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Integrating fractions into a constructivist classroom

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INTEGRATING FRACTIONS INTO A CONSTRUCTIVIST CLASSROOM

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
in
Interdisciplinary Studies: Integrated Studies Option

by
Lorelee Ann Greek
September 1997
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ABSTRACT

The research problem for this thesis was to find an effective way to integrate fractions into an elementary constructivist classroom. Effective was defined as producing a result of having most students learn and remember most of the fraction concepts appropriate for their grade. The classroom had to be not quite as constructivist as is ideal, since the Fontana Unified School District, where this unit was tested, requires that all students take a test at the end of each unit. It therefore requires that a set curriculum is taught and does not allow the freedom desired in a truly constructivist classroom.

A constructivist classroom is one where the teacher works as a facilitator and motivator and the lessons are student generated or modified. A facilitator helps the students find information, solve problems by giving hints rather than a set of rote steps to be memorized, and provide assistance as students require it. This is a much different role for the teacher and means breaking the old habits of lecturing and knowing what is best for everyone. The lessons are structured to specifically provide necessary and challenging activities for the students as individuals, groups, and a class. Constructivist teachers first find where their students are in a subject. This will give
teachers an idea of what misconceptions they need to address, as well as which students have attained some of the objectives of the unit. Then they ask students what kind of activities they want to accomplish. So constructivist lessons are a combination of student input and teacher generation, which bring misconceptions into conflict.

Student-led discussions are used in constructivist classrooms rather than lectures. Discussions are student-led, and include problems and solutions. Teachers can add questions, but usually try to avoid providing answers. If students can not find an answer to a problem in one day, they may bring home their problems to others at home or do further research after school or the next day in class. Longer assignments are more representative of real-world situations that they will encounter as they grow up.

The unit was tested by a teacher who was in the fortuitous situation of teaching three third grade classes of mathematics a day with a short break between classes, so that modifications could be made as needed to the assignments or lesson plans and then immediately implemented. Since these lessons were only implemented by one teacher, they also were given to two respected people in the mathematics field of education with master’s degrees and to Dr. Robert London, a mathematics professor at the
California State University, San Bernardino campus to look over and make suggestions. Suggestions were incorporated into the project.

A pretest and posttest were administered to the students and they showed improvement. There was not the degree of improvement that was expected. Several possibilities may account for this: 1) The number of mathematics tests given the last quarter of the year. The project posttest was one of the last ones given this year; 2) It was administered two weeks after they had completed the unit; 3) It was very near the end of the school year and they were not as focused on the test as desired; 4) Some of the students were absent or out of class for the usual music or resource classes one or more days a week.

Beyond the reasons stated above there may not have been the improvement that was expected, since the pretest and posttest were very difficult and might be better suited for fourth or fifth grade students. The expectations may have been too high for students during their first real introduction to fractions. As stated by the National Council of Teachers of Mathematics (NCTM, 1989), it is more important that students develop a general knowledge of the concept of fractions than to be able to compute with them at the elementary level.
There was a marked improvement in passing scores on the very difficult district required test from the first class of the day to the last class. Even considering that the last group had more potentially gifted students the increase was dramatic. Twice as many students in the second class of the day passed with seventy percent or higher than the first class of the day. Yet the third class of the day had four and a half times as many students who passed with a score of seventy percent or higher. This was a significant increase in scores.
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INTRODUCTION

The purpose of this project is to find an effective way to integrate fractions into an interdisciplinary classroom. The Fontana Unified School District requires that their teachers teach one-and-a-half hours of mathematics and an equal amount of language arts daily. Also, the state of California requires that teachers teach 120 minutes of physical education each week. Following both guidelines leaves little time for science, social studies, the visual and performing arts. An efficient way to work within the guidelines is to integrate the curriculum from these areas into mathematics and language arts.

Fractions were chosen since they have been one of the most difficult mathematics concepts for students to conceptualize (Behr, Harel, Post, & Lesh, 1992). In 1989, Langford stated that fractions were one of four concepts that were especially important for teachers to help elementary school students understood. Children have developed a limited amount of informal knowledge or intuition about fractions and often generalized whole number concepts to fractions as evidenced in a research study by Mack (1995). Although there has been a lot of research on students’ knowledge of fractions, there has been only a small quantity of research on the actual teaching of
fractions, especially in the classroom.

This curriculum project is designed to include the Fontana Unified School District curriculum and prepare students for the district required assessment. The district curriculum requirements are that students can label, compare, and sequence fractions using graph paper models and fraction strips. The district also requires that third grade students be able to draw fractions and realize that the amount represented by a fraction depends on the size of the whole. The district then requires that each student take a four page test with seventy percent covering these requirements and the remaining thirty percent is a variety of computational problems similar to the Iowa Test of Basic Skills (ITBS), yet unrelated to fractions. The fraction part of the test has a free response page that accounts for forty percent and it requires that students answer in written form and provide illustrations to support their responses. The remaining thirty percent is written in the form of multiple choice questions. The lessons in this project will prepare students for this district assessment.

In this project you will find the following: a review of research in the areas of general mathematics, fractions and constructivism, and a curriculum guide for teaching fractions in a constructivist classroom. The research forms
a base for my modifications of the Addison-Wesley Quest 2000 third grade lessons.

In a true constructivist classroom lesson plans are difficult or impossible to do in advance, but since the Fontana District has required their teachers to give the same test to all students this test has to form the basis of the lessons. So sample lessons have been included to demonstrate how suggested changes to a mathematics curriculum can be made. The lessons are based on Addison-Wesley's third grade Quest 2000 series activities. To make them accessible to a wider range of teachers I have suggested challenge activities as regular activities for fourth and fifth grade students and I have made modifications in the difficulty of many of the lessons so that they can be used in kindergarten through second grade, as well. Whenever possible, reasons for changes to the Quest 2000 series will be included to show which research or what classroom experience recommends these modifications.

Constructivist classrooms encourage even more lesson plan modifications, as many of the lessons or activities are coordinated with the students' interests, needs, and misconceptions. Examples of students' desired knowledge, prior knowledge, misconceptions and questions are included in the appendix.
Constructivist and recent mathematics theories are mentioned in the curriculum guide to suggest general methods for teaching and to demonstrate the importance of particular fraction concepts. An example of a new teaching method is Bohan’s (1990) concept of “free rides” which is a form of piggy backing on others’ ideas or hints to come up with student devised algorithms.

The importance of building on students’ informal knowledge (Behr et al., 1992; Mack, 1995; NCTM, 1989) and letting them guide the lessons can be found in the literature review. Integrating literature is another method which helps students build on their informal knowledge. “When students have worked with the manipulatives (tactile), seen illustrations in books (visual), and talked about the relationships (auditory), their definitions will contain specific examples instead of simple repetitions of the definitions stated by the teacher” (Conaway and Midkiff, 1994, p. 431). This also highlights the fact that students are using various intelligences in these and similar activities, as suggested by Gardner (1983).

The goal of this project is to find a way to teach all the students so that they improve their knowledge of fractions. The project includes a test to give before and after the unit to indicate student progress. It also
outlines lessons to help students grasp fractional concepts through the use of manipulatives, group work, journals and problem solving in real world situations.

The real world situations should help students recall what they have learned. At the end of this unit students should be able to make up their own fractional story problems to demonstrate that they have understood what they have learned and know how to apply it to real life situations.
LITERATURE REVIEW

Learning fraction concepts is a major problem in children's mathematical development. Yet, there is no agreement on how to facilitate learning fraction concepts (Behr, et al. 1992). D. Kerslake (1986) discovered that of the 15 middle school children who participated in her research project, all of average ability, only one could locate 1/2 on a basic number line. Most of the students in her study thought of 1/2 as half of the line, even after clarification from the interviewer. Hence, there is a need to understand how to teach fractions in a more effective manner.

This review offers a description of the research in mathematics education related to the teaching and learning of fractions, followed by the prerequisites for learning fractions, students' prior knowledge and fraction activities suggested in current literature. Finally, the concluding section discusses current trends in constructivist teaching and brain-based learning to better prepare students to work in the 21st century.

Fraction and Mathematics Theory and Research

The National Council of Teachers of Mathematics (NCTM) and others offer several general strategies which enhance
mathematics learning. The NCTM (1989) recommends giving more attention to: using manipulatives, working in cooperative groups, having students prove their methods, writing about math and solving problems (p. 20).

Manipulatives can facilitate concept acquisition. A conceptual method of teaching mathematics makes it easier and faster for the students to understand, recall and actually learn computational skills. To apply those skills one needs to consider decalage. Brooks and Brooks (1993) say, "decalage refers to the gap between an individual's use of a cognitive structure in one domain and lack of immediate transfer of that structure to other domains" (p. 71). For example, a child can cut a candy bar equally in half because it has a line down the middle of it, yet the child may not be able to equally divide a candy bar without a line down the center. One way to improve generalization and decrease decalage of fractions is to use a wide variety of manipulative activities as suggested by Robert Ashlock (1994). It is much more important at the elementary level to develop a concept base than it is to develop the actual skills (NCTM, 1989). Coker and Cook (1992) agree and emphasize the fact that upper elementary teachers have to remember that their students profit from the use of manipulatives and concrete models, as well as the younger
students. Coker and Cook also say that the circle model is the most commonly used whole model to represent pizza. For students who do not like pizza it can be used to represent a cake or pie. Simulated or representational food and money make excellent manipulatives that pique students' interest and motivation. Manipulatives can be used individually, in pairs, or in cooperative groups.

Collaboration is essential to working efficiently in cooperative groups. The Mathematics Curriculum Framework and Criteria Committee in 1992 notes that collaboration is indispensable to fully participate as a citizen and to work with others at one's place of employment. Brooks and Brooks (1993) similarly advocate having a chance to express one's ideas, listen to others and to reflect on both. Cooperative groups can actively involve children in problem solving. Collaborative or cooperative groups help students understand different ways to solve a problem, as the students listen to and consider each others' strategies and methods (Mathematics Curriculum Framework & Criteria Committee). They also report that conducting activities in a group is more fun than working independently. Therefore, the students in a group spend more time on the activities and can accomplish more difficult tasks than they could individually. Students also build their mathematics
communication skills faster by interacting in small groups, which offer more opportunity to talk and be heard than do large group settings.

This increase in communication skills along with a better understanding of different ways to solve a problem help students become more open-minded and better at justifying and explaining their solutions. It is important to have students prove their own methods, since sometimes they can get a correct answer with an incorrect method (NCTM, 1989). They can prove their method with manipulatives, drawings or representations, orally or in written form. It is important for the teacher to check students' methods, so they can intervene when necessary. Sometimes the students may not understand a word in the problem or misunderstand a question. However, at other times, when there is a serious misconception at work, the teacher can help students having problems with the concepts, while others are in "interest groups" learning about the specific uses of a mathematical concept, in which members of these groups all have a common interest. Brooks & Brooks (1993) suggest individualized labs constructed at the student's ability levels. Alternately the Mathematics Curriculum Framework and Criteria Committee (1992) recommend helping students with concepts before and after school, as
well as during track breaks or vacations.

To ascertain which students need help consider writing one process to discover how a student derived his or her answer. Journals can have the students reflect on what they learn and how they feel about it or respond to a question the teacher poses. Children can write letters to friends or younger siblings about how to do a particular mathematical problem. Concrete maps (like webs in writing) and flow charts can also show the steps or procedures that were followed (Ashlock, 1994). The students can then trade and check each others' work on the letters, concrete maps and flow charts by seeing if all the steps and necessary information are in the paper.

Writing assignments involving comparing and contrasting methods or concepts can also be given. Children can write their own story problems similar to the ones they have done, including their own experiences or stories and give them to their peers to solve (NCTM, 1989; Brooks & Brooks, 1993). Solving peers' problems can be a great motivator. Then these problems can be made into a class book. All too often writing has been left out of mathematics and students cannot explain how they arrived at the answer. Writing is a very important skill for workers, and it will be even more essential in the 21st century, as technology becomes more
Problem solving is another skill which will be more essential for employees in the 21st century. In fact, the NCTM (1989) says that most mathematics curricula should concentrate on problem solving. To explain this, the NCTM says the following:

When problem solving becomes an integral part of classroom instruction and children experience success in solving problems, they gain confidence in doing mathematics and develop persevering and inquiring minds. They also grow in their ability to communicate mathematically and use higher-level thinking processes (p. 23).

To solve problems where the divisor is larger than the dividend (ex.: \(4 \div 7\)), Kerslake (1986) found that the students did about twice as well when it was in the context of sharing some candy bars versus the equation form. The NCTM recommends that algorithms come from problem situations. Battista (1994) says that teachers need to try to find ways to guide students in groups to find their own solutions to problems versus giving them the set of steps to solve the problem. Burns (1994) agrees saying that following set steps distracts students' attention from the problem to the steps and that the children lose their understanding of the situation. When introducing fraction concepts, as well as other math concepts, the NCTM (1989) suggests activities which draw on students' personal
experiences or intuitive knowledge and use oral language. The NCTM also recommends utilizing the following problem solving strategies: using manipulatives, using trial and error, making lists or tables, drawing pictures, looking for patterns, and acting out the problems.

**Fraction Activities**

This section begins with a description of prerequisite activities for optimum understanding of fractions, followed by a synopsis of students’ prior knowledge, which they acquire mostly outside of the classroom, and methods teachers may use to build on it. Finally, it goes into activities and assessments suggested by various mathematics teachers.

In terms of the prerequisites there are a lot of sources (Behr, et al., 1993; Pothier & Sawada, 1990; NCTM, 1989) which state the importance of teaching both quantitative and partitive division before fractions. Quantitative division asks how many groups the size of the divisor are in the dividend (Ex.: think of $25 \div 5 = $ as how many fives or groups of five are in twenty-five, as in the number of nickels in a quarter). Use partitive division to divide the dividend into the divisor’s number of groups (Ex.: think of $25 \div 5 = $ as dividing twenty-five into five
groups, usually doling out one at a time, as when sharing 25 candies among 5 people). Teaching partitive and quantitative division not only prepares the students for fractions, but it also follows current mathematics theory by demonstrating two ways to solve one type of problem as suggested by the NCTM (1989). Introduce problems requiring partitive and quantitative division, since partitive and quantitative division is often not in a child's informal knowledge.

Much of current literature on teaching mathematics (Mack, 1995; Brooks & Brooks, 1993; Behr et al., 1992; NCTM, 1989) speaks of building on students' intuitive or informal knowledge. Students gain most, if not all, of their informal or intuitive knowledge outside of the classroom through sharing and other activities.

Mack's research revealed that students can use their informal knowledge to identify and compare fractions when the names of fractions are stated as "one of three pieces" instead of "one-third" (1995). Conaway and Midkiff (1994) similarly suggested saying "'one part of four' or 'one of four equal parts'" (p. 430-431). The latter was more precise. Mack (1995) introduced symbols to go with real-life problems, with which the students are already familiar to build on or add to their informal knowledge. Some
problems with building on informal knowledge were encountered, as evidenced by Mack who wrote "I documented that students did not always readily relate symbolic representation to their informal knowledge, especially when they possessed prior knowledge of rote procedures" (p. 424).

Steffe and Olive (1990) similarly say that it is not adequate to learn about students' informal knowledge, but that it is also essential to determine how students construct fractions at school. Steffe and Olive divide fraction knowledge into several conceptual levels, in which students need to master one level before they can achieve mastery at the next level. At the "prefractional concepts" stage students can tell that one of four items is one-fourth, yet the children can not figure one fourth of eight items. At the part-whole level the students can find the whole given two-thirds of the whole. Langford (1989) says that this concept is hard to comprehend and solve for most children under the age of nine or ten. Steffe and Olive say that students with the part-whole concept are ready to compare equivalent fractions. Yet Coker and Cook (1992) disagree and say that students can be introduced to equivalent fractions as soon as they have the basic concepts of fraction identification and labeling. Steffe
and Olive and others state that partitioning shapes which have already been partitioned is imperative to the understanding of equivalent fractions. They also say that we need to go beyond what the students know and can accomplish to what they are thinking and how they are conceiving their answers.

It is important to know how students conceive of their solutions, since part of students’ informal knowledge is incorrect and contains misconceptions about fractions. To deal with them a teacher needs to first discover what the misconceptions are and then structure the lessons to teach to those misconceptions or provide activities that cause their beliefs to come into cognitive conflict. The main misconception experienced by students is that they confuse fraction and whole number concepts. When this happens, students think of the numerator as the number of wholes and the denominator as the number of parts of each whole (Mack 1995). For example, with the fraction three-fourths they would think of three wholes each divided into fourths. This means that extra time needs to be spent on the meaning of the denominator and numerator before proceeding to more complicated operations.

Students also often have a similar problem with the denominator in addition and subtraction problems causing
another common misconception. In this misconception the students add or subtract the denominators, as if they represent quantities of parts instead of the size of the parts. So if they are adding \( \frac{1}{2} + \frac{1}{2} \), then they get \( \frac{2}{4} \) as the sum. This kind of mistake is very common when working with unit fractions (Hiebert & Behr, 1988; Kerslake, 1986). Unit fractions are fractions with a one as the numerator. Langford (1989) states what may be best for these students as follows:

> We may find that the best course for children who experience difficulty is either to learn the rules for adding fractions by heart after a few pictorial demonstrations, or to delay teaching of operations on fractions until the secondary school. (p. 149)

The idea of just providing pictorial demonstrations does not lend itself well to the current emphasis on using a variety of manipulatives to teach mathematical concepts (NCTM, 1989). The teaching of the rote rules could also prove more detrimental than beneficial, if we are to believe that memorized rules actually interfere with attaching school knowledge to intuitive knowledge and the ability to solve problems as suggested by Battista (1994) and Burns (1994) respectively. Watch for students who add or subtract denominators and try to help them better understand the concept before they practice it incorrectly.

Children sometimes have another problem. It involves
the number one and the way that it uniquely applies to fractions in such a variety of ways. Children need to form new ideas of the number one. When working with fractions one is a unit which can be divided into equal parts (NCTM, 1989). To find equivalent fractions, one or both of the fractions are multiplied by a fraction equivalent to one. One is also formed by multiplying a number by its multiplicative inverse. An example of this is \( \frac{1}{4} \times \frac{4}{1} = 1 \). Kieren (1993) also found that students may be familiar with one-half before they start school and that unit fractions (fractions with one as the numerator) are easier for younger students to conceptualize. Once teachers have determined what their students know, teachers are ready to proceed to activities which draw on the students intuitive or informal knowledge.

These activities are to supplement fraction units. Partitioning activities are felt to be lacking in most fraction units. They are essential to a thorough understanding of equivalent fractions. A couple of similar alternative methods of equivalent fractions are suggested. Estimation tasks related to fractions will be introduced, as well. Activities which relate fraction operations to operations on whole numbers will also be addressed. Ott (1990) suggests that this makes it easier for students to
comprehend that fractions are numbers, which is a true concern of Kerslake (1986). Two basic ways to multiply fractions will also be introduced in these activities. Literature and other curricular connections, which can enhance a fraction unit, will also be mentioned. Most of the activities mentioned in this section vary widely from textbooks of the past and somewhat from current textbooks.

One major complaint about textbooks is that they do not give the students enough opportunity to partition their own shapes. All too often the book and accompanying worksheets have prepartitioned pictures. This makes it more difficult for children to show fractions without relying on symbols (Pothier & Sawada, 1990). Pothier and Sawada write that this is a problem since the students do not learn to find the center or radii of a circle, which is necessary to show thirds and other fractions on a circle. Students should be provided an opportunity to partition a variety of shapes. It is also critical that students learn to partition already partitioned shapes to prepare them for working with equivalent fractions (Steffe & Olive, 1990).

Pothier and Sawada (1990) and Goetz and Harris (1996) suggest that partitioning is introduced with paper folding with different shapes and finding different ways to make one-half and one-fourth. This could be part of a science
or mathematics lesson on symmetry or quilting. L. May (1995) and Charles et al. (1995) in the *Quest 2000* series suggest using pattern blocks or power polygons respectively to show that there are different ways to find equivalent fractions and that all halves and other fractions are not equal to other fractions with the same name. Pothier and Sawada (1990) suggest finding various ways to partition the same shape and making a chart to display the results. Coker and Cook (1992) say that typically equivalent fractions are introduced with equal sized strips of paper divided by lines into different fractional parts.

Beyond partitioning, dividing or partitioning an already partitioned shape is an even higher level skill, which fourth grade students should be able to accomplish. This helps students comprehend equivalent fractions. For upper grade students May (1992) and Coker & Cook (1992) suggest similar alternate methods to find equivalent fractions for uncommon fractions. May uses strips with multiples of numbers from two through nine, while Coker and Cook use a multiplication table with unused rows covered or folded back. To find the fractions equal to three-eighths use the three and eight multiple strips or rows. If you want to find how many forty-eighths are equivalent to three-eighths, then follow the denominator or eight strip
or row to forty-eight and look at the corresponding number on the three piece. To find the greatest common factor of the new fraction (18/48) look up to the top number on the multiplication chart, as suggested by Coker and Cook.

Finally Pothier and Sawada go one step further to what they call "dissection motion operations" where you cut a square or other shape apart and then put it together to make another shape (this would be a great connection for upper grade geometry).

Another complaint, which is brought up by Kerslake (1989), about textbooks is that the majority of the pictures illustrate fractions as parts of a whole rather than as parts of a set. Hiebert and Behr (1988) agree with Kerslake saying that children need to work with both continuous quantities, such as wholes, and discrete quantities, such as parts of a set. Charles et al. in Quest 2000 does not have many activities, or pages using fractions with discrete quantities. Pothier and Sawada (1990) write that the ability to show fractions with manipulatives or pictures helps students solve fraction problems and check answers to equations.

There are several books that teachers can use or get ideas from about how to use food as a manipulative to teach fraction skills. One of those books is Gobble Me Up by
Mogard and Mc Donnell. It provides some excellent suggestions about methods to teach equivalency, addition and subtraction of fractions, and fractional parts of sets. AIMS books, especially *Fun with Foods* is another excellent source of food activities which teaches students about equivalent fractions, different ways of adding to make wholes and so much more. May (1994) suggests making simple recipes in the classroom. Conaway and Midkiff (1994) also suggest utilization of small foods to show parts of a set.

Food can be useful in the introduction of operations.

Estimation is one method students can use to verify their answers. Estimation, which is stressed in all areas of mathematics (NCTM, 1989), can be utilized by having students figure which whole number a fraction or mixed number is closest to on a number line (Ashlock, 1994).

This is one excellent example of how measurement can be integrated with fractions. The NCTM (1989) also states that "measurement is a natural context in which to introduce the need for learning about fractions and decimals, and it encourages children to be actively involved in solving and discussing problems" (p.51). Metric measurement is very easy to divide into fifths, tenths, hundredths, and, of course, halves. The correlation between fractions and decimals can also be
easily introduced with the metric system.

Ott (1990) brings up a good point that when we teach basic multiplication in elementary grades we talk about "a groups of b" for \(a \times b\), yet when we get to fractions we use "of" only when multiplying two fractions and not a whole number times a fraction. To use his method have students use manipulatives or drawings to do the following: (1) To use "of" he suggests starting with unit fractions, such as \(\frac{1}{3}\) of \(\frac{3}{4}\). (2) Then he suggests proceeding to nonunit fractions, such as \(\frac{3}{4}\) of \(\frac{4}{5}\). (3) He also recommends applying the concept of repeated addition to fractions when multiplying with a mixed number, or obviously a whole number. To do this, one can use problems similar to \(3 \frac{1}{4}\) of \(\frac{4}{5}\). This will enable them to see the connection between the two kinds of multiplication. Also, he suggests pictures of real items to solve real world problems.

Literature can illustrate real life situations in which fractions can be utilized. Conaway and Midkiff (1994) suggest using pieces of literature such as The Doorbell Rang by Pat Hutchins to demonstrate uses of fractions. They suggest having the students use manipulatives (such as paper cookies, actual cookies, or popcorn) to represent the cookies that are shared in the
book. Many of these books like *The Doorbell Rang* would also provide a great introduction for having the students in groups or individually write and illustrate their own books about how fractions can be used. More literature books, which have correlates to fractions, are provided in the appendix. Literature is one subject area which offers a lot of connections to fractions.

Physical education is one subject area that provides a limited number of connections. To make teams it is imperative to have equal or almost equal fractions of people on each team. For an activity one can have the students see how quickly they can get into various numbers of teams or teams with different numbers of players (Conaway & Midkiff, 1994). Then the class can play a game with one of the newly made teams. A few sports also have quarters, half time and other fraction related terminology. Also some sports, like gymnastics, have scores recorded in decimal fractions. Playing or doing any of the last two sports would be a great way to show the relationship between sports and fractions. There are a variety of ways to utilize fractions with physical education.

**Current Trends in Constructivist Thinking**

High school students, as well as teachers today
realize the need for a change in teaching methods. Teachers are taking on roles more similar to facilitators than instructors, especially with so much technology and information that students can easily access on their own. Constructivist thinking is part of that change; constructivism encourages children to be more responsible for what they learn and how they attain their goals. This is supported by brain-based research of the past five years pertaining to how students learn, which can be applied to the classroom. As Langer (1989) advocates, teachers promote mindfulness in their students, since it makes them more open to other students and their ideas. Gardner’s theory of multiple intelligences (1983 & 1993) is employed in the classroom. Today’s constructivist classrooms differ drastically from classrooms of the past, but most specifically in the changed roles of the teacher and students.

Students advocated this change in roles, as shown by the 1993 Johnson & Henstrands study, which had students interviewed to see why they failed a class. This was done at a high school in Beaverton, Oregon. Even though the interviews were done with high school students, the results can easily be applied to elementary classes. The students suggested the following as ways to improve teaching:
variety of teaching methods, including group work, some choice in assignments, hands-on activities, extracurricular activities, integration of various learning styles, and fewer lectures.

Students also wanted teachers to create an atmosphere in which student work was valued and students were encouraged to contribute in class. Teachers who were the most valued were ones who cared about their students, felt their students were capable of succeeding and that the education they received was important. The students found course work more relevant when teachers accomplished the following: made connections to the real world, were aware of chances to build students' self-esteem, provided an atmosphere in which students understood their own impact on their education and lives, utilized more problem solving and assigned less unnecessary seatwork. Most of the things that the high school students wanted could also be provided in an elementary classroom.

The majority of changes that the high school students recommended are ones that happen daily in a constructivist classroom. Brooks & Brooks (1993) suggest the following basic constructivist principles be followed in classrooms: 1) that relevant real world type problems be posed, 2) that learning is organized around basic concepts, 3) that
student viewpoints and ideas are sought and valued, 4) that curriculum is modified to teach to students' misconceptions, and 5) that students' learning is assessed in the context of their learning. These principles form an essential base for a constructivist classroom and its success.

One important way to ensure success is to ascertain what students want to learn about a concept before starting a unit (Gardner, 1993). Then it is useful to find out if the students have activities related to the concept in which they would enjoy participating. Letting students know that they are responsible for their own learning will help them be responsible later in life; responsibility being a very useful skill when they go out and look for a job. Employers will want employees who can be trusted to take charge when needed, yet be able to work and communicate with a group on other projects and as an individual on some assignments. Creativity will also be a valued skill and part of that skill will include being open-minded and considering all possibilities for an assignment (Caine & Caine, 1997). When teachers promote mindfulness (Langer, 1989) in their students it makes them more open to others and their ideas. Making students responsible for what they learn about a concept and the
method they want to use is an essential part of preparing them for the future.

Educators need to look at brain-based learning to best help students prepare for their future. Brain-based learning is based on brain research. Brain-based learning stresses that learners are active participants in their own learning (Caine & Caine, 1997). Gardner (1993) also advises actively involving students in learning. According to Caine and Caine there are twelve brain/mind learning principles which affect how one learns.

The first two principles deal directly with how the brain works and how it can be affected. Principle one is the most important principle which states that the brain is somewhat ubiquitous as it does everything, instead of being everywhere, at once. Caine and Caine (1997) say the following about how the brain functions: “thoughts, emotions, imagination, predispositions, and physiology operate concurrently and interactively as the entire system interacts and exchanges information with its environment” (p. 104). Principle two says that our brains and learning are profoundly influenced by social interaction with others. Gardner similarly defines intelligence as being “biopsychological,” which means that genetics may limit the upper limits of potential, yet psychology may affect the
development of one's potential. The brain can do a great variety of things simultaneously, yet it can also be affected by social interactions.

The next two principles tell specifically how the brain searches for and stores meaningful information. Principle three says that everyone is born with a desire to look for meaning. Caine and Caine say that the mind looks for knowledge about a wide variety of things including, but not limited to: basic needs, interpersonal interactions, self esteem, personal capabilities and the desire to discover new information, as insights or "ahas." The fourth principle says that meaningless information is not stored where it can be retrieved easily unless the mind can discover a connection to other information stored in the brain. Therefore, it is suggested that teachers give students a chance to discover their own individual and unique patterns for making connections and remembering what they learn. Caine and Caine say that teachers can work with the fact that people are born with a desire to learn and that what one learns is uniquely stored by connecting it to each individual's knowledge and that teachers can help students find those connections.

An educator can help students with the last two principles, as well as the next two. Principle five says
that not only does learning affect emotions, but emotions affect what we learn. “Ahas” are one good example. They can affect someone for a very long period following the actual experience. The sixth principle says that brain concurrently takes in a whole experience and breaks the information into parts. As Armstrong (1994) says “the educational value of metaphor lies in establishing connections between what a student already knows and what is being presented” (p. 73). Both of these principles can be enhanced by teaching using metaphors that make learning experiences easier to recall.

The next two principles relate to the unconscious and conscious methods of learning. Principle seven states that the brain is aware of the unconscious, as well as the more obvious, signals we give. Therefore teachers and others need to be extremely careful about how they may unconsciously express their attitudes and beliefs. The eighth principle says that the brain processes many sensations and experiences at an unconscious, as well as the conscious level. This process can take from hours to days, as an “aha” or an insight of the Gestalt often occurs quite awhile after the experience. The “aha” can provide an individual with both the energy to implement the change in behavior and the excitement necessary to continue the
new behavior. Teachers can facilitate this process by bringing the process to a conscious level by providing students with opportunities to reflect, and creatively add to concepts, skills and experiences. This can be done through mindfulness (Langer, 1989), which keeps them concentrating on the task at hand and exactly how it is to be accomplished. Teachers need to remember that learning can be influenced by unconscious signals and learning from experiences can be improved by giving students reflective assignments.

Teachers also need to realize that memory is stored in two different ways and that developmental levels do affect when one will find it easiest to learn specific skills and concepts. Information is stored as either meaningless or meaningful. The meaningless knowledge, which is stored in individual parts, is most easily recalled for a reward. Meaningful information is remembered by novelty and is stored and recalled holistically, as an entire experience. Even if a portion of the memory is not recalled immediately, people can go back and reenact the experience. They remember not just the information, but also the steps utilized in learning it and its importance in the real world, if they were in the original experience. The ability to store meaningful experiences seems to be always
engaged and inexhaustible for new and exciting experiences. Even though learning is shaped by personal experiences, the tenth principle says that there are also some inborn sequences of development and times when people pick up certain concepts and skills more quickly and efficiently. Gardner (1993) states that one should consider these when devising tests, as well as lessons. Having the basic skills required for specific kinds of learning at an appropriate young age will make the ability to learn more in that area almost limitless in the future. Consideration of how learning is stored in memory and understanding that basic knowledge in specific areas learned early in life will help ensure ease of future growth in those areas which can help a teacher plan when and how to teach specific skills.

Teachers can also encourage or discourage learning by challenge, threat or a lack of variety of learning experiences. Principle eleven stresses the importance of an environment promoting relaxed alertness with a low feeling of fear or threat and a high, yet appropriate, level of challenge. This agrees with Gardner's definition of intelligence being part biological and part psychological or that it is influenced by one's reaction to one's environment. Principle eleven also acknowledges that
we all have to go through a feeling of threat, as our beliefs are called into question before we can revise or change them. This principle pertains to the Caine's (1997) "ahas" or insights and Gardner's (1993) "crystallizing experiences" which cause changes in goals. The principle is also similar to Armstrong's (1994) "paralyzing experiences," which cause one to shut down their use of intelligences and as Caine and Caine (1994, 1997) state "downshift" or lose their creativity and higher level thinking skills.

The twelfth principle states that brain is organized in its own way. This principle emphasizes how essential it is that every teacher uses a variety of modes of instruction, as well as providing activities, or choices of activities, involving all of the intelligences. A variety of appropriately challenging activities in a relaxed environment is essential.

Realizing that these principles are true about the brain suggests that we should provide a wider variety of developmentally appropriate challenging activities which children are interested in focused around metaphors. Teachers should also consider how the brain will assimilate the experience.

Similarly Gardner (1993) urges teachers to use a
variety of developmentally appropriate activities and assessments. Yet Gardner's goal is to meet students' varying needs for instruction in the various intelligences.

To grasp an idea of Gardner's theory of multiple intelligences, some common terms will be defined as Gardner uses them. Gardner currently interprets "domain" to be the specialty as it is used in the real world, and "field" as the places in the world where the products of the domain are judged as worthy of merit or not. Gardner also says that "person's deemed 'at promise' simply exhibit a high degree of intelligence with relatively little need for tutelage" (p. 37). His definition for "expertise" and "expert" vary a bit from the norm, since he says that one can be neither unless they have worked in the domain for ten or more years. He also says that something is creative only if it is new and accepted by the field in which it would be utilized. Gardner continues to say that to be considered a "genius," one must devise or create something which has a worldwide impact. Gardner's definitions of various terms vary a bit from the normal definitions that people hold.

Yet Gardner's (1993) theory of how teachers should teach resembles current theories recommended by many other putative people in the field of education. He suggests
that before teachers plan or start activities they should identify and consider students': developmental levels, needs, cultural knowledge, interests, goals, predelictions, motivation, and brain organization. Gardner feels that education needs to be devised to respond to and not ignore these important differences, so that students can develop to their individual potential. In Gardner's words "the choice of mode of presentation can in many cases spell the differences between a successful and an unsuccessful educational experience" (p. 73). He writes that once teachers are aware of various teaching modalities and learning styles that it is unacceptable to teach to all students as if they have identical individual intelligences. Gardner recommends that school be a place where learning is not controlled and activities or projects have a reason.

His ideas resemble that of brain-based learning and teaching. "Crystallizing experiences" are important individual experiences in Gardner's (1993) theory, similar to "ahas" in brain-based learning. The "crystallizing experiences" are fewer and demand more major changes. Instead of affecting merely changes in behavior, as "ahas" do, "crystallizing experiences" cause one to make changes in their goals to fit their strengths or intelligences.
To decide who is high in an intelligence, Gardner (1993) is against short answer pencil-and-paper tests. He recommends that the assessments are intelligence fair and not merely focussed on one or two commonly tested intelligences. He also states that tests should be devised to provide developmentally appropriate tasks in the domain for which the student is to be tested. He recommend tests that actually have the test takers moving about in the environment where they could use the particular intelligence. Gardner would like to see tests devised so that there would be a direct correlation between the skills tested and the domain. Caine and Caine (1997) recommend that similar tests be used on an ongoing basis in the classroom to ensure that concepts are being learned.

Gardner (1993) states that teachers should change the curricula to emphasize skills and knowledge which are truly essential in our country today. The changes in assessment measures are being made to correlate with the new teaching methods. Now assessment is structured to be more authentic, to have the students more involved through self assessment and to include portfolio assessment to demonstrate individual growth. This means a major "paradigm shift" for educators as their view of their jobs and how they should do them is questioned and changed. If
educators do not go through this "paradigm shift," then they will most likely find themselves replaced by a computer, which can disseminate information at a much more cost effective rate (Caine & Caine 1997). Gardner (1993) also recommends this paradigm shift, when he writes of the importance of teachers not working in the factory model. Teachers as facilitators have a varied, yet equally important role in helping students learn. Now the focus of the teacher is more to motivate children to learn important facts and skills as appropriate. As Caine and Caine succinctly state "The role of educators is to facilitate the making of dynamical knowledge. Dynamical knowledge is revealed through real-world performance" (p. 67).

This dynamical knowledge becomes more personal and meaningful because it is based on insight. This is that moment of "felt meaning," "aha!" or insight. It is a moment to be remembered forever most likely since it taps on the person's emotions and intrinsic motivation.

At the time of an "aha!" a person becomes very mindful of what is happening. The opposite of this can happen when someone feels bored, threatened, or helpless. The opposite is "downshifting," which causes someone to bypass higher level and critical thinking, as well as creativity. It is important to realize that once one is "downshifted" that
they stay there for about thirty minutes.

The use of the multiple intelligences theory is one method to keep students from becoming bored and "downshifting." Multiple intelligences are used daily in the constructivist classroom to try to engage and motivate a variety of students to learn. Assessment also uses as many of the intelligences as possible, definitely more than in the past.

The constructivist classroom of today is definitely different from classrooms of the past. Even when free exploration was encouraged in the classroom of the past, the role of the teacher was often not one of facilitator. For the present the much needed role of facilitator is encouraged and utilized in education. The job market and lives that the students of today will be dealing with is quite different from those envisioned by teachers of the past. Technology is here to stay and we need to prepare students to use it and work with it to their benefit.

Activities, such as Bohan's (1990) "free rides," which invite students to discover algorithms and find methods for solving problems on their own or in a group are utilized. An ideal open environment is where students often initiate new lessons by their free and open questioning of whatever they do not understand or agree with. Gardner (1993)
agrees with students being free to openly question anything and everything. Students making "ahas" are proof that they are achieving a "felt meaning" for what they are learning, which makes it much easier for students to remember later (Caine, R., & Caine, G., 1997).
PROJECT DESIGN

The project will include a curriculum guide containing lessons, extensions or alternatives suggested by current literature that will integrate current fraction and constructivist theory to a third grade *Quest 2000* fraction unit. To show growth a pretest and posttest will be given to the individual students in each of my three classes. Assessments at the end of each lesson are process-oriented whenever possible and include daily writing assignments, as well as a variety of other activities which can be completed individually or in small groups. Most of the assessments will be completed individually. Since I have the opportunity to teach three third grade mathematics classes four days a week, I have the chance to modify my lessons between classes as I see necessary. Two peers with masters' degrees and a mathematics professor, who are all well respected for their mathematical knowledge, will peruse my lesson plans and offer their recommendations for change. To prove that the lessons were effective the posttest will be administered and the results will be compared to the results of the pretest. Results of what the children desire and need to learn will be included in the curriculum guide following the lesson plans as an example of actual third grade student information.
The results of what my students want to learn guide my lesson plans and assessment, as well as the district test and the fraction pretest and posttest, which I devised. The lessons will correlate with all three, as much as possible.

At the end of each lesson there will be an explanation of the importance of the lessons citing current research advocating similar activities, if it was not already included in the literature review. Modifications for different learning modalities will be included whenever possible. Suggested hints and/or clues will be suggested for some lessons, in which students encountered difficulties finding the solutions in groups. All of the lessons will have objectives, a focus problem, and integration into other subject areas wherever possible. To ensure that students are mastering the lesson objectives and being prepared for the district test, the students will be given various forms of assessment including, but not limited to, the following: open-ended questions, daily journals, interviews, real world problems, and portfolios. A combination of the above assessments will provide me with a clear idea of my students' ability levels.

The school at which I teach does not qualify for Chapter 1 funding, so our students are a bit above the
average, yet we are also one of the lowest funded schools in the district for the same reason. The first class has a couple of mainstreamed severely emotionally disturbed students, yet there have been very few problems with them. Our school does not normally have a high rate of students moving in or out of our school, yet it still seems that the majority of incoming students are at lower levels than our current students. This year may be unique in that we serve as an overflow school for several local schools. The result is that my second class of the day will be a second and third grade combination class. My last class of the day has more of the parent requests and higher functioning students and more of its incoming students are functioning at the kindergarten and first grade level mathematically. I would say there are several G. A. T. E. potential students, yet somehow only one of them to our (the teachers’) surprise and the parents’ regret has qualified so far this year. Each class has a couple of students who see the resource specialist for math and a few others who have been referred to the student study team.

I am in the fortuitous situation of having three classes of about thirty third grade students to work with who are of average or slightly above average ability levels in comparison to the socioeconomic break down of our
district. I have each of the first two classes followed by a break of twenty to forty minutes, which allows time to make revisions in my lesson plans as I proceed through the day and discover what works and what does not work as anticipated.

A couple of my peers, who have masters' degrees and a strong familiarity with the Quest 2000 math series, as well as a mathematics professor from California State University, San Bernardino will be reviewing and offering suggestions on my lessons. One of my peers, who will peruse my lessons, works at the Fontana Unified School District office in the mathematics department. The second person is a principal now who was very involved in the adoption and implementation process of the Quest 2000 series. The final person to review the lessons will be Dr. Robert London from CSUSB.

The results of the pretest and posttest will be compared and used as a final proof of the effectiveness of my lessons. The district unit test could also be used to compare my students with others in the district, but administration of the test varies at different sites. I will have students write about what they have learned. Then we will review what they had wondered about, wanted and needed to learn to ensure that all of the topics have
been covered or at least introduced.

The project was devised to combine recent research with the Quest 2000 third grade fraction unit. Learning will be demonstrated by improved test scores between the pretest and posttest. A variety of other forms of assessment will be used as well. Lessons will be altered as I see a necessity or more efficient method of teaching the objectives. Three highly respected people, two with masters degrees and one with a doctorate, will review my lesson and offer their advisements. Results from the pretest and posttest will be used to show growth and progress in the students.
THEORETICAL FOUNDATIONS

In order to have similar results to those in this project it is essential that these lesson plans and suggestions are carried out in a classroom environment similar to the one described in this project. This includes using similar constructivist and brain-based classroom techniques. Student led discussions and activities are an essential part of constructivist classrooms. New mathematical techniques should be used that emphasize the students being more responsible for and thoroughly involved in their own learning and that of their group rather than having the teacher lecture or suggest how to do an assignment or calculation. When the teacher does intervene, the teacher does so as a facilitator. As a facilitator the teacher’s job is to pique the students’ interest, to keep the students motivated throughout the learning process and to be a resource when requested. To make this part of the facilitator’s job easier the facilitator needs to be attentive to students’ individual developmental levels, misconceptions, interests and questions.

As Battista (1994) puts it, teaching a set of steps is just asking students to do rote work that they do not understand and leads to “downshifting,” as described by
Caine and Caine (1997); to avoid this student generated activities should be emphasized. When it is necessary to prepare students to meet set standards and prepare for required tests, activities should then be modified to the students' levels, so they are challenged to pique their interest, yet not challenged into a feeling of helplessness or mindlessness (Langer, 1989). This is essential to keeping the students working at their potential and not functioning at lower levels of thinking where critical thinking and creativity is impossible. Students are encouraged to ask for modifications in lesson and activities. Their suggestions are listened to and attempted whenever possible. The students are also encouraged to ask thought provoking questions of their peers and teachers. Students should feel comfortable in asking both their peers and teacher for help or suggestions as needed. Peers not familiar with this technique may require teacher modeling and discussions of how to give hints and clues, as well as why this is important. Teachers and peers should provide suggestions or hints, but not answers.
APPENDIX A: CONSTRUCTIVIST TEACHING

It is important that anyone who reads this section or any portion of the appendix, realizes that these sample lessons are provided as suggestions and that it is expected that every teacher will adapt or modify them to be consistent with the needs of their students. In keeping with current teaching methods it is not important to complete all lessons or meet all objectives, since a more in-depth study is recommended to improve understanding and retention of concepts. A wide variety of lessons were included to demonstrate how to teach a variety of fraction concepts and skills. A couple of the lessons were included to show how a couple of the intelligences, which had not been addressed daily, could be utilized. This flexibility is an important part of constructivist teaching.

The scope and sequence does not necessarily have to be carried out in the sequence suggested. The order does provide lessons which build on one another, but if students show a great interest in learning a particular lesson on a particular day, do not put the lesson off for another day. Be attentive to students' desires and abilities, since it is possible that some or portions of these lessons may be deleted. The lessons are varied to demonstrate how to teach a
number of important concepts using the theory of multiple intelligences and learning modalities. In the "other" portion of the scope and sequence activities using a variety of intelligences are mentioned, as much as possible.

Beyond the daily writing activities, which fall into the linguistic intelligence, that are listed in the other part of the scope and sequence there are other intelligences addressed daily. Most of the intelligences are utilized in every lesson. The linguistic intelligence is used for discussions and verbal interaction in groups, as well as in the daily writing assignment listed in the scope and sequence. Cooperative groups and most of the activities which they do daily provide experiences in the interpersonal intelligence. The intrapersonal intelligence is utilized for the evaluation activities which are self reflections where individual students usually complete on their own. Daily hands-on activities are for the bodily-kinesthetic intelligence. The logical-mathmetical intelligence is quite obviously addressed in each lesson by the objectives and techniques used to solve the problems. There are also some intelligences that are not in every lesson, yet are in
quite a few lessons. The spatial intelligence is one of those. Spatial activities include, but are not limited to: drawing fractions, using computer programs, using colored fraction manipulatives, visualizing a story, the sharing of items, and art activities.

Since the musical intelligence was not addressed in any of the first ten lessons, the eleventh lesson is devoted almost exclusively to music.

Connections to other subject areas, which are important to brain-based learning, are also included in the "other" part. Using various intelligences and connecting fractions to as many different real life situations as possible is essential to constructivist teaching and retention of concepts.

Another important resource that should not be forgotten are parents, many of whom are very talented in particular intelligences. Try to send out parent surveys to find out which parents would like to come help in the classroom, as well as their areas of expertise.
## Scope and Sequence of Lessons

<table>
<thead>
<tr>
<th>Week</th>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 3</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Fraction Objectives</strong>&lt;br&gt;Define fraction.&lt;br&gt;Use fraction terms.&lt;br&gt;Write about prior knowledge.&lt;br&gt;Introduce comparing and equivalent fractions.</td>
<td><strong>Math Problem Focus</strong>&lt;br&gt;How can fractions be used?&lt;br&gt;What do you know about fractions?</td>
<td><strong>Other</strong>&lt;br&gt;Listen to “Fraction Action” from <a href="#">Fraction Action</a>.&lt;br&gt;Art-color a design.&lt;br&gt;Look for connections to other subject areas in their knowledge.&lt;br&gt;Geometry - area and symmetry review.</td>
<td><strong>Math Problem Focus</strong>&lt;br&gt;How can you share objects equally with more or less people than objects?</td>
</tr>
<tr>
<td></td>
<td><strong>Objectives</strong>&lt;br&gt;Find a need for fractions.&lt;br&gt;Find unequal halves.&lt;br&gt;Introduce partitioning, mixed numbers, numerator and denominator.</td>
<td><strong>Lesson 2</strong>&lt;br&gt;How can you share objects equally with more or less people than objects?</td>
<td><strong>Math Problem Focus</strong>&lt;br&gt;What fraction of the class are boys? girls? or have other attributes?</td>
<td><strong>Lesson 4</strong>&lt;br&gt;Share a snack with your group. Review fractions of sets and partitioning</td>
</tr>
<tr>
<td></td>
<td><strong>Objectives</strong>&lt;br&gt;Find fractional parts of sets.</td>
<td><strong>Math Problem Focus</strong>&lt;br&gt;What fraction of the class are boys? girls? or have other attributes?</td>
<td><strong>Other</strong>&lt;br&gt;Listen to “Fraction Action” from <a href="#">Fraction Action</a>.&lt;br&gt;Review metric linear measurement.&lt;br&gt;List fraction uses.</td>
<td><strong>Other</strong>&lt;br&gt;Listen to “Fraction Action” from <a href="#">Fraction Action</a>.&lt;br&gt;Art, math, and science symmetry.&lt;br&gt;(Optional Geometry - polygon terminology.)&lt;br&gt;Listen to “Fair Share” from <a href="#">Fraction Action</a>.&lt;br&gt;Write a letter (grades 3-5).&lt;br&gt;Tell of sharing (K-2)</td>
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</table>
### Scope and Sequence of Lessons

<table>
<thead>
<tr>
<th>Week 2</th>
<th>Lesson 5</th>
<th>Lesson 6</th>
<th>Lesson 7</th>
<th>Lesson 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction Objectives</td>
<td>Learn numerator and denominator concept. Find different ways to show a fraction. Introduce addition of fractions.</td>
<td>Learn not all halves, thirds, etc. are the same. Review dividing wholes equally. Make a whole given a portion of one.</td>
<td>Write fraction word problems. Add fractions. Review partitioning shapes. Review not all halves, etc. are the same sizes.</td>
<td>Write addition and subtraction problems for sharing of food. Review partitioning of foods.</td>
</tr>
<tr>
<td>Math Problem Focus</td>
<td>What recipe do you want to make? What will the class need to make the recipe(s)?</td>
<td>If this is a quarter or two-thirds of a whole, than how large is the whole?</td>
<td>How many different ways can we partition shapes?</td>
<td>How do addition, subtraction, multiplication and division relate to sharing foods?</td>
</tr>
<tr>
<td>Other</td>
<td>Listen to <em>Eating Fractions</em> and/or <em>Revolting Recipes</em>. Write their own recipes. Review commutative property and arrays.</td>
<td>Listen to <em>The Doorbell Rang</em>. Write a comparison of halves from different wholes and why they are not all equal in quantity.</td>
<td>Creative writing of word problems. Use computer program <em>Fraction Practice</em>.</td>
<td>Do activities tying in science or foods using AIMS “Fraction Fondue” or <em>Gobble Up Math</em>. Write an application response to math focus question above.</td>
</tr>
<tr>
<td>Week 3</td>
<td>Lesson 9</td>
<td>Lesson 10</td>
<td>Lesson 11</td>
<td>Lesson 12</td>
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<tr>
<td>Fraction Objectives</td>
<td>Fold and label strips into fractional parts. Find equivalent fractions on a chart.</td>
<td>Introduce musical notes. Review addition of fractions.</td>
<td>Practice equivalent fractions with standard measurement. Color fractions, repartition and write the new fraction. Introduce decimal fractions with money, the metric system, and time.</td>
<td>Explore customary measurement equivalence. Use fractions to measure ingredients for a recipe. Introduce multiplying by two and one-half.</td>
</tr>
<tr>
<td>Math Problem Focus</td>
<td>How can fractions be used in art?</td>
<td>How do composers write music? How do musicians play music?</td>
<td>What is the pattern here? ( \frac{1}{2}=\frac{2}{4}=\frac{3}{6}=\frac{4}{8}=\frac{5}{10} ) and ( \frac{2}{3}=\frac{4}{6}=\frac{6}{8}=\frac{9}{12}=\frac{12}{16} ). When are fractions of 100 used?</td>
<td>Why are fractions important to chefs?</td>
</tr>
<tr>
<td>Other Subjects</td>
<td>Review linear metric measurement. Art-origami.</td>
<td>Write and read musical notation. Write a letter explaining how to compose music. Optional playing of musical instruments.</td>
<td>Listen to <strong>Math Curse</strong>. Write about life without fractions. Listen to &quot;Lemonade For Sale&quot; from <strong>Fraction Action</strong>.</td>
<td>Listen to &quot;Teacher's Test&quot; from <strong>Fraction Action</strong>. Increase, decrease and/or make a recipe. <strong>Fraction Munchers</strong> computer program.</td>
</tr>
</tbody>
</table>
APPENDIX B: TEACHER SUGGESTIONS

This section of the appendix includes a recommended test, a list of how fractions can be utilized, materials needed and preparation of materials for the lessons in the next section. The test is included to eliminate the need to create an assessment to be utilized as a pretest and/or posttest. The uses of fractions have been included to show the significance of them and to emphasize the wide range of uses for fractions. The materials and preparation necessary for all the lessons have been put together to facilitate easier implementation of the sample lessons. These sections are intended to be useful in planning a fraction unit.

The test to be used as a pretest and posttest has been included to make planning and preparation for the unit easier. It is suggested that this test only be given in the third through fifth grades due to its difficulty. If this assessment is used with a kindergarten through second grade or a low class, then one should give only a simplified version of the first page with all directions read to the students. The questions should be simplified to only use common fractions and problems appropriate for students at their grade and/or their ability level.

Third grade students will find the first page of the
test difficult, yet most fifth grade students will discover the two pages to be challenging. If the pretest is found to be too easy, then modify it before giving it as a posttest by including more complex problems. Before including this test in one’s lesson plans be certain that it is appropriate for the age and ability level of the students taking the test.

In considering changing some of the test questions one can consult the uses for fractions in the real world. This will also make the assessment more applicable to the students and more closely related to an authentic assessment. The uses of fractions can be used to show students, as well as teachers, that there is a wide range of uses for fractions. Too often teachers feel they do not use fractions very often. Hopefully this list will help teacher see the importance of teaching fractions in a variety of situations.

Recommended materials and their preparation have been included to make the teaching of fractions easier. The materials are marked by grade level, where applicable. They are also separated into categories. If the item could fit into two categories, then one category was chosen. Most of the miscellaneous items can be found in students’ homes. Optional items are not essential.
FRACTION TEST
(To be used as a pretest and a posttest for grades 3-5.)

1. Draw a pie or pies showing 2/3.

2. Draw a picture of 5/8 of something:

3. What does 5/8 mean?

4. When and how could you use 5/8?

5. Show one and one-half (1 1/2) pizza(s).

6. Put an x where 1/2 (one-half) inches is on the ruler:

7. How many half cups are in a whole cup?

8. If your mother said you could play Nintendo for half an hour, then how many minutes would that be? Explain.

9. If one quarter of a basketball game is 15 minutes, then how long is the whole game?
10. If your dad said that you can take 1/4 of his 8 baseball cards, then how many cards would you get?

11. What is 3/4 of 16 games?

12. Using the equivalence chart, write each fraction in one or more ways:

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Equivalent Fractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>2/4 4/8</td>
</tr>
</tbody>
</table>

13. 1/4 + 1/4 = 1/4 + 1/2 = 1 5/8 + 1/2 =

14. 3/8 - 1/8 = 3/4 - 1/2 = 1 1/4 - 1/2 =

15. If you have three pizzas and four people, then how much pizza will each person get? Show your work.

16. If this is one half of a candy bar, then how big is the whole candy bar?

17. If this is two-thirds of the whole candy bar, then what does the whole candy bar look like?

18. Write your own fraction problem and give the answer on the back or on a separate piece of paper.
Fraction Uses in the Real-World

To measure:
- recipe ingredients
- medicine
  when you do not have the correct size measuring device
- buying items at the store half gallons, etc.
- fabric needed to make an item(s) of clothing
- wood needed for a project
- windows for blinds or drapes
- screw and nail length needed
- shoe and clothing sizes
- age
- musical notes
- time - half or quarter past, for example
- coin value
- quarter turn adjustment for carburetor fuel for weather
- wrench and bolt size
- budget - spend only one-third of your income on housing
- half of the group
- parts of the yard for different kinds of plants
- half of the items
- 6 for $5
- fractional parts of games (for example: quarters in basketball)
- part of an assignment, job, chore, or book
- how full or empty something is

For increasing and decreasing:
- serving size of recipes
- cutting fat by one-third and substituting apple sauce
- fabric needed to make matching outfits
- half price
- time and a half for working overtime or holidays
- wood or other materials for several projects or for several of the same project
Recommended Manipulatives for the Sample Lessons

Suggested materials for the lessons in the appendix [numbers in brackets refer to lessons numbers]:

Paper:
[Most Lessons] White ditto or copy paper
[Most Lessons] Centimeter graph paper (used more for grades 4 and 5)
[Most Lessons] Inch grid or graph paper (used more for grades K-3)
[5 & 9] Two pieces of colored 9 x 12" construction paper per student.
[9] Origami paper or wrapping paper cut into squares
[5 & 12] 3 x 5 index or recipe cards package of 100
[1, 4, & 7] 4 pieces of large chart paper
[2] (Optional geoboard or dot paper)
[11] 100 square grid paper (for grades 3-5)
[1 & 4] Ruled binder paper

School supplies:
[10] 5-15 overhead thermal transparencies with blank musical measures (for grades 3-5)
[All] Pencils
[1, 5 & 11] Colored pencils and/or crayons (at least one set per group)
[1 & 5] Markers (scented, if possible)
[10] Overhead projector (for grades 3-5)
[10] Overhead pens one per pair or group (for grades 3-5)
[9] Scissors
[9] Tape or glue
[12] Water
[3] Stop Watch
[10] Blank music page (for grades 3-5)
[10] Samples of written music for class to study (for grades 3-5)
[10] (Optional musical instrument(s) for grades 3-5)
[2A] (Optional for grades 3-5 a scale to measure accurately to an ounce or gram.)
[3] (optional video camera)

Mathematical supplies:
[1] Geoboards for pairs
Recommended materials (continued)

[4 & 7] Power polygons and or pattern blocks
[5] 40 square tiles (10 of each of 4 colors) per pair
[6] Two to three rolls of adding machine tape (2 for K-2)
[3, 9, & 11] Metric measuring tapes per pair or individual
[2A & 6] Ruler and/or yardsticks (for grades 3-5)
[11] Base ten blocks or mod blocks
[11] Fraction strips, rods, blocks or towers
[Most] Math Explorer calculator or one which gives fractional solutions should be available.
[7] (Optional Fraction Practice computer program)
[12] Fraction Munchers (computer program)
[Most] (Optional Quest 2000 series, third grade)
[4] (Optional multiplication chart or table for grades 3-5)

Books:
[2B & 5] Eating Fractions by Bruce McMillan
[1, 3, 4, 11, & 12] Fraction Action by Loreen Leedy
[6] The Doorbell Rang by Pat Hutchins
[2A] Fraction Fun by David A. Adler (for grades 3-5)
[8] Fun with Foods by AIMS Education Foundation

Miscellaneous supplies, which students can bring from home:
[4 & 7] 8-15 Ziploc bags
[8] Fruits
[8] Juice
[8] Milk
[8] Crackers
[8] Snacks
[8] Cookies
[8] Cheese slices
[2A] (Optional for grades 3-5 a large quantity of pennies, nickels and dimes.)
[2A] (Optional for grades 3-5 a box of Kleenex tissues.)
[4 & 8] One or two knives per group of 3-4 students
[4 & 8] Plastic forks
[4 & 8] Plastic spoons
Recommended materials (continued)

[2A & 4] 3 paper plates per child (Optional extra 3 of same size per grade 3-5 child)

[4 & 8] Cups
[4 & 8] Bowls
[4 & 8] Napkins
[5 & 12] Recipe(s)

[12] Ingredients for the recipe(s) that are made

[12] Utensils for the recipes and some more on the same day for free exploration

[12] (Optional rice for free exploration with above utensils)

[12] 2 dishpans

[2A] (Optional envelopes for grades 3-5)

[4] Individual servings of food to share (one per student). A variety of items is important to the success of the lesson.
Preparation for Sample Lessons

Preparation to be done with the above materials for the suggested lessons [Numbers in brackets refer to lesson numbers]:

[4,8,12] Write, copy, and send home notes to parents asking them to send the following items with their children during the next three weeks (for lessons 4, 8, and 12):

[4] For food partitioning the students should each bring an individual serving snack which can be divided among their group of two to four children. Encourage a variety of snacks, including ones consisting of pieces and liquids. Plastic knives, forks, spoons, plates, cups, bowls, napkins and any other things you may need to accompany the above and following two paragraphs of items.

[8] For food introduction to operations they are to bring juice, milk, fruit, cheese slices, cookies and crackers.

[12] For food activities involving mixed numbers and operations students need to bring ingredients and a double set of utensils to make a recipe of their choice. Request parent volunteers for the day you plan this lesson.

Further preparation recommended before starting the sample lessons is as follows:

[1] Compose and make copies of a family letter about the unit suggesting that parents can let their children make a recipe or at least measure the ingredients for a recipe.

[1 and most lessons] Student journals with alternating blank paper and graph paper.

[1, 5, 9] Optional copy homework problem of the week from the last page of each of these lessons. (for grades 3-5).

[2] Design or copy students’ papers to make a chart or paper for student to cut apart with geoboard grids divided into halves (or fourths for fifth grade) with just one grid per row or column divided unequally. If one runs off dot, graph or geoboard paper, then the students can fill in the geoboard grids for you. See illustration on the first page of lesson 2 in this appendix.

[4] Separate power polygons or pattern blocks separated into Ziploc bags for individuals, pairs or groups of four depending on the number of pieces you have.
Preparation (continued)

[5] Divide the 40 square tiles into 10 of each of the 4 colors per pair. The Ziploc bags can be used to keep them separate.
[5] Copy or print 10 colored cards with the numerators of 1-10.
[5] Copy or print 5-10 composite (opposite of prime) numbers larger than 10, such as 12, 14, 15, 16, 18, 20, 21, 22, 24, and 25 on white cards to be denominators.
[6] Cut 5 pieces of adding machine tape the same size and vary sets of five for other pairs by at least one inch. (This is very important and should be done in advance by the teacher or an older student, who is not participating.)
[7] (Optional) Copy or print 10 colored cards with the numerators of 1-10.
[7] Copy or print 5-10 composite (opposite of prime) numbers larger than 10, such as 12, 14, 15, 16, 18, 20, 21, 22, 24, and 25 on white cards to be denominators.
[6] Cut 5 pieces of adding machine tape the same size and vary sets of five for other pairs by at least one inch. (This is very important and should be done in advance by the teacher or an older student, who is not participating.)
[7] (Optional) Copy or print AIMS “Fraction Fondue” activity, the last page of lesson 8, and/or pages 101-118 of the Gobble Me Up book.
[7] Find an origami activity which has many fraction connections. Try it out before having the students attempt it.
[10] Make copies of the blank music paper and the samples of written music (for grades 3-5).
[10] Find someone to play or explain how to read notes and play the instruments (for grades 3-5).
[10] Label the instruments with note names, if it would be useful to the students (for grades 3-5).
[11] Make or label fraction circles, strips, rods, and/or towers with fractions and their fraction decimal equivalents.
[11] (Optional handout with two of several items to be partitioned and repartitioned.)
[12] Copy of recipe(s) to be prepared in class.
[12] Preview Fraction Munchers computer program.
[12] Meeting with volunteers to go over stations.
APPENDIX C: SAMPLE LESSONS

These lessons are arranged to be adaptable to the level of one's elementary students. The time required to complete the lessons will vary, as they are modified. Most kindergarten to second grade lessons can be completed in twenty to sixty minutes. Third to fifth grade lessons will last from about one to two hours depending upon which activities are chosen and what children are interested in exploring in more depth.

These lessons are designed to fit into one-and-one-half to two hour blocks of time, if one has to work with smaller blocks of time most lessons can be easily divided into two lessons. The majority of the lessons can be stopped before the elaboration and evaluation part of the lesson. When the lesson is continued on another day, start with a review of what was done on the previous day before proceeding with the remainder of the lesson.

The suggested grouping can also be changed depending on availability of materials and desires or abilities of the children. Do not make the group activities into individual activities, since that is defeating the purpose of cooperative learning experiences. Explanations should be student led discussions whenever possible and they are usually done as a whole group before starting activities in
groups. Evaluation assignments can be done in groups or individually. Try to do a few of each.

Feel free to adapt and modify the lessons as necessary. Teachers need to evaluate the effectiveness of these lessons in their individual situations and consider modifications that will benefit their students.

The goal of these lessons is for students to see the importance and usefulness of fractions. It is not essential that every student fully comprehend the computational aspects, since calculators, like the Math Explorer, can be used for fractional computations. Neither is it essential that every student have a complete understanding of every concept, since some students will not be developmentally ready and the curriculum should spiral, so students build on their fraction knowledge each year. This is especially important to realize in kindergarten and third grade when many new concepts are being introduced and most of them should not be taught for mastery. Even in fourth grade some students are having their first major practice with fractions, so they should not be expected to master every concept. Remember that individual student improvement is more important than having every student fully accomplished each objective.

The explanation part of the lessons should be student-
led as much as possible. Students listen and learn more from their peers, so try to use their valuable knowledge as often as possible. Teachers can add leading questions to direct or redirect the discussion. Sometimes students will also ask for or need hints or clues, so try to be prepared to give them as needed. The majority of explanations should come from the students.
Lesson 1: Prior Knowledge and Fraction Defined

Objectives: 1. Students will be able to define a fraction.
2. Students will orally use fraction terminology to explain fractions. (K-2 may use one of two equal or same size parts.)
3. Students will write about their prior knowledge - understanding of and misconceptions about fractions.
4. Introduce comparing equivalent fractions

Materials: Fraction Action by Loreen Leedy.
Student journals
(Optional: inch graph paper 4th and 5th can use grade centimeter paper for the optional art connection)
Three pieces of large chart paper
(Optional for art tie-in: crayons, markers or colored pencils)
Geoboards (One per pair)
(Optional homework: copy problem of the week at the end of this lesson)
(Optional: geoboard, dot or graph paper to record geoboard solutions)

Preparation:
1. Compose and copy a family letter explaining the fraction unit. (Include how fractions are used in recipes and ask parents to let their child fix or measure the ingredients for a recipe.)
2. (Optional: copy problem of the week for homework.)

Grouping: Pairs

Time: 1 hour and 30 minutes (It can be divided into two parts, start at the evaluation on the second day.) The art and homework can be left out or done with the next couple of lessons.

PROCEDURES

Engage: (Optional art activity, you may skip engage.) Have students make a design on
inch graph paper by coloring complete squares to create their own original design for a couple of minutes. Discuss the artwork, especially the colored versus uncolored parts. Display or save them, so that fractions can be added during Lesson 3.

Exploration: In pairs have the students freely explore fractions on a geoboard. Walk around to pairs and ask them which fraction they are doing, if you don’t hear them talking about fractions. Have each group do two or more different fractions. They may record this to use with the next lesson. (It was first attempted in fourth grade. The students were very interested in this free exploration and learned a lot. Third grade students were equally involved and came up with very good questions. To prove their geoboards were divided equally they were able to connect their knowledge of area, symmetry and/or translations.)

Explanation: Have them share their geoboard fractions. Bring up the idea of other ways of saying the fractions they have illustrated. Have the class decide which fractions are labeled correctly and explain. Look at pictures of things separated into parts. (Quest student book pp. 122 & 123) (Optional explain homework problem of the week due on Friday.) Send home family letter about the fraction unit.

Evaluation: Have students respond to the three questions below in their journals. Then have them share their answers, as they are written on a class journal.
1) What do you know about fractions?
2) What are you unsure about?
3) What do you want to learn?

Elaboration: Have a student led discussion about fractions. Listen for words like parts of wholes, parts of sets, slices, and servings. Read Fraction Action pages 4-10 and discuss which fraction is smallest and why on p. 10.
PROBLEM OF THE WEEK

Food Eaten at a Party

At a party eight people each ate one-half of a pizza. Then sixteen people each ate one-eighth of a cake. Finally four people each drank one-fourth of a liter of punch. How much of each item was eaten? (Hint: draw items)

(Adapted from Quest problem of the week #28.)
Lesson '2A: Sharing Parts of Wholes (Grades 3-5)

Objectives:
1. Students will write about how they have shared an item using fraction terminology (half, quarter, etc.).
2. Students will discover a need for fractions.
3. Students will be introduced to partitioning, mixed numbers, and the terms numerator and denominator.
4. Students will review equal parts.

Materials: Fraction circles with fifths (not Quest's)
Student drawn pizzas which are square or circular
Fraction Fun by David A. Adler
(Optional to supplement above book: 3 paper plates per student, scale, coins, Kleenex, rulers, & envelopes)
Student journals
Centimeter graph paper

Preparation: Make posters or papers, which they can cut apart or count with several lines of designs as below with one in each row or column which is not equal:

![Designs](image)

(Actual student papers from the previous lesson dividing the geoboards into halves or fourths can be used.)
(Adapted from Invitation to mathematics: 6 posters.)

Grouping: Four to five students

Time: One hour or more (another hour or so to complete the activities in Fraction Fun.)

PROCEDURES

Engage: Have students write in their journals about a time when they had to share something with someone else. When students finish, have them find which squares or geoboards have
not been divided equally into halves (fourths for 5th grade students).

**Explanation:** Have the students share their stories. Have the students tell which geoboards are not divided equally using the poster or paper described above in place of p. 124 Quest student book, since the Egyptian fractions could cause additional misconceptions.

**Exploration:** The Quest 2000 third grade teacher guide suggests groups start by finding how much of a pizza each person would get if five people were sharing four pizzas. (If one does this activity, then a good clue might be to figure how much of one pizza each of the five people would get. Then figure for two pizzas and so on.) Third grade students find it very difficult to divide anything into fifths. (Hints: use fraction circles or draw rectangular pizzas for the first problem. Langford (1994) says that students should start with rectangles, since they are easier to partition.) Starting with eight people sharing six pizzas would be another clue. This problem would give an answer of a mixed number, in which case students may need or want to know how to write a mixed number. This is one of only a couple of activities in the third grade Quest 2000 that has a mixed number, which is important for measuring, figuring time and a half and so much more. For that reason it might be a good idea to include a few more of this type of problem.

**Elaboration:** Discuss results of above exploration and different methods to solve the problems. Then introduce the terms numerator and denominator. Read *Fraction Fun* by David A. Adler and use optional items to do activities suggested in the book.

**Evaluation:** Students will use fraction terminology in sharing journals. Students will draw their own ethnic food, partition it and label a part as eaten.
Lesson 2B: Sharing Parts of Wholes (K-2)

Objectives:
1. Students will orally tell of sharing an item using fraction terminology such as half or one of two equal or same size parts.
2. Students will discover a need for fractions.
3. Students will be introduced to the two essential parts of a fraction.
4. Students will be introduced to the partitioning and repartitioning a fraction.

Materials:
- Eating Fractions by Bruce McMillan
- Drawing (ditto) paper in student journals

Grouping:
Groups of 3-4 students

Time:
30 minutes.

PROCEDURES

Engage:
Read and discuss Eating Fractions.

Explanation:
Have a student led discussion of how they know where a number goes in a fraction. Ask the students to determine in groups how the two children in the picture can share the muffin cut into three-thirds. (Adapted from the conference session Fall Into Fractions: Integrating Fraction Concepts Throughout the Curriculum)

Exploration:
Have the students figure it out in groups. If they need a clue, then have them consider how much of each third each child should get. Then figure the fractional size and number of pieces each child would receive.

Elaboration:
Discuss group solutions and/or problems.

Evaluation:
Then have each child draw a favorite food, divide it into fractional parts, label the parts and say how many people it would most easily serve.
Lesson 3: Writing Fractions of a Set

Objective: 1. Students will write fractions in words and symbolically for parts of wholes and sets. (K-2 orally for age appropriate unit fractions.)
2. Students will find the number of centimeters in 1/2, 1/4, 2/4 and 2/10 of a meter. (K 1/2, 1st 1/4, 2nd 1/10, 3rd nonunit fractions, 4th 1/5, 1/20, 1/100, and 5th mixed numbers.)
3. Students will introduced to rounding or estimating to the nearest whole number.

Materials: Metric Measuring tapes.
(Optional video camera)
Stop watch
Fraction Action
(Optional artwork from first lesson)

Grouping: Three to four students

Time: One hour or longer, if you choose to play a team game and/or do the artwork.

PROCEDURE


Elaboration: Have students get into groups by various attributes (such as hair color, eye color, birth month, and other categories). Have them come up with the fraction of the class in each group. You can video tape this. This can also be extended into a physical education activity by talking about how games are played with different numbers of teams and people on the teams. The students can make this into a game to see how quickly they can get into so many groups or groups of a specific size. Third to fifth grade students can also work on estimating or trying to figure how many there will need to be in each group or how many groups will be needed and then checking their estimates and figures by actually dividing up into the teams. When you finish you can also play a
team game.
Adapted from *Quest 2000 Teacher’s Guide, 3rd Grade* and suggestions from Conaway and Midkiff (1994).

**Exploration:** (Optional: Have the students use the art work from two lessons ago. Have them come up with fractions for each design or piece of art.) In groups have the students find the centimeters in $1/2$, $1/4$, $1/10$, $2/4$ and $2/10$ of a meter. Extra credit for third grade groups (required for fourth and fifth) would be $1/5$, $1/20$, $1/100$ and $1 1/2$ of a meter.

**Explanation:** Relate exploration to money and other things in real life. Remind them of *Fraction Fun* which they listened to yesterday. Behr et al. (1993) suggests several problems related to fractions. One of them includes party favors and another pertains to the amount of paint one needs for a project, I have modified both by adding an extra question to the first one and simplifying the second one (for grades 3-5).

1. There are five cups. A helper puts four favors in each. The helper makes a mistake and one cup holds only three favors. How much of a cupful does he have? How much is he missing?

2. A person mixed six tubes of paint. One-eighth of the paint covered two boards. How many tubes would they need to cover 32 boards?

**Evaluation:** Have students list other ways fractions can be used and/or make up their own story about the many uses of fraction. Students will be able to find the number of centimeters in different fractions of a meter.
Lesson 4: Sharing

Objectives:
1. Students will make a symmetrical design.
2. Students will share a snack with a small group.
3. Students will learn the names of the power polygon shapes. (Optional)
4. Review fractions of a group of objects and partitioning.

Materials:
- Power Polygons
- Individual snacks that students bring in to share
- Seven or more large Ziploc bags
- Knives, plates, cups, bowls, spoons, forks, and napkins
- Fraction Action
- Paper for letter writing

Preparation:
Put power polygons into seven or more large Ziploc bags.

Grouping:
Small groups of 3-4 students.

Time:
One hour or more.

PROCEDURES

Engage:
Let them freely explore with the power polygons, which they share with their group. The students can trace or copy their design onto paper and share them with their group or the class. (Save some or make up ones using only squares or hexagons for repartitioning shapes.)

Exploration:
Have the groups categorize the polygons by their attributes and find fractions for each part of the group.

Explanation:
Have the students share the names of the power polygons, which they know. Provide them with the remaining names, if they are interested or have them investigate the names of the others. Look at the students' designs from engage above and discuss symmetry. You can start...
by choosing a few samples that are symmetrical and telling the students that they all are symmetrical. Then give several examples that are not, and see if the students can come up with their own definitions of symmetry. If they cannot figure it out, you can give a few more examples, they can look it up, or you can define it.

Elaboration: Have students partition individual power polygons into as many shapes as they can. Make a class chart of the different ways to partition each shape, as recommended by Pothier and Sawada (1990). Read Fraction Action pp. 16-21. Let students share the snacks they brought with the other members of their group. (Review letter writing format for grades 3-5, if necessary.)

Evaluation: Third to fifth grade students will write a letter to a friend and/or orally tell the class how they shared their snack(s) with their group. Have students partition one shape in several ways. (See elaboration above.)
Lesson 5: Numerator and Denominator

(Grades 3-5 only)

Objectives:
1. Students will learn the concept of numerator and denominator.
2. Students will realize that there are many ways to represent the same fraction with a rectangle.
3. Students will be introduced to addition of fractions.
4. Students will write a recipe using fractions.

Materials:
- 40 square tiles (10 of each color) per pair.
  (Optional: crayons, pencils or markers the same color as the tiles.)
- Activity Master 21 or inch graph paper to record their tile work.
- White and another color of paper, or 3x5 cards.
- Problem of the week (Follows this lesson).
- Roald Dahl's Revolting Recipes by Roald Dahl.
- Eating Fractions by Bruce McMillan (for grades 3-5) (Review for K-2).

Preparation:
- Copy problem of the week.
- Copy or print 10 colored cards with the numerators of 1-10.
- Copy or print 5-10 composite numbers larger than 10, such as 12, 14, 15, 16, 18, 20, 21, 22, 24, and 25 on white cards to be denominators.
- Separate 40 square tiles (10 of each color) per pair.

Grouping: Pairs

Time:
Approximately one-and-one-half hour.

PROCEDURE
Engage:
Have students make designs using all four colors and about half of the tiles. Then have them label the fractions of each color.
for each design. Have students, who finish quickly, write addition equations for each.

**Explanations:**

Use examples from their work to introduce addition of fractions and review numerator and denominator. Explain that they will be using the yellow numerator cards to represent the part which is selected or shaded and the white denominator cards will stand for the parts the whole will be divided into. Have one student in each pair draw a numerator card and the other a denominator card. Each student then records the fraction and draws a rectangular model of the fraction. Have the students compare their rectangles. Stress that they should not always be identical to be correct. Say that today the class is looking for alternate ways to make the same fraction. Then have the students start over with newly drawn cards.

**Exploration:**

Have the students play the above game.

**Elaboration:**

As a class discuss how their rectangular models of the same fraction differ and why. Connect to commutative property of multiplication and arrays. Explain problem of the week. Discuss ways to represent the fraction of games on the shelf. Read *Eating Fractions* and discuss which recipe the class would be interested in making. Encourage students to bring ethnic recipes from home to increase their choice of recipes. Read Roald Dahl's *Revolting Recipes*.

**Evaluation:**

Students will accurately draw rectangles for the fractions, as they play the game. Have students draw a couple of different ways to represent a fraction as a rectangle. Write an addition problem for at least one of the rectangles (Grades 3-5). Students will write a recipe using fractions in the list of ingredients. (Review recipe format, if necessary. Students may also want to complete this in pairs.)
Discuss problem of the week homework.

PROBLEM OF THE WEEK

Fraction of Games

One-half of Joe's games are computer games. One-fourth of his games are Nintendo games. The rest of his games are board games. What fraction of his games are board games?
(Hint: draw them on a shelf. Ask the teacher for more clues, if necessary.)

(Adapted from Quest 2000 Problem of the week # 30.)
Lesson 6: Not All Halves Are Equal and Wholes from Parts

Objectives:
1. Students will learn that not all halves (K-2), thirds, fourths, and eighths (grades 3-5) are the same size.
2. Students will realize that the size of a fractional piece depends on the size of the whole.
3. Students will review dividing wholes equally and fractions of a set.
4. Students will be introduced to making wholes from fractions. (3rd from common unit fractions, 4th from uncommon unit fractions, 5th from nonunit fractions)

Materials: 2-3 rolls of adding machine tape. Yardsticks or rulers for pairs. 
The Doorbell Rang by Pat Hutchins

Preparation: Cut five pieces of adding machine tape the same size per pair. (Different sets of pairs should have lengths of tape varying by at least one inch. K-2 need less pieces.) Do not let students who are going to participate in this lesson cut the pieces for you.

Grouping: Pairs

Time: One-and-one-half hours

PROCEDURE
Engage: Read The Doorbell Rang. Have the students figure what fractional part and how many cookies each child would get on each page. Ask the students to imagine: They have a friend with two cookies. The friend is going to share the cookies with three friends. She cuts the cookies exactly in half. You say that you want the larger half. How could this be possible? Let the students discuss this as a class. It is all right to not come up with the answer. The next activity will give them a clue.
Explore: Give each pair their pieces of adding machine tape. Have them take one piece and divide it into equal halves. Ask the students “Who has the largest half?” Follow by asking “Who has the smallest half?” Then have one student from each pair bring up their half and arrange themselves in order from smallest to largest. Then have the other partner do the same with thirds. If the students have problems making thirds, ask if anyone has folded a letter into thirds to fit it into an envelope and have them demonstrate. If no one has, then demonstrate yourself. Allow them to use a second strip, if they discover that their thirds are not equal.

Explanation: Discuss why the halves and thirds of the same item are not all the same size. Now explain to the students that you want them to consider the strips as a portion of the whole and that you want them to make the wholes.

Elaboration: Start by pretending their thirds are half of a whole. Then have them cut a strip into fourths and pretend it is one-third of a whole. Have them find the length of the whole. Give rulers or yardsticks to students, as a hint to solve the problem. For a challenge say a piece is two-thirds of a whole.

Evaluation: Have them write why all halves or fractions are not the same size. (Adapted from Quest 2000 benchmark p. 79).

(This lesson is adapted from Quest 2000 Teacher’s and Journal, Grade 3 pages 330-331.)
Lesson 7: Partitioning Shapes

Objectives:
1. Students will write a fraction word problem.
2. Students will find different ways to partition a shape.
3. Students will review that all halves, thirds, etc. are not the same size.
4. Students will practice writing fraction equations for shapes. (Grades 3-5)

Materials: Power polygons.
Ziploc bags. (Optional Fraction Practice computer program)
Chart paper or tagboard

Preparation: Arrange power polygons into Ziploc bags for seven to ten groups.

Grouping: Three to four students per group

Time: 1 hour and 45 minutes.

PROCEDURES

Engage: Have students find different ways to partition shapes made of only hexagons or large squares from lesson 4. (Adapted from Quest student text page 125.) Chart different solutions.

Exploration: Give groups a power polygon and tell them that it is a fraction, start with half, of a whole and have them make the whole shape. Then do the same with the piece being a third and a fourth. Have the third to fifth grade students write an addition equation for each shape. For a challenge (or for a regular fourth or fifth grade assignment) say a rectangle and later a hexagon, since it is more difficult and better for fifth grade, is two-thirds of the shape and what does the whole look like? (Adapted from Quest student text pages 126-127.)
Explanation: Discuss multiple solutions and addition equations for the exploration above. (Optional: explain Fraction Practice computer program.)

Elaboration: Add to the earlier group list of ways to use fractions. Have the students write their own fraction story problems in groups. If they appear to be unsure whether they can do that, start by making some class ones. With the list of ways fractions are used in front of them, some students will usually be willing to venture an answer. If necessary the teacher or a student can change the original student’s problem slightly. Once the groups have written some problems, have groups trade their problems with another group and solve each others’ problems. Finally, as a class discuss difficulties encountered while writing and solving problems, as well as favorite ideas or problems.

Evaluation: Have students write their own fraction word problem. Students will be able to draw a shape of their choice, show two or more ways to correctly partition it, and write an appropriate addition equation for it.
Lesson 8: Fractions of Food and Equations

Objective: 1. Students will review partitioning.
2. Students will write addition and/or subtraction equations for sharing of food. (Grades 3-5)

Materials: Plain white paper,
Foods, such as juice or milk, fruit, cheese slices, cookies, or crackers, which a few students bring in to share with the class.
Knives, forks, plates, cups, napkins and any other things you may need to accompany the above items.
(Optional AIMS "Fraction Fondue" activity for grades 3-5 or Gobble Up Math a K-2 book.)
Calculators, which have fractional solutions.

Preparation: Ask a few or all students to bring in the above foods and other necessities.
(Optional make copies of the AIMS "Fraction Fondue" activity and the page following this lesson or a few pages from 101-118 of Gobble Up Math.)

Grouping: Groups of three to four students

Time: One to two hours depending on which activities you are doing. (Be careful to allow adequate time for this activity.)

PROCEDURE

Engage: Have students share orally about the foods they shared in groups last week. Ask "How can addition, subtraction, multiplication and/or division of fractions be applied to what you did?"

Explanation: Explain and/or discuss the following:
1. different ways to divide a food and a section of a food.
2. how all of the parts of a whole add up to a whole.
3. how subtraction can be used to show
a part, which is gone or eaten.
4. how multiple additions of the same size part can be multiplication.
(If you want to introduce division try to keep it simple and connect it to regular division and the related multiplication fraction problem. Examples might include the following:
1. Dividing whole(s) or fractions between two people, who will each get one-half of the original amount.
2. To show when 8\(\div\)1/2=16 would be used, ask how many half dollars are in eight dollars. Many researchers and mathematics teachers suggest teaching multiplication and not division of fractions, since poor explanations and examples are often given by teachers.)

Exploration: Give the students foods and any worksheets you want them to do:
1. For the AIMS worksheet you will need to explain the chart after they have divided all of their fruits into sixteenths. The chart asks the students to share the fruits so that they each have sixteen-sixteenths. It asks how else could they have done this choosing more of some fruits and less of others to come up with sixteen pieces or parts again. Each time they do this they record it on the chart with the fruits’ names. This shows that lots of different fractions add up to one whole. At the bottom of the page they do equivalent fractions, which the students may need to review before attempting that part of the page.
2. Following this lesson you will find an extension page that I use with Fraction Fondue. When using it with third grade it is advisable to do all or most of the worksheet as a class. For fourth and fifth grades go over at least one of each kind of problem. Also have calculators available for all students,
if they want to use them.

3. If the Gobble Up Math pages are going to be used, they can be made more challenging by adding equivalence, multiplication, or division problems. Also students can make up one more addition or subtraction problem to go with each page.

4. If no pages are copied for the students to go with this activity, then have them answer in their groups the four things discussed in engage on the first page of this lesson plan.

Elaboration: To keep students from adding denominators (as Kerslake (1986) says often occurs), suggest that they imagine that they have some quarters and half dollars in their pocket and saying that they have the total number of either, when they know they have a combination of both. Of course, with the actual food pieces in front of them, it is usually pretty obvious. Have the students write about how they could add, subtract, multiply, divide and/or use equivalent fractions outside of the classroom.

Evaluation: Students will draw a favorite food, partition it and write a fractional equation about the food. Look at writing from above (in elaboration) about how to utilize fraction operations outside of the classroom.
Suggested addition to AIMS Fraction Fondue

1. \( \frac{1}{2} \) of \( \frac{1}{2} \) is ___
2. \( \frac{1}{2} \) of \( \frac{1}{4} \) is ___

3. \( \frac{1}{2} \) of \( \frac{1}{8} \) is ___
4. \( \frac{1}{2} \) of \( 1 \) is ___

5. \( \frac{1}{2} \div 2 = \) ___
6. \( \frac{1}{2} \div 4 = \) ___

7. \( \frac{1}{2} \div 8 = \) ___
8. \( \frac{1}{2} \div 3 = \) ___

9. \( \frac{1}{2} \div 5 = \) ___
10. \( \frac{1}{2} \div 16 = \) ___

11. \( \frac{1}{2} + \frac{1}{2} = \) ___
12. \( \frac{1}{4} + \frac{1}{4} + \frac{1}{2} = \) ___

13. How many other equations can you come up with that equal 1 whole? (10 or more?)

14. \( \frac{1}{8} \) of \( 16 \) is ___
15. \( \frac{1}{2} \) of \( 16 \) is ___
16. \( \frac{1}{4} \) of \( 16 \) is ___

17. How did you solve problem 14, 15, or 16?

18. On the back please tell me what you learned today, whether you had fun or not and why.
Lesson 9: Fractions and Art

Objective:
1. Students will fold and label strips into halves, thirds, fourths, fifths, sixths, eighths, tenths, and a fraction of their choice. (K halves, 1st fourths, and 2nd eighths)
2. Find equivalent fractions on an equivalency chart and/or by another method. (Grades 3-5)

Materials:
A colored and white sheet of 9x12 construction paper per student
Tape or glue
Origami book or activity (look for one with a fraction tie-in.)
Origami paper or wrapping paper cut into squares
Metric tapes
Student journals
Scissors
(Optional inch graph paper or multiplication table paper for grades four and five.)

Preparation:
Look through origami books or activities for one in which a fraction tie-in would work well. Good activities would have the students folding the paper into halves at times. The class could also hypothesize and check the fraction made by folding the paper subsequently in half. Directions involving folding a corner or side one-fourth of the way to the center, opposite side, or corner would be another way to use their knowledge of fractions.
Copy problem of the week for third to fifth grade students only.

Grouping: Pairs

Time: 1 hour 30 minutes

PROCEDURE
Engage: Have students in pairs cut eight or nine 20cm strips which are about 3 cm in width.
Then have the students fold three strips into halves, thirds, and fourths.

**Explanation:**
Discuss how the students found thirds and could do fifths. (Clue: the strips are 20 cm long.) Discuss how they can make sixths and tenths. Have them fold fifths, sixths, When they have finished making the strips, have them label the parts and arrange them with tape or glue them onto a white piece of construction paper so the left side of the strips are directly above each other.

**Explore:**
Explain or have the students figure how they can use their finished paper as an equivalency chart. As the pairs finish have them write equivalencies, as they find them on their charts. (For gifted and fourth or fifth grade students May (1992) and Coker and Cook (1992) suggest the following method to find equivalent fractions with uncommon fractions: 1. Have students write the multiples of two through nine in separate rows going across inch graph paper or use a multiplication table chart. 2. Cut the rows apart. 3. Lay the strips for the fraction they want an equivalent fraction for one above the other to find many equivalent fractions. If they are trying to figure how many fifty-sixths there are in three-eighths, then the students would put the three multiple strip above the eight multiple strip and follow the later out to fifty-six to find the numerator directly above it.)

**Elaboration:**
Have the class make an origami item using fractions in the directions, as much as possible. (For example: fold the square in half diagonally and then again making what fraction? Or fold the corner or edge down 1/4 of the way to the opposite corner or edge.) Then have students estimate how much of the white or lighter side shows in their final piece. Work an answer to problem of the week.
Evaluation: Check equivalency answers.
Have students write in their journals about how they made the origami shape.

PROBLEM OF THE WEEK

How many students like to play team sports?

If one-third of the class likes to play team sports, then how many students could there be in the class? There are several answers. Try to come up with more than one answer. In your work show the number of students who might be in the class and the number of those who like to play team sports for each answer.

(Adapted from Quest 2000 problem of the week 31.)
Lesson 10: Musical Notation  
(Best suited for grades 3-5)

Objective:  
1. Students will learn the fractional number for each note.  
2. Students will be able to compose music with the correct number of beats per measure.  
3. Students will review adding of fractions.

Materials:  
One transparency with blank musical measures per pair or group,  
One transparency pen per pair or group,  
Overhead projector,  
Samples of written music,  
An instrument or instruments.

Preparation:  
Make copies of the blank music paper and the samples of written music.  
Find someone to play or explain how to read notes and play the instruments.  
Label the instruments with note names, if it would be useful to the students.  
Make 5-15 overhead transparencies of the blank music sheet (for grades 3-5).

Grouping:  
Pairs or groups of three.

Time:  
One hour or more, especially if students will be playing instruments.

PROCEDURE  
Explanation:  
As a class go over the names of the notes, explain what time signatures are and how they are utilized, define measure and demonstrate how they are counted or thought of as one plays. Practice counting out a few measures as a class. Have students show how the notes in several measures add up to the time signature (fraction) as suggested by May (1994). Explain how where they place their notes affects how high or low the pitch will be. Encourage them to use a variety of notes.
Exploration: Have the students in groups write their own musical measures and record them on the transparencies.

Elaboration: When a few groups have finished, display them without names on an overhead projector and have the students count out the measures to see if they are done correctly. If you do not have instruments or people to play, then just clap or say the count of them out loud as they are displayed on the overhead. Play or let a gifted student play one or two that are done correctly. If some groups are unsure of how to correct theirs or are willing to have it shown on the overhead, please do so without giving group names. Let the class discuss what might be wrong or how they can improve. Then let the students add to their music and revise.

Engage: Teach the students where the notes are on an instrument and let them play their own tunes. Play every group's tune.

Evaluation: Have individual students write at least one measure or have them write a letter to a friend about how they learned to compose music. (Ask them to explain it as clearly as possible.)

(Adapted from Quest 2000 Teacher’s Guide and Journal page 333 Musical Notation and Mr. Thielacker, music teacher with the Fontana Unified School District.)
Lesson 11: Repartitioning and Decimal Fractions

Objectives:
1. Students will be able to find equivalent fractions through repartitioning (grades 3-5).
2. Students will learn decimal fractions for common fractions (K-2 for money only).
3. Students will review the metric system (grades 3-5).
4. Students will realize how important fractions are.

Materials:
- Crayons,
- Blank paper or paper with two of each item to be partitioned,
- Colored pencils (2 or more different colors) per group,
- Metric measuring tapes (grades 3-5),
- Math Curse by Jon Scieszka (grades 3-5)
- Fraction Action by Loreen Leedy,
- 100 square grid paper,
- Fraction circles, strips, rods, blocks or towers labeled with both fractions and decimal fractions,
- Base ten blocks or mod blocks,
- Box of colored chalk.

Preparation:
Make or label fraction circles, strips, rods, blocks or towers with fractions and decimal fractions, if they are not already labeled.
(Optional handout with two of several items to be partitioned and repartitioned.)

Grouping:
Groups of 2-4 students depending on the amount of available manipulatives.

Time:
Two hours.

PROCEDURE

Engage:
Ask the class to tell about different ways they have found to show that two fractions are equivalent. If no one comes up with repartitioning, then bring it up. You can probably connect it to drawings of
equivalent fractions. Have different students come up to the chalkboard to do the following:

1. Draw two objects, which are identical in size and shape.
2. Divide the two shapes into the same fractional parts.
3. Divide, repartition, or bisect each fraction of one of the shapes in half with a different color chalk.
4. Lightly shade in the same fraction on both shapes.
5. Label the fraction colored on the first shape.
6. Label the fraction colored on the second shape.
7. Give another name or label for the shapes, if they can think of one.
8. With different colored chalk represent any added equivalent fractions on the two shapes.

Explore: Do more of the above in groups with colored pencils instead of chalk. Then ask the students to color in a design on a piece of 100 square grid paper and then give the fraction for each color. Allow the children free exploration with the fraction strips, rods or towers.

Elaboration: Discuss discoveries during the repartitioning activity with colored pencils and free exploration with the fraction manipulatives. List things that come in groups of one hundred. Read "Lemonade For Sale" in Fraction Action to the students. Have students list the fractions that were represented by money in this selection. Then have students come up and write the decimal fraction equivalents. Ask if anyone knows when else decimal fractions are used and list them on the board. If students can not think of any other times when decimal fractions are used, then bring up that they are used in the metric system, in calculating grades, in determining honor roll, and in figuring military time (which
is often used on time cards when employees have to punch in on a time clock.

**Explanation:** Explain how to use base ten or mod blocks to represent decimal fractions. Tell them that today they are going to think of the 1,000 block as one. See if the students can then determine what fraction and then decimal will be represented by each of the other shapes. With mod blocks there are ten thin squares that when put together equal a one cube. Then as a class and in groups make several dollar amounts with the blocks. (For higher third grade students and fourth and fifth grade students demonstrate how to use decimals with the metric system.)

**Evaluation:** Read *Math Curse* to the third to fifth grade students. Have the students then write individually, in pairs, or in small groups about a day without fractions.
Preparation for Fraction Uses in Cooking

For this last activity students will rotate between stations or centers in groups. Parent or older student volunteers will be essential for the effectiveness of this lesson. The station activities will need to be explained to volunteers and students before embarking on the lesson. The order of rotation is also important to consider and demonstrate before starting the activities. Extra time should be allowed for the first rotation and for a discussion following the first session at the stations or centers.

Before implementing the rotation of the lesson it is essential that volunteers and students know what will be expected of them. Preferably without the students in the room, explain to each volunteer what they will be doing at their particular station or center. Acquaint the volunteers with any methods you would like them to encourage, especially those which may differ from those that are familiar to them. This would include instructing them on how students could use manipulatives, calculators or other materials and how to give hints rather than answers to student questions. Then ask for questions or suggestions. Next, when the students are in the room, explain what the students are expected to accomplish at each of the centers. This will provide a review for the volunteers. For the lesson to proceed efficiently, make expectations clear for each station and encourage questions and/or suggestions again.

The rotation between stations is also important to the efficacy of the activities at each station. It is important that the first group to attend the cooking station is knowledgable about fractions and measuring with customary measurement used in cooking.

Extra time is necessary for the first rotation. First the volunteers need to become familiar with what they are to accomplish with each group. Second it is beneficial to stop after the first rotation and discuss how things have proceeded, how they can be improved, and any other problems or suggestions that the students, volunteers, or teacher feel need to be addressed or discussed. This will make the remainder of the station sessions proceed much more efficiently. If the recipe the class has planned will take more than twenty minutes to prepare, then extra time will also need to be provided.
To make this lesson work for kindergarten through second grade there are a few modifications that should be implemented in the lesson plan and objectives. First of all the younger students would benefit by having a separate center to explore freely with the measurement utensils. They should also not be expected to cut a recipe in half unless they are working with whole number measurements. It is possible that the students could double a recipe without fractions, as a group by repeated additions. High students could probably double a recipe with fractions assuming that they use manipulatives. Calculators could also be used, just be careful to choose a calculator which gives fractions as solutions and make sure the volunteers and students know how they work. The Fraction Muncher program is too high for the majority of kindergarten to second grade students, so it should not be attempted.
Lesson 12: Fraction Uses in Cooking

Objectives: 1. Students will learn how to cut in half and/or double recipes. (or K-3)
2. Students will use fractions and/or customary measurement to make a recipe. (or K-3)
3. Students will review what they have learned about fractions.

Materials: Ingredients for the recipe,
Fractio n Munchers, a computer program for grades 3-5 only,
Fraction Action book by Loreen Leedy,
One or more 3x5 index or recipe cards per student,
Copy of the recipe on papers, a poster or chart,
Utensils to make the recipes and extras with which to freely explore,
Water and/or rice to use for exploration,
2 dishpans,
Calculators, which provide fraction solutions,

Preparation: Send home a letter asking parents to volunteer and/or provide needed ingredients or utensils for the recipes and exploration.
Copy recipe(s) onto a student paper or chart,
Make sure volunteers helping understand how to use the fraction keys on the calculators,
Ensure that volunteers know how to use the computer and Fraction Munchers program.

Grouping: Four groups of eight or less students.

Time: Two hours or longer. (This lesson may be made into two days by providing one hour and fifteen minutes the first day and the remainder of time on a subsequent day.)

Explanation: Explain centers and what the students with the volunteers will be participating in at each of the stations. Remember to ask
for and be open to questions and/or suggestions.

Engage:  
(Center 1)  Students prepare a recipe following directions and measuring ingredients using fractional measurements. Upper grades can combine this station with the following exploration one.

Exploration:  
(Center 2)  Students can freely explore customary measurement filling utensils used in cooking with water and/or rice over dishpans.

Elaboration:  
(Center 3)  Teach students how to double and cut in half a recipe. Review or teach how calculators are used for fractions. (K-2 should simplify or skip.)
Explain the keys and give some examples, if necessary. Calculators may be used to do the calculations or to check the solutions. (Suggested by May 1994.)

Evaluation:  
(Center 4)  Read “Teacher’s Test” from Fraction Action to the students. Then have the students write their own teacher’s test or fraction story.

Evaluation:  
(Center 5)  (grades 3-5)  Explain the Fraction Muncher program to the students. Let students work on the program in pairs, while the others write and/or tell of their favorite fraction activities or lessons.
Multiple Intelligence Centers

1. Listening station - Students listen to tapes of musical measures and a look at a worksheet with several measures, where the students can order the measures or decide which one of two or three are playing. Pairs or groups doing this activity together can compare and discuss their individual answers to see what makes more sense.

2. Recording station - Students will use a written musical composition, which needs to have some measures corrected. They can correct the paper and then count it orally into a tape recorder.

3. Art center - The students will make a quilt using various colors of squares and/or triangles or another shape which tessellates. Figure the fraction of each color. Draw an original symmetrical design, partition it, color it, and provide the fraction represented by each color. Fold the design and make sure that it is partitioned correctly.

4. Reading center - Students read a book about the history of a quilt. Have them share it with their partner or group. Then as a group try to figure how to make an origami shape.

5. Writing center - Students invent a game which uses fractions. Write the rules. Make a game board. Play the game with others to make sure it works.
APPENDIX E: ACTUAL STUDENT INFORMATION

Prior Knowledge and What Students Want to Learn

This is what my students knew about fractions:

1. Fractions are a type of math.
2. Sometimes you use different shapes with fractions.
3. You have to color parts of a fraction and leave some not colored or shaded.
4. If you do it backwards (reverse the top and bottom numbers of one of the fractions), it is multiplication.
5. Fractions are used at work.
6. In three-fourths, the three is the number shaded and the four is the number of parts.
7. Fractions are shapes.
8. Some are colored in and some are not.
9. Fractions can be anything - like a box, a book, cups, and bowls.
10. This is a picture of a fraction.
11. A fraction is a circle that has half of it colored.
12. The circle does not have to have half colored.
13. A fraction is something that might be colored on one side and the other side is not.
My Students Wondered the Following Things about Fractions:

1. How many fractions are there?
2. Can we use them to play games?
3. Can you put a big number where the little one is?
   Can you put a bigger number where the big number is?
4. How do we make fractions?
5. How to do times all the way up? (RSP student - her other questions were related to fractions, but she wanted to keep this one.)
6. Do you count half squares as halves or wholes?
7. Do all fractions have squares in them?
8. Is there a sign for fractions? (Something that shows it as a fraction?)
9. Can fractions be used at the grocery store?
10. Can fractions be used at a bank?
11. Can fractions be used to measure things?
12. Can fractions be used to give money?
13. Is it the opposite of division?
14. Is a fraction like five squares with two colored?
15. Do fractions help students do their work?
My Students Want to Learn the Following about Fractions:

1. How to do fractions.
2. How to use fractions.
3. How do they help people?
4. When to use fractions.
5. What is a fraction? (What does fraction mean?)
6. How to turn fractions around to use in times.
7. Why are there fractions? (Do we really need fractions?)
8. Is there something related to fractions?
9. Can you use fractions to count things?
10. Are fractions important? (Why do we need fractions?)
11. Where do we use fractions?
12. Can we use fractions when we are teaching someone?
13. Who invented fractions? (To find out the students decided they could look in an encyclopedia, or on the computer.)
14. How can we use fractions in art and science?
15. Can we use fractions as numbers?
16. How do you make one-half of a circle divided into twelfths?
Student Questions That Came Up During Lessons

What does \( \frac{8}{4} \) look like?

\[
\frac{8}{4} = 2 = \frac{4}{4}
\]

\[
\frac{4}{2} = \frac{4}{2} = \_
\]

Is the shaded portion:

a. \( \frac{2}{2} \)

b. \( \frac{1}{2} \)

c. \( \frac{4}{2} \)

Are there remainders in fractions?

What is the pattern?

\[
\frac{4}{8} = \frac{2}{4} = \frac{1}{2} \quad (\text{Does 1/2 of work?})
\]

\[
\frac{10}{40} = \frac{5}{20} = \frac{1}{4}
\]

\[
\frac{6}{12} = \frac{3}{6} = \quad \frac{4}{4} = \frac{8}{8} =
\]

What fraction is shaded in here?
Which is bigger 4/8 or 9/4?
How many 1/8 cups are there in 1/4?
What is 1/2 of 1/4?
If you have 8/4 and take away 1/2, then how much will you have?
What does 1/2 round to?
What is 1/2 of 4?
Three people had six pizzas. How much did each person get?
What does 12/12 mean?
What is 10/80?
Does 1/2 + 2/2 = 1 1/2?
If this is 1/5 of the candy bar, then how big is the whole candy bar?

Joseph had half of the basketball cards. There were 60 cards. How many did he have?

What is shaded? (It is not 8/12.)

What is shaded? (Clue make them the same size.)
Parent Involvement in Homework Provides Insight

Textbooks of the past and many of the activities in current textbooks have prepartitioned shapes and have the students shade in a fraction, but students need to be able to partition shapes on their own. A greater quantity of partitioning activities need to be included in fraction units. These activities will help children learn where the center of circles are and how to divide circle shapes equally using radii.

One of my students came in with an interesting response to Quest 2000 Review and Practice page 114, which I had assigned for homework. The page asked the students to divide up several foods to serve various numbers of guests. This G. A. T. E. potential student probably had some help at home with the assignment because the foods came divided into more portions than necessary. Yet it led to an interesting lesson. The initial attempt to explain it to the student individually failed. The next day it was introduced to the class and met as a challenge. They were able not only able to clearly explain to her how to share the forty slices of food among ten people, but they also came up with the appropriate fraction for each person’s portion. Beyond that the students came up with several similar problems and different students explained their solutions. This kind of problem can be added for fourth, and fifth graders, as well as for more capable third grade students.

Kindergarten students can partition foods that they draw or make into halves, while first grade students could partition to fourths, and second grade students, eighths.
REFERENCES


