: Public

School Setting: Suburban

Level: Middle

School Design: Traditional

Content Presented By:
Eisenhower National Clearinghouse

The following is adapted from a story by Marie Appleby, a mathematics teacher at South Hadley Middle School in South Hadley, Massachusetts. The original version appeared in **ENC Focus: A Magazine for Classroom Innovators** (vol. 6, no. 2, 1999), entitled "Inquiry and Problem Solving."

Graphics included with the online version are helpful in understanding the mathematical problem being described in the story. There are also additional materials, such as student journal entries and a description of a new mathematical puzzle. The full story can be found online at:

http://www.enc.org/focus/inquiry/document.shtm?input=FOC−000711−index

Petals Around the Rose: Building Positive Attitudes About Problem Solving

The sound of five rolling dice caught everyone's attention.

I continued rolling the dice until a small group of curious students gathered around me.

"What are you doing?" asked Sarah.

"What do you think she's doing? She's playing with dice!" croaked Danny disdainfully.

With a gleam in my eye but keeping a straight face, I started my routine: "The name of the game is Petals Around the Rose. The name is very important. For each roll of the dice, there is one answer, and I will tell you that answer."

I rolled the dice: five; one; two; two; four. "The answer is four," I said without changing expression.

I paused and then rolled the dice again: five; one; three; three; three. "The answer is ten."

"How did you get that?" asked Sarah suspiciously.

"You must be a mind reader or something," chimed in Jamie.

"Can I roll the dice next?" asked Danny, trying to take control of the situation. Danny rolled the dice three times, and I gave only answers.

By this time, the students were hooked. Here were materials they knew very well but presented in a way that was new to them.

Early in each school year, I want my students to examine the methods they use to approach problem solving. The Petals Around the Rose problem confronts students with a lot of data and an answer, but no formal question and no explicit conditions of the problem.

I am always intrigued by the observations students make and about the hypotheses they sometimes mutter out loud. I do want them to be observant −− to check for similarities and differences in the outcomes of the rolls of the dice −− and to generate many possible explanations or rules for the game. I also want them to feel the joy of working on a seemingly difficult problem in math and solving it. More importantly, I want them to begin making judgments about right and wrong solutions without depending on the teacher for verification.

Two days later, there was an opportunity to continue the game.

"Can we play Petals Around the Rose?" asked Jamie.

Her question was quickly followed by a chorus of "Can we?" from nearby students. I began: "The name of the game is Petals Around the Rose. The name is very important. For each roll of the dice, there is one answer, and I will tell you that answer."

I rolled the dice: five; two; four; one; five. "Eight."

"There's no eight there!" moaned Jamie.

"You didn't tell us the rules," wailed Danny.

Looking at my students' puzzled faces, I thought back to how I had learned the game at an educational conference. The head of our math committee had pulled five dice from her pocket and started rolling them. She repeated the same directions and kept a noncommittal face.

My colleagues included teachers from language arts, social studies, science, and industrial arts, and we were all trying to figure out how the answer fit the name. It was aggravating. I remember trying many different possibilities including combining dice in arithmetic ways, disregarding some dice, looking for patterns in the way dice landed, and on and on.

The language arts teacher, an admitted "math−phobe," was the first to find success. I admit I wondered what he had tried that worked so easily. The "ah−ha" feeling that hit me when I saw the Rose and the Petals around it was wonderful and gratifying. I decided that feeling was something every student should experience.

When guesses from my students started flying fast and furiously and seemingly without much thought, I halted the game. There would be no more playing of the game that day, but I asked, "What do we know about Petals Around the Rose?"

As the students generated a list, I wrote the items on the board, as I do with other investigations:

1. The name of the game is Petals Around the Rose.
2. Use five dice with dots.
3. We know the answers.

4. The color of dice is not important.
5. It has something to do with "around."
6. Roll the dice to get answers.
7. All answers are even.
8. Focus on what is the Rose.

The next day Ted arrived first to class and said, "Test me! Test me about Petals Around the Rose. I think I've got it!"

Ted was well−liked and a hard worker but not the star of the math class. While his "test" was going on, the other students came into class and were both surprised and delighted that he had found a solution. I handed the dice to Ted, and he ran the game for the next ten minutes with small groups of students while other students and I were getting organized for the class.

As each day passed, I felt the excitement grow as I watched more and more students solving the problem. They could pick up a set of dice from the materials table and help small groups at the beginning or end of class or any transition time in between. The game was no longer mine; it belonged to the students.

There are other activities that carry students to an "ah−ha" discovery or experience. However, Petals Around the Rose offers a change of pace, a non−traditional problem that engages the students in light−hearted activity while requiring them to use several important strategies:

- guess and check
- make a list of known facts
- draw samples or diagrams
- write ideas in a journal
- make the problem simpler

Petals Around the Rose has developed a feeling of success and power in my students and a positive view of problem solving.

Demographics

This information will be added soon.

Background

This information will be added soon.

Design &Implementation

This information will be added soon.

Results

This information will be added soon.

Replication Details

This information will be added soon.

Costs and Funding

This information will be added soon.

Contact Information

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Rating Criteria

This information will be added soon.

This story exemplifies the following practices:
Inquiry and Problem Solving in Middle School Mathematics

Central Middle School

Central Middle School

Eden Prairie, MN

School Type: Public

School Setting: Suburban

Level: Middle

School Design: Traditional

Content Presented By:
Eisenhower National Clearinghouse

The following story was written by Jennifer Williams, a science teacher in Eden Prairie, Minnesota. It was originally published in **ENC Focus: A Magazine for Classroom Innovators**, vol. 7 no. 2, entitled "Assessment that Informs Practice." Although the author is a middle school science teacher, the technique she describes is one that can be adapted and applied to middle school mathematics classrooms. The supporting material she refers to in "A Potpourri of Portfolios" and "Guidelines for Portfolio Reflection" can be found at http://www.enc.org/focus/assessment/document.shtm?input=FOC−001560−index

Implementing Portfolios and Student−Led Conferences

Learning about alternative assessment methods during graduate school inspired me to implement portfolios in my classroom. There are many different kinds of portfolios that are appropriate for use with K−12 students; just a few are listed in the box "Potpourri of Portfolios" (see reference in introduction above).

In my work with my own students, I decided that portfolios would be a collection of student work or artifacts that is self−evaluated and reflects the learner's skills and thinking. I emphasize to students that their portfolio should show growth in their learning. Building portfolios invites students to communicate with teachers, peers, and parents while increasing their confidence and self−esteem. Students grow as they take responsibility for evaluating their own learning.

As I committed myself to using portfolios with my students, I realized that I had much to learn. I contacted teachers and area education consultants who had experience using portfolios. I gathered research articles that I would later share with other staff members and parents (see suggested readings).

A four−drawer filing cabinet and three−ring binders for 100 students were donated so that I could organize and store my students' work. As part of their weekly or biweekly classroom routine, my students collected graded assignments and stored them in a "work−in−progress" manila folder. These folders were kept in the filing cabinet where they were easily accessible to students.

Initially, I assumed students would be able to reflect on and evaluate their own work with little effort. I was quickly proven wrong. Self−evaluation is a skill that must be taught.

To help them get started, I developed "Guidelines for Portfolio Reflection" (see reference in introduction above). Using the questions and start−up phrases, students write their reflections on half−sheets of notebook paper or on sticky notes that they attach to their work. Once several pieces have been reflected upon, students organize this work in their binders, turning them into portfolios to showcase to teachers, peers, and parents.

One way for students to showcase their work is to conduct student−led parent conferences, in which students share their portfolios. They are held accountable for their learning and have evidence to support the grades they have earned. Each student's strengths, areas for improvement, and future goals become integrated throughout the child's dialog with his or her parents. Work samples also provide evidence that the child is making progress toward meeting state graduation standards.

Typically during teacher−parent conferences, the teacher does almost all the talking. Often, the student is not present. But in student−led conferences, the teacher is there to support and encourage the child. It is gratifying to hear the students describe their work, acknowledging their growth and learning.

Changing from the traditional to an innovative conference style takes time and practice. Before the first conference, I allow students to practice with their peers. I have also learned to educate parents early about the rationale of portfolios and student−led conferences. Clear explanations −− a letter combined with informational portfolio sessions early in the school year −− help them to accept this process and encourage their child.

I have found that parents want their child to be accountable for the grades they earn. I am so pleased when parents direct their conversation toward their child during the conference. Parents know that they are welcome to sign up for a separate conference without their child, but these are seldom necessary. After the parent conference, the portfolio is taken home for further review. The students and I develop questions they would like their parents to respond to regarding their portfolios and conferences. Parents include their answers in a follow−up letter addressed to the child.

In my classroom, student−led conferences are conducted twice per year, once in October and again in March. At the end of the year, we hold a portfolio fair. Students become more confident and proud of their portfolios as the school year progresses.

Implementing portfolios and student−led conferences is a gradual process, but once these ideas are in place, they are contagious. Once one teacher or team begins, others will follow. I started using portfolios four years ago. At first, the idea was confined to my team of students; now the entire school uses portfolios. To support the process, three−inch binders with the school name and mascot on the cover were purchased for every child. This year, for the first time, the portfolios have been passed on to the next grade level.

Student assessment is often a negative experience for all involved. Our school's experience with portfolios shows it does not have to be that way. Allowing students time to reflect on their progress and to communicate what they have learned is a step in the right direction.

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Demographics

Central Middle School is a public middle school located in Eden Prairie, a subruban community of about 50,000 people. The town is surrounded by rolling hills and picturesque lakes and creeks. It is a short distance from downtown Minneapolis and St. Paul. Eden Prairie was Minnesota's fastest growing city from 1980 to 1990, with a 142% increase in population over that time.

Background

Learning about alternative assessment methods during graduate school inspired me to implement portfolios in my classroom. There are many different kinds of portfolios that are appropriate for use with K−12 students. In my work with my own students, I decided that portfolios would be a collection of student work or artifacts that is self−evaluated and reflects the learner's skills and thinking. I emphasize to students that their portfolio should show growth in their learning.

Design &Implementation

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In my classroom, student−led conferences are conducted twice per year, once in October and again in March. At the end of the year, we hold a portfolio fair. Students become more confident and proud of their portfolios as the school year progresses.

Results

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Replication Details

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I also have learned to educate parents early about the rationale of portfolios and student−led conferences. Clear explanations−−a letter combined with informational portfolio sessions early in the school year−−help them accept this process and encourage their child.

Costs and Funding

The cost of a four−drawer filing cabinet and one three−ring binder for each student.

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Rating Criteria

This information will be added soon.

This story exemplifies the following practices:
Assessment That Informs Practice in Middle School Mathematics

Related Web Resources

This is an annotated list of resources found on other Web sites that relate to this spotlight topic on The Knowledge Loom. We encourage you to access them from the links provided on The Knowledge Loom. To do this, go to the Web address noted in the header. Then click on the Related Resources link.

For an overview of additional content presented on The Knowledge Loom Web site that may not have been selected for this print document, see the Spotlight Overview located earlier in the document.

1) Educational Technology
http://enc.org/topics/edtech/

Find the best ways to use technology to enhance teaching and learning. Much of this material was published in the "Integrating Technology in the Classroom" issue of **ENC Focus**.

2) Educational Technology Resources
http://enc.org/topics/edtech/selections/

Resources to help teachers make the best use of technology in teaching their day−to−day math curriculum.

3) Graphing Calculators in the Mathematics Classroom
http://www.ed.gov/databases/ERIC_Digests/ed433183.html

This ERIC digest article provides a sampling of four types of enrichment with graphing calculators that are used for expediency, conceptual understanding, critical thinking, and integration.

4) PBS Mathline Grades 6−8
http://www.pbs.org/teachersource/mathline/lessonplans/search_6−8.shtm

Mathline provides lesson plans and videos for Grades 6−8 with links to Internet resources about teaching mathematics with technology. Under Categories and Topics, select "Computers."

5) Synergy Learning
http://www.synergylearning.org

Synergy Learning is a comprehensive site covering math, science, and design technology for Grades K−8. Many computer−using educators will be familiar with its magazine Connect¨. Archives from the magazine, information on inquiry learning, a sample magazine issue, and resources for science labs are available on the site. Synergy Learning offers support materials through free online information, summer institutes and workshops, and magazine subscriptions.

Content Providers

This is an annotated list of organizations that provided content for this topic on The Knowledge Loom.

1) Eisenhower National Clearinghouse

The Eisenhower National Clearinghouse for Mathematics and Science Education (ENC) is funded through a contract with the U.S. Department of Education to provide K−12 teachers with a central source of information on mathematics and science curriculum materials. ENC was established in 1992.