



Chapter Two

Managing projects in your math class

A successful math class in which projects are an important part of the course of study is the result of effective planning and management. Along with teaching required material, you must provide meaningful projects that have real-life applications. These are not easy charges. As students work on projects, they will be engaged in various tasks: they will need to consider different strategies, gather and analyze information, confer with each other, manipulate models, perform calculations, and test possible solutions. All this requires an environment that promotes vigorous inquiry, encourages students to assume the responsibility for their learning, and supports both individual and group activities.

Structuring Your Class

Math projects provide students a chance to use various skills in solving authentic problems. Since projects often reach beyond the math class, they offer an excellent way to broaden the scope of your curriculum and introduce exciting new activities to your teaching. There are many ways you can incorporate projects into your

classes. Perhaps the easiest is to select projects that support the unit you are teaching. For example, if you are studying a unit in geometry, Project 6, "Designing a Flower Bed," in which students work with rectangles, squares, circles, and scale, will be useful. If you are teaching a unit on data analysis, Project 12, "An Election Poll," will supplement your instruction.

Projects used to enhance a unit can be built into your daily schedule. We suggest that you take a class period to introduce and begin the project. Explain the project; distribute any materials students might need; organize teams; and give students twenty minutes or so to plan, brainstorm potential strategies, and get started.

After this introductory period, resume your regular lessons, reserving about twenty minutes at the end of each period for students to continue working on the project. Providing students with time at the end of class eliminates the need for them to arrange to meet outside class (although sometimes students become so involved with a project that they meet on their own). This also allows you to assign the ordinary amount of homework and continue moving forward with the unit. Since not all teams will finish at the same time, groups that finish early may work on extensions of the project, write in math journals, or simply do homework. When every team is done, you should schedule a period for sharing results.

Another way to incorporate projects into your classes is to periodically set aside time for them. After you complete a unit, take three or four days to work on a project. Some teachers prefer this method because it gives students a break from the routines of the class but does not interfere with the general curriculum.

Perhaps you will decide to build projects into your schedule. You might reserve every Tuesday and Friday for working on projects. This plan has the advantage of establishing a regular schedule that ensures time for project work. Since the projects in this book stand alone, each can be used at any time during the year and still provide the benefits of using a variety of skills in meaningful contexts.

Some projects, especially those for individuals, may be completed at home. You might give students a choice of these projects as either assignments or bonus activities. Although the projects are completed on the students' time, you should provide class time for sharing. Responses to their results are important to students.

When selecting projects for your students, be sure to consider their needs and abilities. Never assign projects that require skills your students have not yet mastered. Students will find such projects to be a frustrating struggle, and any new skills they acquire will be offset by the negative emotions they come to feel for math.

Without question, math projects offer students several benefits. They permit students to use many skills in solving various problems, give students a chance to take ownership of their mathematics learning, and help students to see the relevance between math and real life.

Creating and Maintaining a Positive Environment

Problem solving thrives in an environment in which people work on problems that have valid applications to life, feel free to risk making mistakes, and are encouraged to share their ideas. The best problem solving occurs in classes where students enjoy the freedom to pursue learning in their own way. The tone you set in your classroom, your expectations, and the procedures you maintain are the foundation for such an environment.

Since students usually rise, or fall, to a teacher's expectations, always discuss your goals for the class with your students at the beginning of the year. Share with them how you intend to conduct the class, how the class will be organized, and what will be covered. Note what you expect from them.

For students to work efficiently on math projects, they need a classroom that is logistically comfortable for problem solving. Tables are ideal; however, if you do not have tables, you can push desks together. Either way, you should provide enough room between teams so that they can function as single entities without distractions from other groups. Along with enough space between teams, there should be enough work area for students to discuss possible strategies with each other, confer about data, manipulate and examine models, and work on calculations.

Support problem solving in whatever ways you can. Bulletin boards, corridor display cases, media center exhibits, and math fairs are just some ways to draw attention to your program. Always look for ways to highlight lists of problem-solving strategies, interesting articles about math, and the work of your students.

While there is much you can do to promote success in your classes, students too must strive to make the class beneficial. This is particularly true during group activities. Your students must be willing to accept more responsibility than is demanded by the traditional class. During project activities, they must remain focused on the tasks. Group work is not a time to talk about who might be named homecoming king or queen. Distributing copies of "The Responsibilities of the Math Student" to your students is an excellent way to share basic expectations for student behavior.

Unquestionably, student learning flourishes in a conducive environment. One of your most important tasks as a teacher is to create a classroom filled with enthusiasm, the spirit of inquiry, and the desire to learn. The best classes are founded on the spirit of cooperation and energetic intellectual pursuit, in which students believe that everyone can learn (and enjoy!) math. For a summary of characteristics of math classes that have a positive atmosphere, see "The Right Environment."

The Responsibilities of the Math Student

A successful math class results when people work together to learn math. Accepting the following responsibilities is the first step to making this class worthwhile:

- Each day report to class on time and ready to work.
- Remember to bring your text, notebooks, pencils, calculators, and other materials to class.
- Pay attention in class, and ask questions when you do not understand something.
- *Everyone can learn math.* Work hard, and finish your class work and homework.
- Work cooperatively with other students in groups. Share your ideas, and be willing to listen to the ideas of others.
- Try various strategies in solving problems.
- Remember that solving complicated, multistep problems takes time. Be persistent.
- Follow the classroom rules and procedures.
- Behave properly.
- Recognize the importance of math in your life.

The Right Environment

The following characteristics are found in math classes described as having a positive atmosphere:

- The goals of the class are high enough so that students have to work hard, but not so high that they feel frustrated with math and its applications.
- The classroom is built on openness, fresh ideas, and sharing.
- Teacher and students believe that everyone, regardless of gender and ethnicity, can learn math.
- Students' work is prominently displayed.
- The classroom is designed to support inquiry and problem solving.
- The classroom is bright and cheerful.
- The classroom adheres to orderly procedures. Students maintain appropriate behavior and follow the classroom rules.
- Goals and objectives are clear to students.
- Classroom rules are fair and consistent.
- The grading system is reasonable and equitable.
- The teacher interacts with students and is a guide, nurturer, cheerleader, and provider of information.
- Teachers model problem-solving behavior and share with students their own enthusiasm for finding solutions.
- Math is connected to real-life problems and situations.
- Cooperation is encouraged.
- Enough time is provided for problem solving.
- Students are encouraged to consider and explain their reasoning during problem solving.
- Students are encouraged to use various strategies in solving problems. They come to recognize that the same problem may have many solutions.
- Sharing is encouraged, especially how students found solutions to problems.
- Calculators, computers, and other technologies are used regularly in class.
- Math is related to other subjects as much as possible.
- Manipulative materials are used whenever possible to show students relationships.
- Students learn the value of mathematics in their lives.
- Students and teachers become partners in learning mathematics.

Teaching Suggestions

While every teacher has his or her individual techniques and methods, we have found that the following plan is helpful in presenting projects and problem solving. It can be broken down into three parts: introduction, work time, and wrapping up.

Introduction

Begin a math project by presenting the situation and problems that are to be solved. Offer examples, review any concepts or specific skills that students will need to solve the problems they will confront, and relate the project to real-life scenarios as much as possible. Encourage students to ask questions. Having a student paraphrase the project and what needs to be solved can be helpful in clarifying what everyone is to do.

Once students understand the project, distribute copies of student guide sheets and discuss the information presented there. Data sheets and additional materials, if any, should also be distributed. Having everything they need to begin helps students to see the full scope of the project.

Work Time

As students work in teams, your task is to circulate around the room, offering help, encouragement, or simply observing. This is also a time to monitor and model student behavior.

Pay close attention that a team does not stray off the topic. If you see this happening, you might point out their mistake or nudge them in the right direction. However, avoid giving answers to any problems. If students feel that you will provide answers, they will be less inclined to do the hard thinking that will result in finding answers themselves. To encourage students to find their own answers, some teachers insist that they (the teachers) may be asked a question only after the question has been presented to the team and no one else is able to answer it.

As you observe students, you may find that a team has trouble starting. Sometimes this is caused by students' not being able to focus the problem. Have students restate the problem and break it down into parts, concentrating their efforts to identify the most important facts. Teams may also have trouble finding strategies that will lead to solutions. In this case, suggest that teams brainstorm various strategies, and examine each one to see if it leads to a possible solution.

As you move around the room, be aware of the interactions of the members of each team. You will likely see that some groups work well together with everyone sharing ideas, others are dominated by one or two members, and some are just unmotivated. When a team is working well, leave it alone. Even offering a comment might disrupt its momentum. Remember that a project is a time for students to discover their own solutions. If a group is not working well, you should sit in on it and model appropriate behavior. Make sure that everyone is participating, and encourage team members to help each other. If necessary, for a time, assume the role of team leader to get things going, then gradually fade

into the background as students begin to assume ownership of the project. With some teams, you may need to remind students of the proper procedures and behavior often, especially during the first few weeks of class.

Wrapping Up

Sharing is essential to the successful culmination of a math project. Discussing methods and results helps students to realize that some problems have multiple solutions that may be discovered through various strategies. This is an important lesson of authentic problem solving. In the real world, many problems have several solutions and can be solved in many ways. For more information on sharing, see "The Importance of Sharing" presented later in this chapter.

Individual and Team Conferences

As students work on projects, you will monitor the progress of the teams. In many cases, they will have questions, or you will need to discuss procedures, rules, or behavior. You will undoubtedly be conducting conferences with individuals or the entire team.

A conference does not have to be long; in fact, it may last only a minute or two. In most cases, it will be conducted at the students' work area. The purpose of any conference is to help students better understand the project they are working on, as well as help them to improve their understanding of mathematics. Often you may find that students need you only to answer a simple question. In such instances, provide guidance and let them get back to work. If an individual or team seems stuck, use this as your starting point for the conference.

Focus any conference on a particular problem or skill. If you try to do too much, you will confuse students or provide them with too much information. Either way, you will end their efforts to solve the problem. During the conference, be sure to keep your tone positive, and offer specifics. You may need to point a team in the right direction to find more information, offer encouragement to the team that is about to give up, or assure a team that their efforts are worthwhile.

When you give praise, it should be genuine, because students can tell when it is not. Always avoid negative or sarcastic remarks, for these will only discourage students. The conference should be a time of help and support.

The Value of Cooperative Problem Solving

In many jobs, people work in teams, and the experience your students gain now as they work together on math projects will serve them not only in your class but in the future as well. Teamwork fosters inquiry and discussion, and students often learn more when working together than they do trying to solve a complicated problem alone. Cooperative learning also provides students with the opportunity to acquire valuable social skills.

When students work in teams, they are more likely to take an active role. It is easier for them to get involved because the team provides support to individuals. Seeing other team members struggling with the same problems helps students feel less intimidated about offering their thoughts, and many students who would not risk sharing ideas with the whole class usually will share with their team. Furthermore, when they offer suggestions toward the solution of a problem, they receive immediate feedback. This sharing frequently results in a free-wheeling give-and-take of mathematics that is as stimulating as it is useful.

As a team works on a math project, it becomes involved in various activities. Team members need to discuss and assign tasks, reflect on how to approach the problem, test strategies, gather and analyze data, reach solutions, and determine how to justify and share results. Teamwork helps build student confidence, promotes critical thinking, and results in a sense of ownership of the problem.

Organizing Teams

Random groups tend to make the best math teams, although you should reserve the right to make adjustments. Groups of four to six generally work well for complex projects. With fewer than four, it is sometimes hard to generate enough ideas, especially if one of the students is absent or is shy or quiet.

An easy way to make random pairings is to simply count down your roster in sets of five, assigning the numbers 1 to 5 to students. Then all of the number 1s in the class would be on team 1, all of the 2s on team 2, and so on. Before announcing the teams to the students, review them and make sure that you have a mix of students of high and low abilities, as well as a mix of gender and ethnicity. It is also often a good idea to avoid having best friends or students who do not get along on the same teams. Make any final changes before informing students about the groups.

You should also change teams periodically. Rearranging groups allows students to interact with various personalities and see different viewpoints. In the real world, individuals are often required to work with people of varying outlooks and abilities. When making new teams, you can easily switch two members from each of the existing teams. Switching only one member keeps too much of the original team together.

After you have arranged your teams, explain to your students the purpose of working together. Suggest that a team may work most efficiently when tasks are divided. You may also suggest that students assume various roles that will help define responsibilities. For example, one student might serve as team leader. Her purpose is to keep the group on task and guide it toward the solution of the problem. Another might be the recorder, whose responsibility includes writing down the team's ideas, strategies, and conclusions. The list "How to Set up Project Teams" provides suggestions for organizing groups.

Unless your students have worked in teams before, they will probably need training in the procedures of effective teamwork. You should focus much of your attention on team interaction during the first project. You will likely need

How to Set up Project Teams

Working together in teams offers students an excellent way to learn math. The following guidelines can help you to organize your math teams:

- For complex projects, groups of four to six work best for middle and high school students.
- Organize your teams randomly; however, be sure to mix abilities, genders, ethnicities, and personalities.
- To build team spirit, suggest that teams select a name and design a team logo.
- Rearrange teams periodically. This gives students the chance to interact with others and experience new working relationships.
- Always explain the purpose of group work and expected behaviors. Some students may have little experience working in teams.
- Since teams often benefit from a division of labor, consider having students assume specific roles—for example:

Leader, who guides the team toward its goal and makes sure everyone stays on task

Recorder, who keeps notes of the team's ideas, strategies, and solutions

Time monitor, who keeps track of time and helps the leader keep the team moving

Checker, who reviews the work of the team

Materials monitor, who assumes responsibility for any materials the team uses

Presenter, who shares the team's findings with others.

- In small groups, students may assume more than one role.

Rules for Working in Math Teams

The success of a math team depends on the ability of its members to work together. Keeping the following suggestions in mind can help you and your team work more efficiently.

Each member of the team:

- Is responsible for his or her own behavior.
- Should work with other team members.
- Should help other members.
- Should share his or her ideas.
- Should carefully consider his or her ideas before speaking.
- Should give the floor to others after speaking.
- Should listen carefully and politely when others are speaking.
- Should ask questions when he or she does not understand something.
- Should strive to keep the discussion on the project and keep comments constructive.
- Should keep his or her emotions in check. When disagreements arise, they should be discussed calmly.
- Should carry out his or her role in the group the best he or she can.

to model behavior and remind students of procedures often, especially at the beginning of the year. Sit in on the various groups and show them how to act and behave. Acquiring the skills necessary for effective group work may take students a few weeks, and distributing copies of "Rules for Working in Math Teams" can be helpful in discussing expected behavior.

The Importance of Sharing

Sharing is crucial to projects and problem solving. Becoming aware of other strategies and solutions can broaden students' understanding of math. Sharing may take the form of an oral report, a presentation incorporating the use of technology such as an interactive whiteboard or Microsoft PowerPoint, or a written log or summary.

At the end of a project, you should provide time for teams to share their methods and findings. For oral sharing, the student designated as presenter shares the team's results with the rest of the class. Encourage students to discuss successful strategies, as well as earlier strategies that they attempted but which did not work. It is possible that other teams tried the same strategies but got different results or experienced different problems. The more that math is discussed, the more opportunities students have to gain new insights.

After the presentation, encourage questions from the class. Do not permit questions during sharing, because the presenter might become distracted and may not cover all of the essential points. During questioning, other members of the team may help the presenter, but only one student should speak at a time. This is also the time for members of other teams to offer comments or observations. Emphasize that any discussion should be positive, and do not allow sarcastic or negative statements.

Sometimes presenters may need help to cover all the issues. Guide students to report the strategies they used, their methods, procedures, and solutions. If a student becomes blocked, a helpful question from you can get him started again. Consider asking questions like the following:

"How did you divide tasks in your group?"

"What was your initial plan?"

"What strategies did you consider?"

"What problems or obstacles did you run into?"

"What kinds of data did you need to gather?"

"What sources did you use for finding information?"

"How do you know your solution is valid?"

"Are there other possible solutions? If yes, what made you select one over the others?"

At the end of the session, summarize the project and the results that the teams obtained. Highlight any unusual strategies or problems encountered, and be sure to discuss how the mathematics applies to real life.

Writing in Math Class

The benefits of writing in math class are well documented. Writing provides students with a method through which they can examine and share their thoughts about mathematics in a formalized manner. Through writing, students can connect concepts they have already learned with new ideas, summarize their understanding of math, and communicate their thoughts to others. Few will argue that only when we truly understand something can we explain it and put it clearly into words.

Many types of writing can be done in math class. Some of the most common are:

- Writing about specific problems
- Summaries or reports
- Biographies of famous mathematicians
- Word problems for other students
- Publication of a mathematics magazine (see Project 24)
- Keeping a math journal (see Project 31)
- Maintaining a math portfolio (see Project 32)

Whenever your students write in math class, encourage them to share their thoughts and information about mathematical concepts, methods, and applications. Avoid allowing students to write about math in ways that show little thought, purpose, or insight. Students should select meaningful topics on which they can share information and their ideas.

It has been found that people write according to a process that has been aptly named the writing process. It is likely that the English teachers in your school are familiar with it. You might consult with your students' English teacher, who may be willing to support your efforts for having students write in math class. To help your students understand the writing process, distribute copies of "The Writing Process and Math," and discuss the stages of the process with your students.

Using Technology with Math Projects

Technology such as calculators and computers is essential for teaching, learning, and doing mathematics. Such devices are especially helpful for work on multifaceted math projects because they enable students to collect, organize, and analyze data; view dynamic images of mathematical models; and perform computations with accuracy and efficiency. We live in a technological world, and the technologically related skills your students learn in school will serve them throughout their lives.

The Writing Process and Math

When you are writing articles in math, it will be helpful to follow the stages of the writing process. You have probably learned about this in your English classes. Writing can be broken down into various stages, or steps. Authors go through these steps when they write, moving back and forth through the various stages as necessary. Understanding this process can help you with your writing. Following are the stages of the writing process.

Stage 1: Prewriting

- Thinking of a purpose
- Generating ideas
- Brainstorming
- Researching and gathering facts
- Analyzing ideas
- Organizing ideas
- Focusing ideas

Stage 2: Drafting

- Writing
- Rearranging information and ideas as needed
- Expanding ideas

Stage 3: Revising

- Rewriting
- Rethinking, rearranging, deleting, adding
- Clarifying ideas
- Checking ideas and mathematical facts
- Conducting more research
- Redrafting

Stage 4: Editing

- Proofreading
- Making any final corrections, including those relating to math

Stage 5: Publishing or sharing

- Sharing your written work with others
- Producing copies of your work
- Displaying your work

Calculators

Calculators are an essential component of any math class. Freeing students from the slow work of manual computation, they provide a means of proficient computing and allow more time for investigation, reasoning, decision making, and problem solving.

Calculators are particularly helpful for students who might have difficulty with computation. These students often become so worried about the basic operations that they do not enjoy the many benefits of project work such as collaboration, gathering and analyzing data, and making decisions. Without question, calculators are critical to your students in their work on math projects, because they enable students to focus on problem solving rather than computation.

Computers

Like calculators, computers are vital to modern math classes and assume a significant role in project work. Computers can be used to gather, analyze, and organize data; provide visual images of mathematical concepts and ideas; and link students to the Internet and mathematical Web sites throughout the world. They can support student studies and investigations of all areas of math and provide a foundation on which problem solving flourishes. Moreover, they can be used to print results and are essential in presenting the conclusions of a project using applications such as PowerPoint and interactive whiteboards.

PowerPoint Presentations

Microsoft's PowerPoint and similar applications enable users to design and give presentations, ranging from the basic to the sophisticated. Such presentations can be a fine culminating activity for your students' work on math projects. PowerPoint is not difficult for students to use, and mastery of it will serve students not only in your class but in other classes as well.

A typical PowerPoint presentation requires a computer that is running PowerPoint software, a display screen, and a projector. At its simplest, the information appearing on the computer's monitor is projected onto the screen. The presentation itself may contain text and images, including photographs, illustrations, tables, spreadsheets, and graphs. The images, which may be created with other applications or may be downloaded from the Internet or other media, are easily inserted into PowerPoint. Written material is simple to enter, arrange, and edit, commands being similar to word processing software. Presentations can be set up and run according to a timed sequence, or they can be manually controlled by use of a mouse. Once they understand the basics of the program, both high school and middle school students will find a PowerPoint presentation to be relatively easy to create and present.

PowerPoint presentations provide an organized visual as well as auditory learning experience and are particularly suited to sharing the results of a math project. Rather than simply reporting their findings to the class, students can present their results in a meaningful manner using PowerPoint.

Interactive Whiteboards

Interactive whiteboards have been in use since the early 1990s. Models today, also known as electronic whiteboards and digital whiteboards, encompass a whiteboard (which is an electronic display), a computer, and a digital projector. A basic interactive whiteboard system enables its user to create, arrange, and manipulate data on the electronic display. Typical features include:

- Writing over information or objects displayed on the board
- Moving objects
- Rotating objects
- Resizing or recoloring objects
- Inserting backgrounds or images
- Saving files
- Sharing files
- Changing to the next screen when used with PowerPoint

As the original whiteboard technology has advanced, the software and interplay of the equipment have become seamless and relatively easy to use. Interactive whiteboards can help make the presentations of the results of math projects appealing and interesting.

Technology Training

While many, if not most, of your students will likely possess general computer skills, you should assume that most of them will not have had much experience with applications such as Microsoft's PowerPoint or interactive whiteboards. Yet this technology can support and enhance the work of your students on math projects. Incorporating it in your program offers significant benefits. Not only will your students learn the skills necessary to use the equipment, but they will be able to share ideas in an effective and interesting manner.

If your school has a computer specialist who works with students, meet with her and discuss the needs of your students. Perhaps she can incorporate the use of PowerPoint and interactive whiteboards in her instructional program. If your school does not have a technology or computer specialist who works with students, you must provide your students with the training they need to incorporate the use of such technologies with their project work. This is not as difficult as it may sound.

Although you need not be a technology expert, you should be familiar enough with the equipment so that you can demonstrate its basic use to your students. If necessary, ask the tech person at your school to show you how to use the equipment and software. Do not overlook the fact that most technology comes with tutorials that can show you the basics, and many vendors offer free technical support.

If you have the equipment in your classroom, set aside a period or two to provide students with basic instruction. If you do not have the equipment in your classroom, perhaps your school has a computer room or a section of the library in which computers containing PowerPoint or interactive whiteboards may be used. Reserve the equipment, and demonstrate its use to your students.

Start with a general overview, explaining the purpose and benefit of the equipment. For example, PowerPoint is an excellent tool for sharing the findings of a group, particularly if the presentation is to be done in a slide show format. If the presentation requires that images and information need to be moved or highlighted, the use of an interactive whiteboard may be more practical.

Guide students through the basics, explaining and demonstrating the most important commands. You might then have students come up in groups for more specific instruction. Base the amount of detail of your instruction on the abilities of your students. For most students, advanced commands are unnecessary. Approach the use of technology as a learning experience; there is no need to try to do more than students can comfortably manage.

Many students today are computer savvy and are able to learn the operations of new equipment quite readily. Consider organizing students into groups in a manner that places one or two technically inclined students with some whose technical skills may be weaker. The students with technical skills will take the lead with technology, reducing any anxiety other members of the group might have in regard to working with the equipment. Monitor the groups closely to ensure that the less technically minded do in fact gain experience working with the equipment and applications.

When it comes time to create a presentation of the results of project work, encourage students to work in school as well as at home (provided they have compatible software, which in many cases they will). They should save their material on a disk or CD, which they will then be able to use on the equipment in class. *A word of caution:* whenever students are bringing disks or CDs from home, using disks or CDS with computers in other classrooms, or even e-mailing files from home to school, the chance increases that your equipment could become infected with a computer virus. Always maintain updated virus protection software.

Depending on the abilities of your students, you may find it practical to work with individual groups as they set up presentations in the class. You can provide the guidance students will need when using equipment for the first time. Note, however, that not every project needs to culminate in a presentation using PowerPoint or an interactive whiteboard. To manage the workload, consider limiting major presentations to two or three groups per marking period. This permits you to spend more time with the groups. Keep track of the groups so that by the end of the year, everyone has a chance to use technology in their projects.

Math Projects and the Internet

The Internet contains thousands of Web sites devoted to mathematics, ranging from the history of math and basic operations to calculus and imaginary numbers and beyond. While some projects in this book have a specific technological

component, for example, Project 25, "Rating Math Web Sites," Project 55, "Maintaining a Class Math Web Site," and Project 56, "Selecting a Sound System Using the Internet," many others require extensive use of the Internet for investigation.

Searching the Internet for Math

Because of the vast number of Web sites available, it is necessary for students to understand how to conduct practical searches of the Internet for math topics. Being able to search the Internet for information is an essential skill that will be useful for students far beyond math class.

Unless a person knows the Web address of a particular site (called its URL) that is likely to provide the information he seeks, he will have to conduct a search to find relevant information using a search engine, a sophisticated program designed to find information on the World Wide Web. Some of the most widely used search engines are:

Google	www.google.com
Webcrawler	www.webcrawler.com
All the Web	www.alltheweb.com
Alta Vista	www.altavista.com
Ask Jeeves	www.ask.com
Excite	www.excite.com
Lycos	www.lycos.com
Yahoo!	www.yahoo.com
Yahooligans	www.yahooligans.com

You can find more search engines at www.allsearchengines.com.

One of the best search engines for students, especially those in middle school, is Yahooligans. Yahooligans, a special part of Yahoo! is designed for young people. Instruct your students to go to the site and click on School Bells, then click on Math. A list of some of the best math sites for students (as determined by Yahoo editors) will be displayed.

If you would like to find more math Web sites, do a general search with one of the other search engines, for example, using the search term "math for students," and numerous sites will be offered.

Using Search Engines Effectively

The best search engine is only as effective as the precision of the search terms used. General search terms yield general results. They can result in so much data that the person searching for information finds it difficult, if not impossible, to locate the information she needs. Offer your students an example. Suppose a student is searching for information about quadrilaterals, a topic in geometry. If she searches using the term *geometry*, she will be presented with close to 2 million Web sites (we were when we conducted this search), all of which will provide information on geometry but not necessarily quadrilaterals. If she focuses her topic on quadrilaterals, she will be offered about twenty thousand Web sites,

most of which are likely to offer information on her topic. Twenty thousand sites is still an unwieldy number, but 2 million is *a lot* more, and students will grasp the point of the example. Moreover, since most search engines list the most popular Web sites first, the chances of finding useful information with the first few hits are increased.

The following suggestions can make researching on the Internet more effective:

- Enter precise search terms and words.
- Use single words or precise topics when possible.
- Be specific. "Pascal's triangle" is more specific than "triangles," for example.
- Enter multiple spellings of words when applicable.
- If the search engine you are using offers guidelines for searching, be sure to follow its instructions.

Another search option is to check online encyclopedias. Although encyclopedias typically provide somewhat general information, many also offer links to other Web sites for the topic. These sites often contain specific information.

Using search engines effectively will enable your students to find information on the Web that can support them in their work on math projects. Understanding how to access information the Internet contains is a valuable skill that extends well beyond math class.

Conclusion

A math class in which students are actively engaged in working on projects appears on the surface to be quite different from a traditional math class. However, a close look shows that these seemingly different models have much in common. In both, students are learning math, discipline is necessary, and motivation is crucial. In the traditional math class, however, students sometimes fail to recognize the far-reaching importance mathematics has in our lives. They do not realize that math is just about everywhere. Math projects demonstrate to students that it is. Projects not only show the connections of math to other subjects but offer students the chance to incorporate various skills, strategies, and methods in finding solutions to meaningful problems.