Texas Council of Teachers of Mathematics
TCTM
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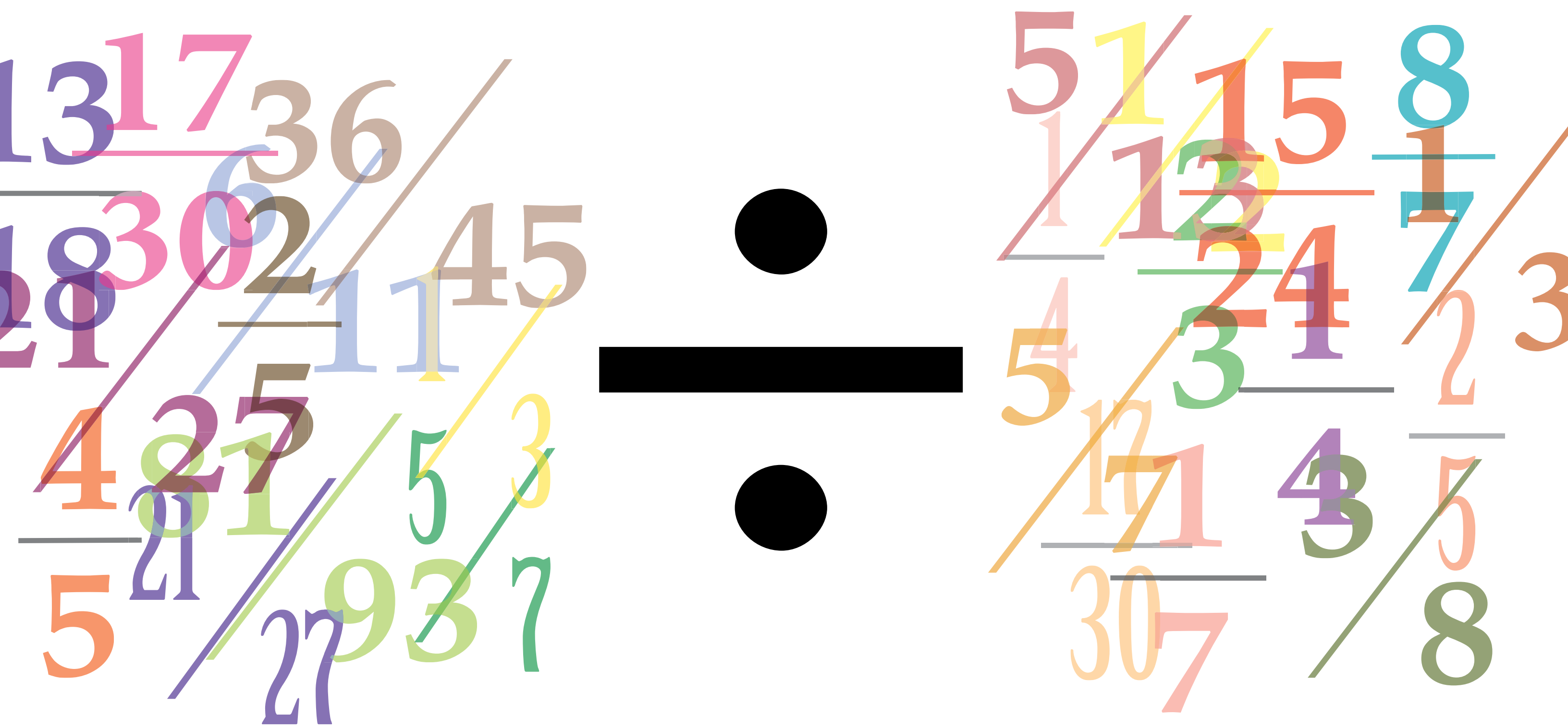
Texas Mathematics Teacher

Volume LII Issue 2 Fall 2005



Fraction Division

A visual guide

page 6

Check the Back Cover
for your membership card
and renewal date

Interested in Algebra Curricula? *see page 22*

http://www.tctmonline.net/

Texas Council of Teachers of Mathematics
2005-06 Mission and Goals Statements

MISSION

To promote mathematics education in Texas

GOALS

Administration
- Investigate online membership registration through CAMT and/or the TCTM website

Publications
- Survey membership to identify what they want in the Texas Mathematics Teacher (TMT)
- Review and redesign the TMT journal and the TCTM website
- Improve the review protocol, establish criteria for reviewers
- Provide tips for new teachers in the TMT and on the website

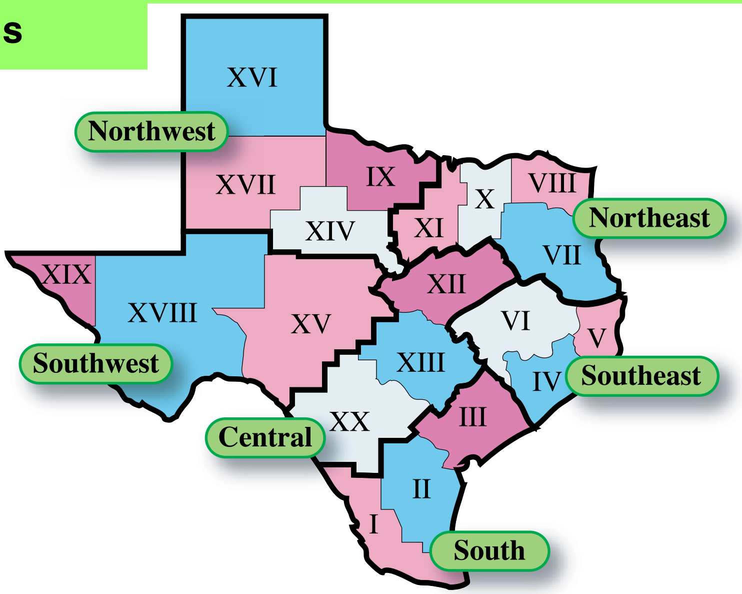
Service
- Increase the donations toward Mathematics Specialist College Scholarships
- Staff CAMT with volunteers as necessary
- Advertise affiliated group conferences on the TCTM website, in the TMT and at CAMT

Communication
- Maintain an e-mail list of members for timely announcements
- Communicate with affiliated groups in a timely manner

Membership
- Encourage affiliated groups to include TCTM registration on their membership forms

Public Relations
- Sponsor and staff the TCTM booth at CAMT
- Follow NCTM Advocacy Toolkit (2004) for increased voice of TCTM membership on issues relevant to our mission

TCTM Regions



TCTM Past-Presidents

1970-1972	James E. Carson	1982-1984	Betty Travis	1994-1996	Diane McGowan
1972-1974	Shirley Ray	1984-1986	Ralph Cain	1996-1998	Basia Hall
1974-1976	W. A. Ashworth, Jr.	1986-1988	Maggie Dement	1998-2000	Pam Alexander
1976-1978	Shirley Cousins	1988-1990	Otto Bielss	2000-2002	Kathy Mittag
1978-1980	Anita Priest	1990-1992	Karen Hall	2002-2006	Cynthia Schneider
1980-1982	Patsy Johnson	1992-1994	Susan Thomas		

Texas Mathematics Teacher

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Volume LII Issue 2 **Fall 2005**

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Texas Mathematics Teacher (ISSN# 0277-030X), the official journal of the Texas Council of Teachers of Mathematics, is published in the fall and spring. Editorial correspondence should be mailed or e-mailed to the editor.

Call For Articles

The ***Texas Mathematics Teacher*** seeks articles on issues of interest to mathematics educators, especially K-12 classroom teachers in Texas. All readers are encouraged to contribute articles and opinions for any section of the journal.

Manuscripts, including tables and figures, should be typed in Microsoft Word and submitted electronically as an e-mail attachment to the editor with a copy to the director. No author identification should appear on or in the manuscript. A cover letter containing author's name, address, affiliations, phone, e-mail address, and the article's intended audience should be included. After refereeing, authors will be notified of a publication decision.

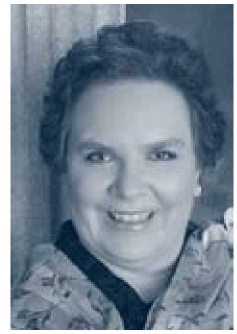
Teachers are encouraged to submit articles for ***Voices From the Classroom,*** including inspirational stories, exemplary lessons, or management tools. If submitting a lesson, it should include identification of the appropriate grade level and any prerequisites.

Items for ***Lone Star News*** include, but are not limited to, NCTM affiliated group announcements, advertisements of upcoming professional meetings, and member updates.

Businesses interested in placing an **advertisement** for mathematics materials should contact Mary Alice Hatchett.

Deadline for submissions: Fall, July 1 Spring, January 1

Letter from the President



Dear TCTM Members,

I apologize for the delay in the production and distribution of this journal. There are, of course, no excuses. I can provide only the honest explanation that work and family responsibilities took precedent over completing this responsibility. I know many of you may be disappointed in your TCTM membership because you have not received this service in a timely manner. I respectfully request your understanding and hope you find the information provided of sufficient value to overcome your disappointment.

Because of the lateness of this edition, you will see an important change to the CAMTership award and eligibility rules, implemented by the TCTM board in January. We will now be awarding eight $500.00 CAMTerships. To be eligible to apply, you need to be a classroom teacher with five or fewer years of teaching experience (previous winners are not eligible). You must apply by the May 31, 2006 deadline. Winners will be determined by random drawing and will be required to work two hours as a volunteer at CAMT. Additional information is on the application.

I want thank all the volunteers that worked at CAMT 2005, both in the registration area and at the TCTM booth. We had a lot of walk-up help that was invaluable. Every year we get new volunteers and it is so nice to see young, fresh faces learning the ropes from behind the scenes. I also notice a core group of volunteers that return each year to help all around the conference. Your expertise and ongoing support are very much appreciated.

Another group of volunteers helped review the many articles we receive for the journal. I want to thank Mary Alice Hatchett and Geoff Potter for the wonderful support they give me in producing the journal. If you would like to be a reviewer for the journal, please contact Mary Alice, or me, our contact information is listed on the inside back cover of this journal.

With CAMT Board changes in the registration policies for 2005, TCTM membership is now at more than 3,500 mathematics educators across Texas. The registration process for CAMT 2006 will support our membership even more. All paid participants at CAMT 2006 will be given a complimentary membership in TCTM. The dues will be donated by CAMT to TCTM. Paid participants may opt to decline the free membership if they wish. With this change we may become one of the largest NCTM affiliates in the country. The added membership will increase our status as we reach out to the State Board of Education and the Texas Legislature with our opinions on policies related to mathematics education. Since speakers are given a complimentary registration at CAMT, they will need to pay for their TCTM membership. However, we do provide a reduced membership rate of $10.00 when submitting through CAMT. I hope all speakers take advantage of this opportunity.

The membership voted the following nominees into office: President-Elect: Jo Ann Wheeler of ESC Region IV; Vice-President Elementary: Angela Murski of Pflugerville ISD; South Regional Director: Barba Patton of the University of Houston-Victoria; Southwest Regional Director: Rebecca Ontiveros of ESC Region 19; and Southeast Regional Director: Paul Gray of ESC Region IV. For my last year in office, I have made several changes to the TCTM Board. This includes the following appointments: NCTM Rep: David McReynolds of ESC Region IV; Government Relations Rep: Garland Linkenhoger from McAllen; and CAMT Board Rep: Nancy Trapp of Lyford ISD.

I hope many of you have the opportunity to attend the NCTM Annual Meeting in St. Louis in April. If you have questions or concerns you would like to share with me, please do not hesitate to contact me.

Sincerely,

Cynthia L. Schneider
TCTM President 2004-2006

Lone Star News

Affiliate Groups

These are local affiliated groups in Texas. If you are actively involved with them, please send future meeting and conference information to Cynthia Schneider at *<cschneider@satx.rr.com>* so we may publicize your events. Contact information for each group is available on the NCTM website,

http://www.nctm.org

Contact information for regional directors is located on the inside back cover.

SOUTHWEST REGION: *Service Centers 15, 18, 19*

Rebecca Ontiveros, Regional Director

Greater El Paso CTM
Annual fall conference; regular meetings throughout the year. Contact: Bob Kimball *<kimball2rc@gmail.com>*.

SOUTHEAST REGION: *Service Centers 4, 5, 6*

Paul Gray, Regional Director

Fort Bend CTM
Holds a short meeting in August, a fall mini-conference, a spring mini-conference and an end-of-year banquet to serve the districts of Alief, Fort Bend, Katy, and Stafford. Contact: Jan Moore, *<Jan.Moore@fortbend.k12.tx.us>* or Susan Cinque, *<olsoncinque@alltel.net>*.

Houston CTM

1960 Area CTM
Holds two meetings and one competition a year to serve the districts of Aldine, Klein, Katy, Humble, Tomball, Spring, and Cypress-Fairbanks. Provides scholarships for students in mathematics education and awards for local mathematics education leaders. Contact: Sheila Cunningham, *<scunningham@kleinisd.net>*.

NORTHWEST REGION: *Service Centers 9, 14, 16, 17*

Nita Keesee, Regional Director

Big Country CTM & Science
Will hold their annual conference January 28, 2006. Contact: Leslie Koske, *<lkoske@esc14.net>* or 325-675-8661.

Texas South Plains CTM
Thirteenth Annual Panhandle Area Mathematics and Science Conference, September 30, 2006, Canyon, TX. Contact: Gilberto Antunez, *<gantunez@mail.wtamu.edu>*, or see *http://www.wtamu.edu/academic/ess/edu/*

NORTHEAST REGION: *Service Centers 7, 8, 10, 11*

Jacqueline Weilmuenster, Regional Director

East Texas CTM

Red River CTM
STEAM (Successfully Training Educators As Mathematicians) is held every four years at the campuses of Texas A&M University-Texarkana and Texarkana College, Contact: Debra Walsh, *<dwalsh@redwater.esc8.net>* or Susie Howdeshell, *<showdeshell@pgisd.net>* or see *http://www.tamut.edu/~rrcmath/*

Greater Dallas CTM
Holds two mathematics contests (W. K. McNabb Mathematics Contests) for students in grades 7 - 12 - one in the fall (early Nov.) and one in the spring (early April). A banquet in May is held for the winners. Contact: Tom Butts, *<tbutts@utdallas.edu>* .

SOUTH TEXAS REGION: *Service Centers 1, 2, 3*

Barba Patton, Regional Director

CTM @ Texas A&M University at Corpus Christi (Student Affiliate)

CTM @ Texas A&M University at Kingsville (Student Affiliate)

Rio Grande Valley CTM
The 41st annual conference, Saturday November 18, 2006, at the University of Texas - Pan American, Edinburg, Texas, from 8:00 to 4:00 p.m. Contact: Nancy Trapp, *<nancy.trapp@lyfordcisd.net>* or see
http://www.rgvctm.org

CENTRAL TEXAS REGION: *Service Centers 12, 13, 20*

Patricia Rossman and Scott Fay , Co-Regional Directors

Austin Area CTM
Holds a fall conference in October and spring meeting May 2, 2006. Contact: Carol Lindell, *<clindell@taylor.isd.tenet.edu>* .

Alamo District CTM
Normally holds a fall and spring conference. Contact: Kathy Mittag, *<kmittag@utsa.edu>*, or see
http://www.adctm.net

Central Texas CTM
Holds a fall meeting and a spring mini-conference on March 4, 2006, in Waco at the Region 12 Service Center. Contact: Trena Wilkerson, *<Trena_Wilkerson@baylor.edu>* or see
http://www.baylor.edu/soe/ctctm

NON-AFFILIATED CONFERENCES

The Fifth Annual San Antonio Science and Mathematics Saturday, October 2006, at San Antonio College, San Antonio, TX. Contact: Roger Kramer, *<roger.kramer@harlandale.net>* .

STATEWIDE

Texas Association of Supervisor's of Mathematics (TASM) Spring Meeting February 1-3, 2006 in Austin. For membership and registration information, please see

http://www.tasmonline.net/

Membership is required to register for this meeting.

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Making Fraction Division Concrete:
A New Way to Understand the Invert and Multiply Algorithm

Introduction

"Ours is not to reason why, just invert and multiply." This is a rhyme that I remember learning way back in the fifth grade. Fifteen years later, at the beginning of my career as a mathematics teacher, I found that I wanted to give my students more than instruction on what to do to get the right answer. I wanted them to understand why the mathematics made sense. Fast forward the clock and twenty-five years after fifth grade I began an earnest quest to discover why the "invert and multiply" algorithm for fractions made sense. Oh, I knew about the algebraic manipulations and the use of complex fractions to prove that $\frac{a}{b} \div \frac{c}{d}$ actually does equal $\frac{a}{b} \times \frac{d}{c}$, but that wasn't what I was looking for. I wanted a strategy that I could use to develop the algorithm using concrete materials and mathematical concepts that were accessible to an upper elementary or junior high student.

My quest paid off and my objective for this article is to share the logic and reasoning involved in fraction division and the step-by-step construction of a concrete model using Cuisenaire® Rods that the experienced teacher can use as a guide when developing lessons for naïve learners. While other excellent fraction division activities using Cuisenaire® Rods are available, this article goes further than most of those activities. It also:

- Constructs fraction division as an extension of whole number division and fraction multiplication;
- Illuminates not just that the algorithm works, but also why the algorithm makes sense; and
- Facilitates the development of strong estimation strategies and skills.

Part 1 of this article revisits the language and meaning of division with whole numbers as a springboard for constructing the meaning of division when fractions are involved. Part 2 presents a sequence of fraction division examples that can be modeled with the Cuisenaire® Rods. These examples are designed to illuminate the meaning of fraction division, set up strategies for estimating the quotients, and finally, to establish a pattern that will be analyzed in Part 3 and then linked to the logical construction of the "invert and multiply" algorithm in Part 4.

A Brief Word About Readiness

Before I launch into constructing the logic of the fraction division algorithm, it is important to take a brief moment to list the concepts that a student needs to know and understand in order to be ready to learn why the invert and multiply algorithm makes sense. The following readiness concepts provide the foundation upon which the fraction division concepts developed in this article can be constructed:

- The language and meaning of fractions and fraction notation (vocabulary, the information communicated by the numerator and denominator, etc).
- The language and meaning of multiplication with whole numbers and fractions (vocabulary, the information communicated by the factors and the product, multiplication as a representation for multiple[1] groups of a fixed quantity, etc).
- Why the traditional fraction multiplication algorithm (numerator times numerator over denominator times denominator) makes sense.

None of these concepts are developed in this article, however a companion article, entitled "Fraction Multiplication" (Rusch, Texas Mathematics Teacher, Spring 2005), develops all of these readiness concepts with an eye toward setting the stage for developing the fraction division concepts addressed here.

A Note About the Strategies Used to Develop the Concepts

There are two strategies I use to develop the fraction division model when working with my own students.[2] Since my students have found these strategies to be helpful, I will also use them in this article. The

[1] In the case of fraction multiplication, "multiple groups" may include a fractional part. For example: $\frac{5}{8}$ of a group of $\frac{1}{3}$ or $3\frac{1}{2}$ groups of $\frac{3}{4}$.

[2] Pre-service teachers in both mathematics content and mathematics methods coursework and experienced in-service teachers participating in professional development courses and workshops.

first strategy is to begin with very simple examples and then methodically increase the complexity of those examples while emphasizing the logic that links one to the next. The second is to emphasize the use of formal language as a tool to illuminate the connections from one example to the next. The simplicity that may be evidenced in the examples and the explanations are in no way intended to insult the reader. Instead, they are designed to highlight the logical connections between concepts that are comfortable and the new concepts that are being constructed.

PART 1: Setting the Foundations

Revisiting the Language And Meaning of Division

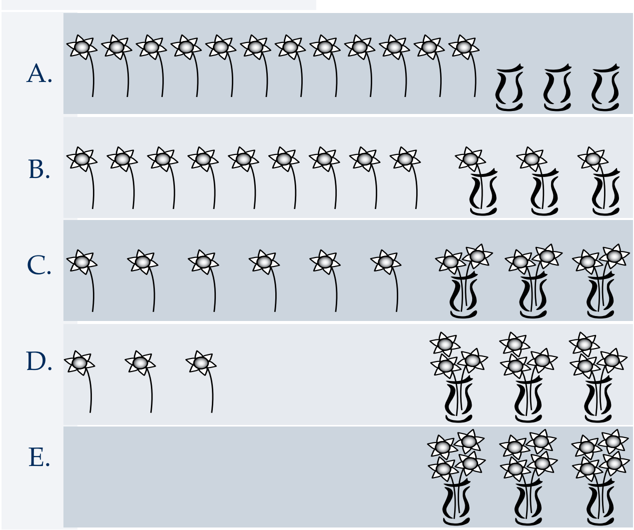
One of the key factors to constructing an understanding of fraction division and the "invert and multiply" algorithm is having a clear and precise understanding of the information being communicated by the dividend, divisor and quotient, and then using that language very consistently throughout the development of the new concepts and connections. The language and meaning of division is a bit more complicated than the language and meaning of multiplication because the information communicated by the divisor and the quotient are dependent on the context of the problem. For example:

Context #1:

I have 12 flowers and 3 vases. I want to put the same number of flowers in each vase. How many flowers will each vase get?

12 ÷ 3 = 4

To illustrate the division process for this context (partitive division), I begin with three vases and distribute the 12 flowers equally among those vases:



In the "partitioning" context pictured above, the dividend communicates the quantity you begin with, the divisor communicates the number of groups, and the quotient communicates the quantity in each group:

12 is the dividend.

It tells you the quantity *you begin with.*

3 is the divisor.

It tells you the quantity *of groups.*

12 ÷ 3 = 4

4 is the quotient.

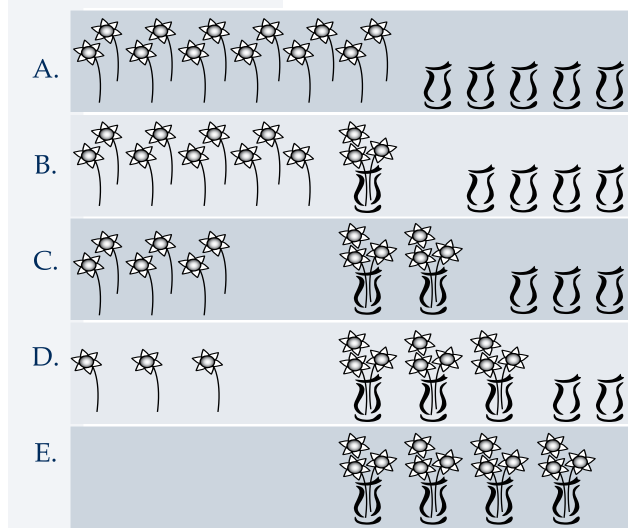
It tells you the quantity *in each group.*

Context #2:

I have 12 flowers and some vases. I want to put 3 flowers in each vase. How many vases will I need?

12 ÷ 3 = 4

To illustrate the division process for this context (measurement division), I begin with some vases and distribute the 12 flowers so that there are three flowers in each vase:



In the "measurement" context pictured above, the dividend again communicates the quantity you begin with, but this time the divisor communicates the number in each group, and the quotient communicates the number of groups.:

12 is the dividend.

It tells you the quantity *you begin with.*

3 is the divisor.

It tells you the quantity *in each group.*

12 ÷ 3 = 4

4 is the quotient.

It tells you the quantity *of groups.*

The fraction division algorithm is much more easily developed using the second context, so from this point on all of the examples will model the second (or the "measurement") context. In all of the following examples, I will emphasize statements that define the dividend, divisor and quotient as follows:

Dividend
The amount you begin with.

Divisor
The size of each group.

a ÷ b = c

Quotient
The number of groups of the divisor in the dividend.

and the division statement will always ask: "How many groups of the divisor can I get from the dividend?"

PART 2: An Introduction to Fraction Division Using Cuisenaire® Rods

A Concrete / Pictorial Development of Fraction Division

This section provides a series of examples that are designed to construct a framework for reasoning that will lead to an understanding of the meaning of fraction division, strategies for estimating the quotients, and ultimately shed light on the logic underpinning the "invert and multiply" algorithm. These examples begin with very simple tasks, and then the complexity of the tasks gradually increases. When I'm working with my students I ask them to bear with me through the simple tasks – there is more challenge coming and the simple tasks will serve a purpose later on down the road.

The standard symbols for Cuisenaire® Rod colors are in the following table.

Symbol	Color
w	white
r	red
lg	light green
p	purple
y	yellow
dg	dark green
bk	black
br	brown
b	blue
o	orange

An important part of the Cuisenaire® Rod exploration tasks is data collection. While the explorations serve to illuminate the logic and meaning of fraction division and provide an opportunity to develop estimation strategies, the data collected and recorded during the explorations will later be used to discern the patterns that will help illuminate the logic of the fraction division algorithm. As I work through the exploration tasks here I'll model a helpful strategy for recording the data. I'll explain how to use the data in the table in Part 3, after all the data has been collected and recorded.

Although I provide pictures for the examples presented, I think it might be very helpful (and certainly more fun!) to pull out a set of Cuisenaire® Rods and work through the tasks concretely as I present the pictorial and abstract representations. When I work through the questions in each example with my students I watch them carefully and wait until they have had enough time to find the rods they need and they begin to register the concrete connections before I proceed to the next question or example. This is especially important in the initial examples while the students get used to the rods and how to represent a fraction of the unit using another color rod. For the purposes of efficiency in this presentation however, I have listed all the questions for each example as a group and I have shown only a picture of the model that the students are likely to construct in order to answer the division question asked.

In this section, the dividend is always one and every division question asks "How many groups of … are in one whole?" The reason for this strategy will become clear in Part 3.

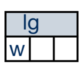
Example #1: Let the orange rod represent one whole.

What color rod would represent $\frac{1}{10}$ of the whole?
How many groups of $\frac{1}{10}$ are in one whole?

To help emphasize thinking that will support using reasoning to determine the quotient, I introduce the division question using "symbolic" terms, but then restate the problem using "visual" terms. For example, I would initially pose Example #1 with the symbolic statement "How many groups of $\frac{1}{10}$ are in one whole?" but then almost immediately restate the question using visual terms: "How many groups that are the size of the white rod can I make from the orange rod?" It is not at all unusual for me to need to restate the problem in visual terms multiple times. Once the students have determined the quotient in visual terms (i.e., that there are ten groups that are the size of the white rod in the orange rod), I restate and answer the question in symbolic terms, "So there are ten groups of $\frac{1}{10}$ in one whole" to emphasize the connection between the concrete/visual and the symbolic representations. I have the students write out the verbal statement of the problem to reinforce the meaning of fraction division and facilitate development of estimation skills.

Example #2: Let the light green rod represent one whole.

> What color rod would represent $\frac{1}{3}$ of the whole?
> How many groups of $\frac{1}{3}$ are in one whole?



The white rods illustrate that one can get three groups of $\frac{1}{3}$ from the light green rod that represents one whole.

The next examples of data should be similarly modeled.

Example #3: Let the brown rod represent one whole.

> What color rod would represent $\frac{1}{4}$ of the whole?
> How many groups of $\frac{1}{4}$ are in one whole?

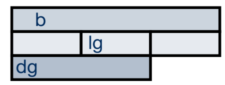
Example 4: Let the orange rod represent one whole.

> What color rod would represent $\frac{1}{5}$ of the whole?
> How many groups of $\frac{1}{5}$ are in one whole?

Example #5 below begins to increase the complexity of the reasoning by introducing divisors that are no longer unit fractions. As the examples are presented, I have found that it is important to repeatedly emphasize that the quotient tells us *how many groups of the divisor* are in the dividend. In this case, we want to know *how many groups of 2/3 can we get out of one whole*?

Example #5: Let the blue rod represent one whole.

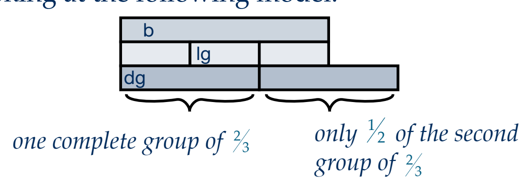
> What color rod would represent $\frac{1}{3}$ of the whole?
> What color rod would represent $\frac{2}{3}$ of the whole?
> How many groups of $\frac{2}{3}$ are in one whole?



This example provides a good place to introduce the thinking that will lead to reasonable estimation skills. Questions like the following begin to construct those estimation skills:

> *Before you determine the quotient, let's first try to determine a reasonable estimate by asking some questions:*
>
> > *Do you think there is more than one group of $\frac{2}{3}$ or less than one group of $\frac{2}{3}$ in our unit? Why?*
> >
> > *More than two groups of $\frac{2}{3}$? why?*

It is fairly easy for my students to decide that there will be more than one group of $\frac{2}{3}$ in the whole but less than two groups of $\frac{2}{3}$. What is not so easy is subsequently articulating that there are exactly $1\frac{1}{2}$ groups of $\frac{2}{3}$ in the whole, even when they are looking at the following model:



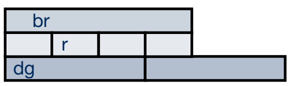
It is not unusual for students to incorrectly conclude that the quotient is $1\frac{1}{3}$. It takes some mental gymnastics to wrap themselves around the logic that suggests the correct quotient is $1\frac{1}{2}$.

When the students record the data from this example in their table, I ask them to record the information using mixed numbers. I specifically tell them not to convert the mixed numbers to improper fractions. I also tell them not to simplify any fractions. The rationale for not simplifying will become clear in Part 3.

Examples #6 through #19 provide similar tasks that develop a visual image as well as, the meaning of a fraction division statement. Asking the students to generate a reasonable estimate before determining the exact quotient helps to develop their estimation skills, and it also helps to refine the reasoning of why the quotient makes sense within the context of the problem. Examples #6 through #8 are of similar complexity. Example #9 introduces contexts in which there are more than two groups of the divisor in the dividend.

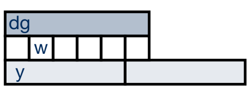
Example #6: Let the brown rod represent one whole.

What color rod would represent $\frac{1}{4}$ of the whole?
What color rod would represent $\frac{3}{4}$ of the whole?
How many groups of $\frac{3}{4}$ are in one whole?



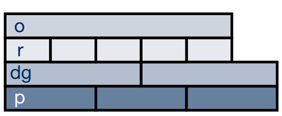
Example #7: Let the dark green rod represent one whole.

What color rod would represent $\frac{1}{6}$ of the whole?
What color rod would represent $\frac{5}{6}$ of the whole?
How many groups of $\frac{5}{6}$ are in one whole?



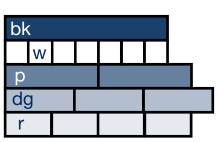
Examples #8 :Let the orange rod represent one whole.

How many groups of $\frac{3}{5}$ are in one whole?
How many groups of $\frac{2}{5}$ are in one whole?



Examples #9 : Let the black rod represent one whole.

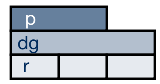
How many groups of $\frac{4}{7}$ are in one whole?
How many groups of $\frac{3}{7}$ are in one whole?
How many groups of $\frac{2}{7}$ are in one whole?



Finally, examples #10 through #13 ratchet up the complexity just one more notch by introducing a divisor that is greater than one. It is especially useful to have students generate a reasonable estimate before determining the quotient on these examples. First I'll pose Example #10, and then I'll go through the estimation reasoning before posing Examples #11 through #13.

Example #10: Let the purple rod represent one whole.

What color rod would represent $1\frac{1}{2}$?
How many groups of $1\frac{1}{2}$ are in one whole?



Before you determine the quotient, generate an estimate:

The question is asking "How many groups of the size of the green rod can we get out of the purple rod?"
Is there enough "quantity" in the purple rod to be able to create one complete group of the size of the green rod?
How does this inform our estimate?

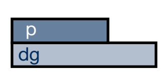
It can take students some time to figure out what to do when the divisor is larger than the dividend. I usually have a handful of students who resist exploring the question asked (How many groups of the size of the green rod can we make from the purple rod?) and instead, in their heads, revise the question to ask, "How many groups of the purple rod can we make from the green rod?" It is important for the teacher to keep up the intellectual "press" so that the students confront the dissonance head on and work through to a state of clarity in their understanding.

Very specifically linking the verbal "symbolic" with the verbal "visual" and the picture can be helpful:

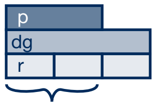
How many groups of $1\frac{1}{2}$ *are in one whole?*

How many groups of the size of the green rod can we get out of the purple rod?"

When the rods are stacked it becomes easier to see that there is not enough "quantity" in the purple rod for us to create a group the size of one green rod. It is possible to get part of a green rod, but not all of a green rod from the purple rod:



The quotient (the number of groups of the green rod that we can get from the purple rod) will be only part (or only a fraction) of one green rod. The red rods provide some help when trying to determine exactly what fraction of one complete group of the green rod can be garnered from the purple rod:



$1 \div 1\frac{1}{2} = \frac{2}{3}$

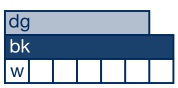
There is only ⅔ of a green rod in the purple rod.

Example #11: Let the dark green rod represent one whole.

What color rod would represent $1\frac{1}{3}$?
How many groups of $1\frac{1}{3}$ are in one whole?

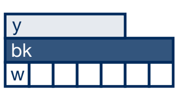
Example #12: Let the dark green rod represent one whole.

What color rod would represent $1\frac{1}{6}$?
How many groups of $1\frac{1}{6}$ are in one whole?



Example #13: Let the yellow rod represent one whole.

What color rod would represent $1\frac{2}{5}$?
How many groups of $1\frac{2}{5}$ are in one whole?



Color of the Unit	Statement in Words	Statement in Symbols	Change all divisors & quotients to mixed numbers
Orange	How many groups of $\frac{1}{10}$ are in 1?	$1 \div \frac{1}{10} = 10$	$1 \div \frac{1}{10} = \frac{10}{1}$
Lt. Green	How many groups of $\frac{1}{3}$ are in 1?	$1 \div \frac{1}{3} = 3$	$1 \div \frac{1}{3} = \frac{3}{1}$
Brown	How many groups of $\frac{1}{4}$ are in 1?	$1 \div \frac{1}{4} = 4$	$1 \div \frac{1}{4} = \frac{4}{1}$
Orange	How many groups of $\frac{1}{5}$ are in 1?	$1 \div \frac{1}{5} = 5$	$1 \div \frac{1}{5} = \frac{5}{1}$
Blue	How many groups of $\frac{2}{3}$ are in 1?	$1 \div \frac{2}{3} = 1\frac{1}{2}$	$1 \div \frac{2}{3} = \frac{3}{2}$
Brown	How many groups of $\frac{3}{4}$ are in 1?	$1 \div \frac{3}{4} = 1\frac{1}{3}$	$1 \div \frac{3}{4} = \frac{4}{3}$
Dark Green	How many groups of $\frac{5}{6}$ are in 1?	$1 \div \frac{5}{6} = 1\frac{1}{5}$	$1 \div \frac{5}{6} = \frac{6}{5}$
Orange	How many groups of $\frac{3}{5}$ are in 1?	$1 \div \frac{3}{5} = 1\frac{2}{3}$	$1 \div \frac{3}{5} = \frac{5}{3}$
Orange	How many groups of $\frac{2}{5}$ are in 1?	$1 \div \frac{2}{5} = 2\frac{1}{2}$	$1 \div \frac{2}{5} = \frac{5}{2}$
Black	How many groups of $\frac{4}{7}$ are in 1?	$1 \div \frac{4}{7} = 1\frac{3}{4}$	$1 \div \frac{4}{7} = \frac{7}{4}$
Black	How many groups of $\frac{3}{7}$ are in 1?	$1 \div \frac{3}{7} = 2\frac{1}{3}$	$1 \div \frac{3}{7} = \frac{7}{3}$
Black	How many groups of $\frac{2}{7}$ are in 1?	$1 \div \frac{2}{7} = 3\frac{1}{2}$	$1 \div \frac{2}{7} = \frac{7}{2}$
Purple	How many groups of $1\frac{1}{2}$ are in 1?	$1 \div 1\frac{1}{2} = \frac{2}{3}$	$1 \div \frac{3}{2} = \frac{2}{3}$
Dark Green	How many groups of $1\frac{1}{3}$ are in 1?	$1 \div 1\frac{1}{3} = \frac{3}{4}$	$1 \div \frac{4}{3} = \frac{3}{4}$
Dark Green	How many groups of $1\frac{1}{6}$ are in 1?	$1 \div 1\frac{1}{6} = \frac{6}{7}$	$1 \div \frac{7}{6} = \frac{6}{7}$
Yellow	How many groups of $1\frac{2}{5}$ are in 1?	$1 \div 1\frac{2}{5} = \frac{5}{7}$	$1 \div \frac{7}{5} = \frac{5}{7}$

PART 3: Making Connections

Completing a Data Table

I use a data table with my students that looks like the one pictured below. This table helps students make the connection between their concrete representations and symbolic representations when they complete the second and third columns. When they complete the last column, students should begin to discover that all of the quotients are the recriprocal of the divisor.

This pattern illustrates that whenever the dividend is one, the quotient is the reciprocal of the divisor.

Dividend — Divisor

$$1 \div \frac{2}{3} = \frac{3}{2}$$

Quotient

An alternate, and very helpful, way to state this discovery is: The reciprocal of the divisor always represents the number of groups of the divisor in one whole.

PART 4: Constructing the Invert and Multiply Algorithm [3]

This is it, the last step in the construction of the invert and multiply algorithm. The process to get from here to the end will rely on understanding and using the following concepts:

- In multiplication, one factor communicates the size of the group and the other factor communicates the number of sets of the group that we want. For example, 3 x 5 = 15 communicates that we have "three groups of five." If either or both of the factors contain a fractional part, the same "communication" applies. For example, $1\frac{1}{2} \times 6$ communicates that we have "one and one half groups of six." We can think of this as having one complete group of six, and an additional half a group of six. This reasoning is consistent with the distributive property: $1\frac{1}{2} \times 6 = (1 \times 6) + (\frac{1}{2} \times 6)$.
- In the model of division that we have used for this exploration, the dividend communicates the amount we begin with, the divisor communicates the size of each group, and the quotient communicates the numbers of groups of the divisor in the dividend. In more colloquial language, the quotient tells us how many groups of the divisor we can make from the quantity we began with (i.e., the dividend).
- From the explorations, data collection, and rewriting of the symbolic statements, we discovered that the reciprocal of the divisor tells us how many groups of the divisor we can make from the dividend.

Keeping these three concepts in mind, we'll take a look at the first illuminating example.

Example #1: Let the orange rod represent one whole.

What color rod would represent $\frac{1}{10}$ of the whole? How many groups of $\frac{1}{10}$ are in one whole?

The symbolic statement for this question, with the quotient, is $1 \div \frac{1}{10} = \frac{10}{1}$. The reciprocal of the divisor, 10/1, tells us that there are ten groups of $\frac{1}{10}$ in 1. Now suppose I began with two units rather than only one. My question would then be "How many groups of $\frac{1}{10}$ are in two wholes?" The concrete/pictorial and the symbolic representations would look like this:

$2 \div \frac{1}{10} = ???$

Since I know that there are ten groups of 1/10 in one unit, then it would make sense to think about two units as two sets of one unit:

$1 \div \frac{1}{10} = 10$ $\quad$ $1 \div \frac{1}{10} = 10$

This illustrates that I have one group of ten "one tenths" from my first unit, and a second set of ten "one tenths" from my second unit. Thinking this way, I could say that I am able to create two groups of ten from my two units. I can represent "two groups of ten" using symbols this way:

10 + 10

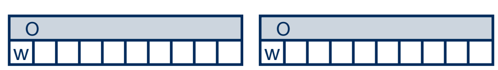
or I can represent it using multiplication this way:

2 x 10

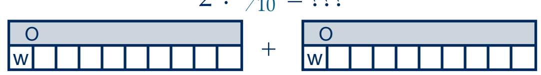
Now I'll put this all together so that it is easier to see the flow of the thinking. The original question asked "How many groups of 1/10 can I get from 2 units?" The picture and the symbolic statement are shown together.

$2 \div \frac{1}{10} = ???$

The next step in the thinking is to look at two units as two groups of one unit:



$2 \div \frac{1}{10} = ???$



$(1 \div \frac{1}{10} = 10) + (1 \div \frac{1}{10} = 10)$

[3] The understanding to be developed in this section is dependent on the student's prior understanding of both whole number and fraction multiplication. If the student's ability to explain the logic of the whole number and/or the fraction multiplication algorithms is weak, it is likely that it will be difficult for the student to grasp the concepts constructed below.

The number of groups of $\frac{1}{10}$ in two units is the same as the number of groups of $\frac{1}{10}$ in one unit plus the number of groups of $\frac{1}{10}$ in the other unit

Step three is to record the number of groups of 1/10 that can be made from the first unit and the number that can be made from the other unit.

$1 \div \frac{1}{10} = 10$ $\quad$ $1 \div \frac{1}{10} = 10$

There are ten groups of $\frac{1}{10}$ in the first unit and ten groups of $\frac{1}{10}$ in the other unit so I can represent this information by writing **10 + 10**

Step four is to restate the repeated addition statement as a multiplication statement:

Now, I can rewrite 10 + 10 as a multiplication statement by writing **2 × 10**

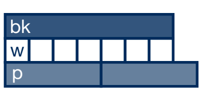
This reasoning process enables us to show that our original symbolic statement is the same value as the last symbolic statement.

$2 \div \frac{1}{10} = 2 \times 10$

This same reasoning can be applied to any fraction division statement to illustrate the logic that leads to the "invert and multiply" algorithm. To help show this, I'll walk through the steps of reasoning with one more example:

Example #2: Let the black rod represent one whole.

How many groups of $\frac{4}{7}$ are in three wholes?



The purple rod represents $\frac{4}{7}$ of the black rod. The picture shows that there are $1\frac{3}{4}$ purple rods, or $\frac{7}{4}$ purple rods in one black rod. Symbolically, I would write this as $1 \div \frac{4}{7} = \frac{7}{4}$.

The question asked is "How many groups of $\frac{4}{7}$ are there in three wholes?" Since I know that the reciprocal of the divisor tells us the number of groups of the divisor in one whole, I could illustrate the question being asked using the picture below to show that I have three sets of $\frac{7}{4}$ in three wholes:

$\frac{7}{4} + \frac{7}{4} + \frac{7}{4}$

This representation illustrates that

$3 \div \frac{4}{7} = \frac{7}{4} + \frac{7}{4} + \frac{7}{4} = 3 \times \frac{7}{4}$

And there we have it, the "invert and multiply" algorithm!

Summary

Both national and state standards documents, and the modern needs of our economy, suggest that students need to learn mathematics with understanding. Unfortunately, common justification for the fraction division algorithm depends on mathematics that is inaccessible to most students who are learning fraction division for the first time. Furthermore, those algebraic justification strategies show that the invert and multiply algorithm works; that $\frac{a}{b} \div \frac{c}{d}$ does in fact equal $\frac{a}{b} \times \frac{d}{c}$, but they do not explain why it would make sense that this would be so. This article has provided a line of reasoning, supported by concrete and visual images, which teachers can use to help their students construct the type of understanding recommended in both the national and state standards in mathematics.

■

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Assistant Professor, Wright State University, Ohio

TEA Talks

Hot News

For additional information, refer to the websites listed

- Well, the October 18, 2005 meeting of the State Board of Education was certainly an important one for those of us in mathematics. The SBOE invited the following outstanding Texas educators to testify and advocate for the critical need for funding of mathematics textbooks and the adoption of the elementary math TEKS.

  Your TCTM president, Dr. Cynthia Schneider; Michelle King, TASM Governmental Relations Representative and Director of Mathematics at Coppell ISD; Pat Rossman, Austin ISD math specialist; Anne Hoskin, Houston ISD Math Manager; Diane McGowan, Independent Consultant; Dr. Joyce Fischer, Assistant Professor of Mathematics, Texas State University, and Norma Jost, Austin ISD Secondary Math Supervisor deserve major kudos for a job well done!

- Please note: even though the SBOE has released Proclamation 2004 (secondary math textbooks), the funding for any proclamation is a decision made by the legislature. We will not know the status of funding for Proclamation 2004 until the 2007 legislative session. Also, Proclamation 2005 (elementary math textbooks) was on the agenda for the November 2005 SBOE meeting.

- The secondary math TEKS were approved in February 2005, thereby allowing an optional early implementation date of fall 2005. (Implementation is scheduled for fall 2006.) The spring 2006 math TAKS tests for secondary mathematics will not assess skills/concepts that have been removed from the secondary math TEKS.

  The Student Assessment Division developed an online survey to gather input as to whether the additional TEKS content should be assessed in whole or part by TAKS. This TAKS mathematics survey for grades 6-10 and exit level included new student expectations and student expectations with additional content. The survey did not include student expectations that were not changed. These will continue to be assessed. The survey did not include student expectations that were reworded for clarification. These will continue to be assessed just as they are now. The survey did not include student expectations that are currently not eligible to be assessed on TAKS.

  The online survey was available through January 31, 2006. The survey was submitted on a per campus basis and should have reflected the consensus of the campus stakeholders. Your campus voted on whether the additional content (in whole or part) should be included on TAKS. The survey also included questions regarding the addition of graph paper, isometric dot paper, and changes to the math charts.

- Starting in the school year 2006-2007, secondary math TAKS tests may include field test items that assess additional skills/concepts. Then, during the 2007-2008 school year, the secondary math TAKS tests may include live items (for accountability) that assess the additional skills/concepts.

- The SBOE approved the adoption of the elementary mathematics TEKS with an implementation schedule of fall 2006. For elementary mathematics, schools should have started this school year teaching the original mathematics TEKS; therefore, classroom instruction for this school year should continue to reflect the original elementary mathematics TEKS. The spring 2006 elementary TAKS tests for mathematics will reflect the original elementary math TEKS and NOT the refined elementary math TEKS. Timelines for implementing the elementary math TEKS refinements on TAKS will be coming in the near future.

- Since we have revised/refined our mathematics TEKS, TEA has identified monies to create TEKS professional development modules to assist teachers in the implementation of the revised math TEKS. Two sets of professional development training modules are currently being developed.

  Teaching the Math TEKS through Technology (TMT3) has been developed by the Education Service Center, Region 4, in Houston, and Texas A&M-Commerce. This training will focus on the following four areas: Middle School, Algebra I, Geometry, and Algebra II. There was a training of trainers (TOT) in December 2005 for ESC math specialists and at least one other training for district math specialists during the February 2006 TASM meeting.

  The purpose of this professional development is to equip teachers to be effective and judicious users of technology as they teach to the depth and complexity outlined by the TEKS for mathematics. Each session is activity-based so as to encourage professional discourse about the decisions surrounding the use of technology to strengthen student learning about mathematics.

  Another set of professional development modules have been developed by Dr. Pam Littleton at Tarleton State University. These modules will assist teachers in implementing the revised math TEKS and are categorized by grade bands: K-2, 3-5, 6-8, and 9-12. The training of trainers (TOT) for ESC math specialists will be in the winter and spring of 2006, starting with the 6-8 and 9-12 grade bands.

- As more information becomes available, I will send it out via the math listserv. I encourage you to join the math listserv at www.tea.state.tx.us/list.

- The list of TEKS student expectations tested during the spring 2005 math TAKS tests were released in September 2005. You can access this information from the student assessment website: www.tea.state.tx.us/student.assessment/resources/release/expect/index.html

- TEA will release the TAKS tests for the 2005-2006 school year and produce item analysis reports.

- The release of the 2005 SDAA II tests was approved during the December SBOE meeting. Student assessment released the 2005 SDAA II tests in January 2006.

  <http://www.tea.state.tx.us/student.assessment/resources/release/sdaa/index.html>

- Monies have been allocated to all 20 ESCs to provide training and support for districts in the Texas Math Diagnostic System (TMDS). Your ESC TMDS contact may be the technology specialist or the math specialist. I encourage you to contact them with any questions you may have regarding TMDS.

- A TETN was held on Friday, Oct 21, 2005, that addressed the need for a strong alignment between classroom instruction and the Linguistic Accommodated Testing (LAT) process since all linguistic accommodations used during a LAT administration of TAKS must be a regular part of the student's mathematics instruction. This session was truly a learning experience for many of us, and hopefully, the beginning of a long and successful collaborative effort. You can obtain a copy of the PowerPoint presentation at

  <http://www.tea.state.tx.us/student.assessment/>

  Look under What's New! You can also obtain a copy of the videotape by contacting your local ESC.

Norma Torres-Martinez • <norma.torres-martinez@tea.state.tx.us>
Director of Mathematics • Texas Education Agency

FEATURES

Recommended Readings and Resources

Math Fables: Lessons That Count by Greg Tang

Math Fables: Lessons That Count by Greg Tang; Illustrated by Heather Cahoon
ISBN 0-439-45399-2

Where do you find a counting book that would help teach primary students that numbers are made up of other numbers? Greg Tang's recent book MATH FABLES is the perfect answer. Now, through winsome "fables" about concepts that are relevant to the very youngest math learners -- sharing, teamwork, etc. -- Greg encourages kids to see the basics of counting in entirely new ways. Each "fable" tells a rhyming story in a 2-4 page spread, with each setup more complex than the last. The last fable tells of 10 beavers leaving for work, regrouping and reorganizing their numbers all day (7+3; 9+1; 6+4; 5+5; and 8+2). The text and perky, computer-generated cartoons show youngsters that there are many different ways of putting numbers together. Featuring words like "sultry," "wholeheartedly," and "procrastinate," the enriching vocabulary is an added bonus. *Math Fables* by Greg Tang is a fine addition to math shelves.

Other books by Greg Tang that give kids a head start in math and at the same time encourage a love for reading and learning include *The Grapes of Math*, *Math For All Seasons*, *The Best of Times*, *Math Appeal*, and *Math-terpieces*.

FEATURE

2005 PAEMST Award Recipients

Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST)

The Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) identifies outstanding mathematics and science teachers, kindergarten through 12th grade, in each state and the four U.S. jurisdictions. These teachers serve as models for their colleagues and leaders in the improvement of science and mathematics education. The 2005 Texas nominees are:

- **Kay Neuse** is a teacher at Wilson Middle School in Plano ISD.
- **Lyneille Meza** is a teacher at Strickland Middle School in Denton ISD.

The 2005 PAEMST Awardees will be announced at the beginning of April 2006. Each Presidential Awardee will receive a $10,000 award from the National Science Foundation. Each award recipient will also be invited to attend, along with a guest, recognition events in Washington, D.C. during April 2006. These events will include an award ceremony, a Presidential Citation, meetings with leaders in government and education, sessions to share ideas and teaching experiences, and receptions and banquets to honor recipients.

The competition alternates each year between teachers of grades K-6 and teachers of grades 7-12. The nomination form for 2006 (K-6 teachers) can be downloaded at :

http://www.paemst.org/2006_Nomination_Form.pdf

Nomination forms must be submitted to Norma Torres-Martinez at the Texas Education Agency prior to the application being sent to qualified candidates. Email her at *<Norma.Torres-Martinez@tea.state.tx.us>* if you would like to nominate a colleague.

Using Pi Day Activities

Each spring semester, my students in Topics in Mathematics and Independent Study in Mathematics, two courses for mathematically gifted students at Georgetown High School, participate in a nine-weeks-long project involving both self-selected independent study and the creation of a group (class) project. This year, I was inspired to immerse my students in pi-related research by the *Texas Mathematics Teacher* Fall 2004 issue which featured preparing for "Pi Day." I found many great ideas in the very informative article by Larry Lesser, "Slices of Pi: Rounding Up Ideas for Celebrating Pi Day," along with the websites referenced in the article and other publications and websites. The decision to use the number pi as the unifying factor in my students' independent study proved to be an excellent starting point for some fascinating research with a surprising amount of mathematical variety.

Pi Day, usually celebrated on March 14 (3-14), fell on our Spring Break, so we "rounded" Pi Day to the nearest tenth and celebrated it on March 1 (3-1). My two classes of mathematically gifted students had prepared an exciting morning of hands-on geometry activities centered around the number pi for a group of thirty middle school students at nearby Forbes Middle School. The high school students had created activities which encompassed the history, application, and characteristics of the number pi, in addition to simulations of probability experiments and ways to estimate pi.

We started this "Pi Day Project" early in the second semester in order to be ready by March 1. After a week of general research of pi in books and journals and on the internet, the students selected their individual research topics and began their in-depth research with the purpose of discovering something fascinating about pi which could be developed into an engaging hands-on activity to share with the middle school students. Three weeks later, each class then determined which activities each student would develop into a 12-minute activity, and they created an activity plan using a template I created. To complete the template, students had to include:

- the title of the activity
- the objective/main concept
- time needed; materials needed
- description of the display/station for that activity
- an actual introduction that the Pi Day facilitator for that activity would use and handouts or posters that would be used
- the detailed step-by-step description of the activity and what the facilitator would be doing
- description of the product that participants would produce as evidence of their having completed the activity, met the objective, and understood the concept
- other relevant notes about the activity

Because some of the activities required more knowledge of pi than others, we carefully planned the order of the activities, starting with basic concepts such as the universal similarity of all circles, the related idea of proportionality and common ratios between elements of similar geometric figures, the definition of pi as the ratio of the circumference of a circle to its diameter, and the derivation of some of the elementary formulas involving pi. We had a couple of contests: one was a pi memorizing contest, and the other involved accurate measurement of a very long length using only a circular object such as a large hula hoop or the rim of a small can. Later activities allowed students to derive pi using a program on a TI-83+ calculator or by the Buffon's Needle method using the floor tiles in the hallway and craft sticks.

We tried to engender some curiosity and excitement for the activities with our titles, which we printed on banners and placed throughout the gym in areas where each activity would take place. Some of the titles were "Hula Hoops, Pots, Frisbees, and Pi," "Rolling Pi," "Pi and Polygons," "Pieces of Pi," "Concentric Circles and πr^2," and "Popsicle Sticks, Probability and Pi." Students were cutting up paper plates, gluing concentric circles of rope, rolling hula hoops and tiny Vienna sausage cans, plotting dot stickers on huge coordinate planes (graph paper posters), dropping Popsicle sticks, measuring the circumference of each others' heads and the lengths of the gym floor. They heard many stories about pi throughout the history of mathematics. They learned about its irrationality and its transcendental nature, compared ratios of polygons and circles drawn on transparency film to their projected images on a screen, and learned to program on the graphing calculator. Contest prizes were pies donated by local businesses and parents, and the participants and facilitators all ended the morning by eating real pieces of pie on picnic tables just outside the gym.

The high school students related well to the middle school students and made the morning really fun and the challenging material engaging. The prospect of sharing their research gave purpose and meaning to the high school students' independent study. I felt that our Pi Day Program demonstrated in a "well-rounded" way the inter-connectedness of the different branches of mathematics and showed how mathematicians have developed mathematics over the centuries. Both groups of students were exposed to the beauty and fascinating nature of one of humankind's most beloved and well-used numbers, the ubiquitous pi.

■

Tricia Rothenberg • <mathweb99@hotmail.com>
Teacher • Georgetown High School, Georgetown ISD

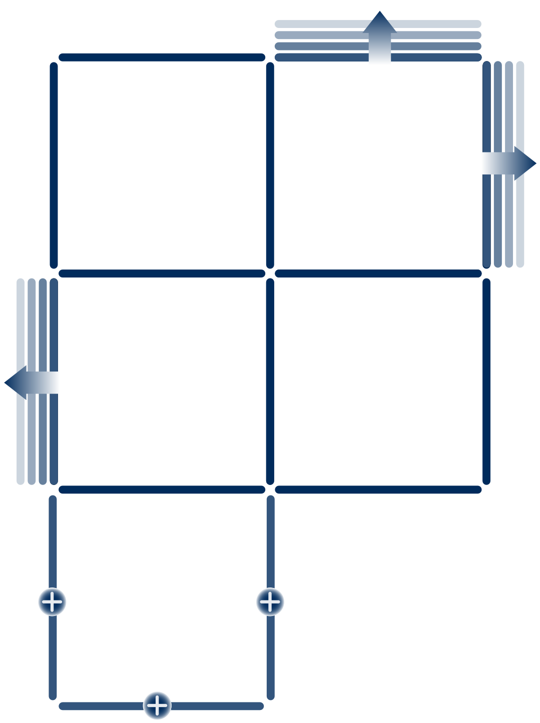
FEATURE

Puzzle Corner

Sticks #5 Answer

Arrange 12 craft sticks to form the origional figure. Rearrange three sticks to form a figure that has three congruent squares.

Shown is a diagram of a solution

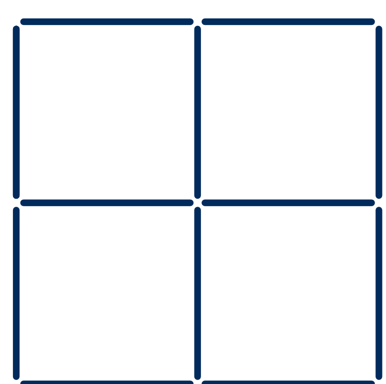


Sticks #6 Puzzle

We are interested in how your students responded to this problem and how they explained or justified their reasoning. Please e-mail copies of your students' work, include your name, grade level, campus name and district name to Mary Alice Hatchett, Director of Publications, *Texas Mathematics Teacher*. Selected submissions will be acknowledged and published in subsequent issues.

Please prepare a sketch of your solution

Arrange 12 craft sticks to form the following figure.



Rearrange two sticks to form a figure that has seven squares. (Hint: think small)

APPLICATION

TCTM Mathematics Specialist Scholarship

Amount: $1500 **Deadline: May 31, 2006**

Eligibility: Any student attending a Texas college or university – public or private – and who plans on student teaching during the 2006-07 school year in order to pursue teacher certification at the elementary, middle or secondary level with a specialization or teaching field in mathematics is eligible to apply. A GPA of 3.0 overall and 3.25 in all courses that apply to the degree (or certification) is required.

Applicant Information

Name:	Last	First	Middle
Address:	Number and Street		Apt. number
	City	State	Zip Code
Contact:	( ) Home Phone	( ) Cell Phone	Email Address
Personal:	Social Security Number		Birth Date

College Information

What college or university do you plan to attend? If you are awarded this scholarship, TCTM's treasurer will send a check directly to the business office of the college. We need the college's complete address.

Name:	College or University		
Address:	Number and Street		
	City	State	Zip Code

You must submit three (3) copies of each of the following documents:

1. Completed application form.
2. College transcript. One must be an official copy.
3. Two letters of recommendation:
   - One from either a mathematics or mathematics education professor you have taken coursework from and is not related to you.
   - One from a K-12 classroom teacher of mathematics you have worked with recently or that was a former teacher of yours and is not related to you.
   - It is required that at least one of these recommendations come from a current member of TCTM, it is preferred that both recommendations come from current members of TCTM.
4. An essay of 1,500 words or more that describes your philosophy of teaching mathematics and how you will implement this philosophy with your future students. Specific examples of how you will teach a mathematics concept are required to illustrate your teaching philosophy. Or you may write an essay that explains a specific mathematics topic or concept, for example, a paper on proportionality.

Please submit all materials in one envelope to:

by mail: **Cynthia Schneider**
234 Preston Hollow
New Braunfels, TX 78132

by fax: **(512) 232-1855**
ATTN: Cynthia Schneider

TCTM Leadership Award Application

Deadline: May 31, 2006

Eligibility: The TCTM Leadership Award is presented to a TCTM member who is nominated by a TCTM Affiliated Group. This person is to be honored for his/her contributions to the improvement of mathematics education at the local and state level. He/she has designed innovative staff development and has promoted the local TCTM Affiliated mathematics council.

Information about the **TCTM member** nominating a candidate

Name: Last / First / Middle

Address: Number and street / Apt. number

City / State / Zip Code

Contact: ( ) Home Phone / ( ) Work Phone / Email Address

Affiliation: District or Professional Affiliation / ESC

Are you a member of TCTM? Y N

Are you a member of NCTM? Y N

Information about the **nominee**

Name: Last / First / Middle

Address: Number and street / Apt. number

City / State / Zip Code

Contact: ( ) Home Phone / ( ) Work Phone / Email Address

Affiliation: District or Professional Affiliation / ESC

Is the nominee a member of TCTM? Y N

Is the nominee a member of NCTM? Y N

Is the nominee retired? Y N

Applications should include 3 pages:

- ☐ Completed application form
- ☐ One-page, one-sided, typed biographical sheet including:
  - Name of nominee
  - Professional activities
  - National offices or committees
  - State TCTM offices held
  - Local TCTM-Affiliated Group offices held
  - Staff Development
  - Honors/awards
- ☐ One-page, one-sided essay indicating why the nominee should be honored for his/her contribution to the improvement of mathematics education at the local/state level

Send the completed application, biographical sketch, and essay to

by mail: **Cynthia Schneider, 234 Preston Hollow, New Braunfels, TX 78132**

by fax: **(512) 232-1855 ATTN: Cynthia Schneider**

by email: ***<cschneider@satx.rr.com>***

APPLICATION

Texas Council of Teachers of Mathematics Membership Form

Applicant Information

Name:	Last	First	Middle
Address:	Number and street		Apt. number
	City	State	Zip Code
Contact:	( ) Home Phone	( ) Work Phone	Email Address
Affiliation:	District or Professional Affiliation		ESC

Individual TCTM Membership — Cost : $13.00 per year

Membership includes 1 copy of the biannual TMT journal.

Circle area(s) of interest: **K-2** | **3-5** | **6-8** | **9-12** | **College**

Circle one : New Member | Renewal | Change of Address

___ year(s) x $13.00 = $

Professional TCTM Membership — Cost : $40.00 per year

For schools, institutions, or affiliated groups. Membership includes 3 copies of the TMT journal.

Circle one : New Member | Renewal | Change of Address

___ year(s) x $40.00 = $

National Council of Teachers of Mathematics Membership

Circle one : New Member | Renewal | Change of Address

Full Individual membership includes a print subscription to the NCTM News Bulletin and one NCTM Journal. Select one journal below.		*Additional print journals may be selected to enhance your membership, and includes online access.*	
Teaching Children Mathematics	$76	Teaching Children Mathematics	$32
Mathematics Teaching in the Middle School	$76	Mathematics Teaching in the Middle School	$32
Mathematics Teacher	$76	Mathematics Teacher	$32
Journal for Research in Mathematics Education	$100	Journal for Research in Mathematics Education	$56

Membership Dues $

Additional Journals $

Amount Due NCTM $

Scholarship Donations

TCTM awards scholarships to college students planning to pursue a career in mathematics teaching either as a mathematics specialist in elementary school or as a secondary school teacher with certification in mathematics. Your contributions in any amount are greatly appreciated. Please write a separate check for scholarship donations.

Scholarship Donations $

Make check(s) payable to TCTM and mail to:

TCTM Treasurer
2833 Broken Bough Trail
Abilene, TX 79606

TOTAL AMOUNT DUE $

TCTM E. Glenadine Gibb Achievement Award Application

Deadline: May 31, 2006

Eligibility: The E. Glenadine Gibb Achievement Award is presented to someone nominated by a TCTM member to be honored for his/her contribution to the improvement of mathematics education at the state and/or national level.

Information about the **TCTM member** nominating a candidate

Name: Last | First | Middle

Address: Number and street | Apt. number

City | State | Zip Code

Contact: ( ) Home Phone | ( ) Work Phone | Email Address

Affiliation: District or Professional Affiliation | ESC

Are you a member of TCTM? Y N

Are you a member of NCTM? Y N

Information about the **nominee**

Name: Last | First | Middle

Address: Number and street | Apt. number

City | State | Zip Code

Contact: ( ) Home Phone | ( ) Work Phone | Email Address

Affiliation: District or Professional Affiliation | ESC

Is the nominee a member of TCTM? Y N

Is the nominee a member of NCTM? Y N

Is the nominee retired? Y N

- ☐ Completed application form
- ☐ One-page, one-sided, typed biographical sheet including:
  - Name of nominee
  - Professional activities
  - National offices or committees
  - State TCTM offices held
  - Local TCTM-Affiliated Group offices held
  - Staff Development
  - Honors/awards
- ☐ One-page, one-sided essay indicating why the nominee should be honored for his/her contribution to the improvement of mathematics education at the state/national level

Please submit the completed application, biographical sketch, and essay

by mail: **Cynthia Schneider, 234 Preston Hollow, New Braunfels, TX 78132**

by fax: **(512) 232-1855 ATTN: Cynthia Schneider**

by email: ***<cschneider@satx.rr.com>***

From Equation-based to Function-based Algebra Curricula:
Some Investigations and Reflections

Two types of algebra curricula

Equations and functions are two major content themes in secondary school algebra. Most traditional algebra curricula are equation-based, which have the following characteristics:

- Building and solving equations is the dominant theme
- The major use of letters is for unknown quantities in equations
- The study of functions is at the end of the curricula, mostly isolated from the study of equations
- In teaching and learning, emphasis is often put on grasping and applying established routines to symbolically manipulate expressions and equations
- Many exercises are skill-driven and context-free

As a result, equation solving and the related routines have been deemed by many students as the synonym of algebra, and have actually caused their dislike or even fear for algebra.

Since the 1980's, the weights of equations and functions in algebra curricula have been altered by the infusion of computers and hand-held technologies into classrooms, the popularization of problem solving and modeling in mathematics education, and the impact of the Algebra for All movement in the United States. Many mathematics education researchers and specialists have been advocating the idea of making functions the central theme of school algebra, or, function-based algebra curricula.

In function-based algebra, letters are primarily used to denote variables that are involved in dynamic changes and functional relations. The memorization of routines and the proficiency in symbolic manipulations are de-emphasized. In modeling and solving real-world problems, students are expected to determine variables and their interdependent relations, formulate function rules, find solutions and make predictions with multiple representations (verbal, symbolic, tabular, and graphic, etc.)

Problem scenarios such as the following one may help to contrast these two types of algebra:

Johnny just signed up for a cell phone service plan. The fixed monthly service fee is $20, and it costs 30 cents for each minute of use. If Johnny's first month phone bill shows a total charge of $52.40, how many minutes has he used in the first month?

When this problem is given in equation-based algebra, students are supposed to approach it by denoting the unknown minutes of use as x, setting up an equation like $20 + 0.3x = 52.4$, then applying a few symbolic transformations on both sides and eventually finding the solution $x = 108$ minutes. In this process, figuring out the value of unknown x is the sole goal, and symbolic manipulation is the standard strategy for solving. Procedural fluency and accuracy may naturally become the main criterion for assessing student learning.

In a function-based algebra, however, students would first need to determine the variables that have dependence relation (the total minutes of use, x, the corresponding total charge, y), then formulate a function rule between these variables (such as $y = 20 + 0.3x$). To answer the original question, students need to figure out the value of variable x when variable $y = 52.4$. This can be done in several different but equivalent ways:

- graphing the function and tracing the points on the line, until the y-coordinate is 52.4;
- generating and checking the numerical data table of the function; or
- replacing y in the function rule with 52.4, then solving the subsequent equation.

In this process, students have the opportunity to approach the problem in a more general manner, exploring and making connections among multiple concepts and strategies, including the symbolic solution. This provides greater chance for them to make sense of what they are doing and what could be done rather than merely focusing on solving an equation.

The call for a shift from equation-based to function-based algebra has been echoed by professional recommendations (such as the 2000 NCTM standards), state curriculum standards, and algebra curriculum materials. Nonetheless, discrepancies still exist in views, policies, and practices across the US. For example, in a recent comparison of secondary mathematics curriculum standards in Texas and California, the author categorized fundamental algebraic topics into two major groups: equation-oriented topics versus function-oriented topics (see Table 1 below), and analyzed the number of specific knowledge and skills covered within each group. In the Texas standards (Texas Essential Knowledge and Skills), 18 specific knowledge and skills are covered under the equation-oriented topics, and 31 are under the function-oriented topics. In contrast, in the California mathematics content standards, these two numbers are 24 and 14, respectively.

Table 1

Equation-oriented Fundamental Topics	Function-oriented Fundamental Topics
General knowledge of equations	Foundations of functions
Linear equations	Linear functions
Lines	Quadratic functions
Quadratic equations	
Linear inequalities	

A structural analysis of Algebra I textbooks

The materialized forms of algebra curricula are algebra textbooks. At a first glance, most current algebra textbooks seem to embed mathematics in real-world contexts, encourage problem solving and modeling activities, use of technologies, and multiple representations. Many of them even discuss the concept of functions at the very beginning of the books. Does it mean that these books are all function-based? If not, what would differentiate one of them from another, then?

Following the comparison of curriculum standards, the author conducted a survey on 16 sets of Algebra I textbooks that are currently used in the US (see Table 2), pertaining to the question of how they handle the relationship between equations and functions as two core conceptual strands, and more specifically, how they structure and sequence equation-oriented and function-oriented topics. An abbreviation was created to refer to each book (see the first column of Table 2). All of these books appeared in at least one of the following three booklists as indicated in Table 2.

Book Lists

TX: The Algebra I textbooks officially adopted by Texas Education Agency in 1998;
<http://www.tea.state.tx.us/textbooks/materials/bulletin/index.html>

DoE: The 10 Exemplary and Promising Mathematics Programs selected by US Department of Education's Mathematics and Science Expert Panel in October, 1999;
<http://www.ed.gov/PressReleases/10-1999/mathpanel.html>

AAAS: The 12 algebra textbooks chosen and evaluated in April 2000 by Project 2061 of American Association for the Advancement of Science;
<http://www.project2061.org/publications/articles/textbook/hsalg/outcome.htm>

Three distinct content structures emerge from the survey: equation-based, function-based, and mixed.

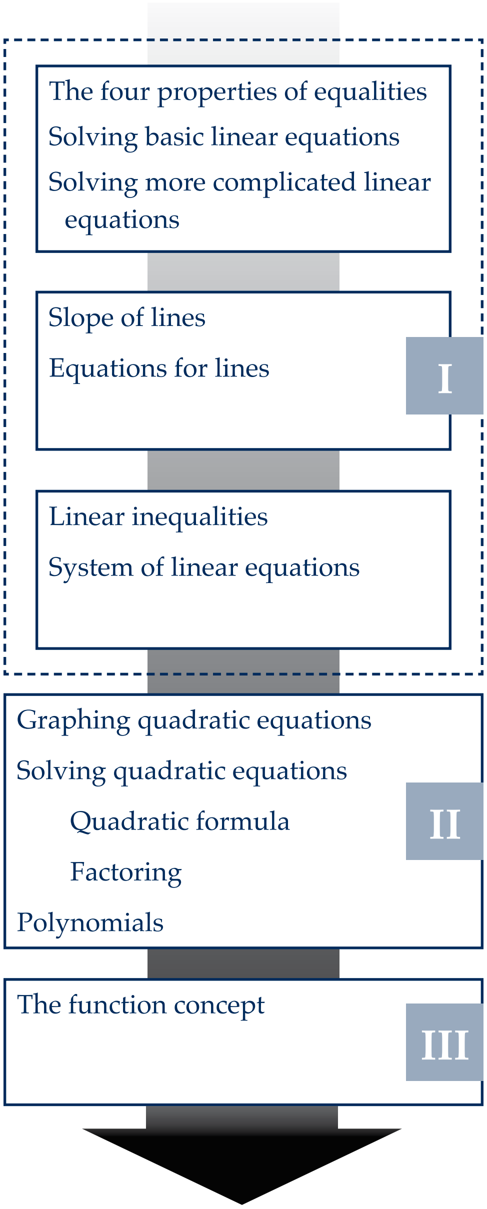
Table 2

Abbreviation	Book Title	Publisher	Year	TX	DoE	AAAS
AW	Addison-Wesley Secondary Math: An Integrated Approach – Focus on Algebra	Addison-Wesley	1996	√		√
CA	Concept in Algebra: A Technological Approach	Everyday Learning	1999			√
CPLUS	Core-Plus Math Project – Contemporary Mathematics in Context: A Unified Approach (Courses 1 & 2)	Everyday Learning	1998		√	√
COMAP	COMAP's Mathematics: Modeling our World (Courses 1 & 2)	W. H. Freeman	1998			√
CORD	CORD Algebra 1: Mathematics in Context	South-Western Educational	1998	√		√
CT	Cognitive Tutor – Algebra I	Carnegie Learning	1998		√	
GLENC	Glencoe – Algebra 1: Integration, Applications, Connections	Glencoe/ McGraw-Hill	1998	√		√
HRW	HRW Algebra: Explore, Communicate, Apply	Holt, Rinehart and Winston	1997	√		
IMP	Interactive Mathematics Program: Integrated High School Mathematics	Key Curriculum Press	1997		√	√
MC	MATH Connections (1a, 1b)	It's About Time	1998			√
ML	Algebra 1: Explorations and Applications	McDougal Littell	1998	√		√
PH	Algebra: Tools for a Changing World	Prentice Hall	1998	√		√
SAXON	Algebra 1: An Incremental Development (3rd Edition)	Saxon Publishers	1997	√		
SIMMS	Integrated Mathematics: A Modeling Approach Using Technology (Level 1)	Simon & Schuster	1996	√		√
SW	South Western Algebra 1: An Integrated Approach	South-Western Educational	1998	√		
UCSMP	The University of Chicago School Math Project – Algebra	ScottForesman	1996	√	√	√

Equation-based structure

MC, SAXON, and UCSMP have an equation-based structure. The corresponding concept flow is illustrated in Figure 1. The entire content scope is divided into three major content blocks, numbered by the order in which they appear. The arrows indicate the sequences of the content blocks and the sub-blocks within a major block.

Figure 1

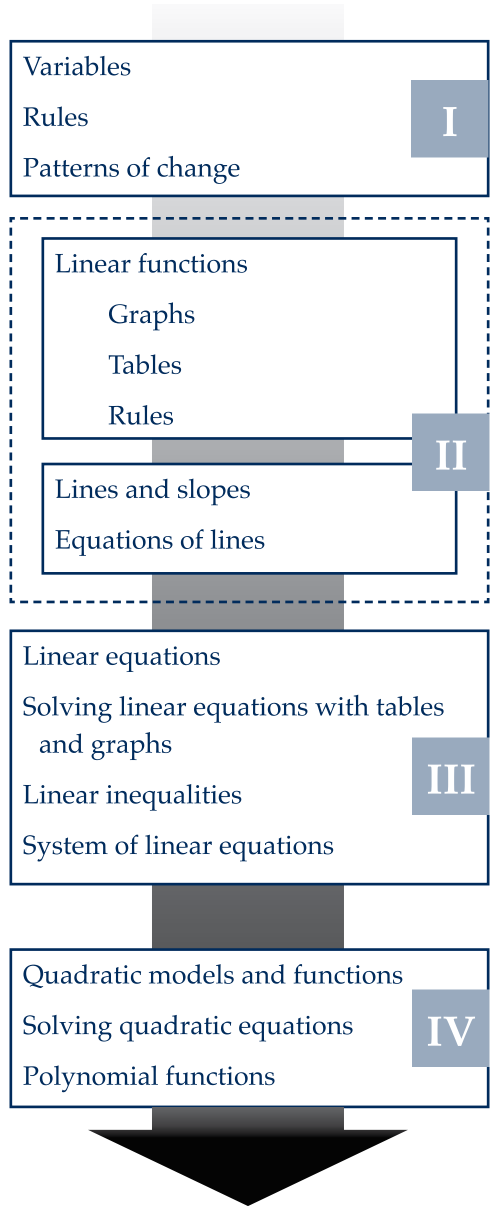


In content Block I, equations are introduced as certain conditions put on unknown quantities. Symbolic transformations are used to find out the values of the unknowns. Later, graphs, slopes, and equations of lines in the Cartesian plane are discussed, without necessarily situated in real world functional relations. The mathematics is explained in relative rigor, generally, and thus theoretical or formal style. Block II introduces quadratic equations as associated with quadratic curves in the Cartesian plane or as containing unknowns (up to two) to be solved. Explicit discussions on the function concept don't begin until Block III which is at the end of the book.

Function-based structure

CA, CPLUS, COMAP, CT, IMP and SIMMS can be put into this category. Figure 2 displays their concept flow.

Figure 2



Textbooks with a function-based structure introduce mathematical content through modeling scenarios and activities. They begin with identifying variables, looking for and describing patterns (content Block I), then introduce linear functions and their multiple representations. Based on that, the slopes and equations of lines as linear functions are discussed

(Block II). In Block III, the books demonstrate linear equations derived from functional contexts, and solve them particularly with tables and graphs. The rules for symbolically solving equations are not stressed. These are followed by Block IV which is about quadratic and polynomial functions and equations.

Mixed structures

In the remaining 7 textbooks (AW, CORD, GLENC, HRW, ML, PH, and SW), both equation-oriented and function-oriented topics are weighted to a certain extent and intertwined. There are mainly three ways of sequencing the topics:

- In AW and HRW, the general concepts of patterns, functions, and their multiple representations come first. Linear equations and solving strategies are then introduced. Afterward, the graphs and slopes of linear functions are further discussed.
- In PH, most chapters are about equations and solving. The second to last chapter introduces the concept of functions, linear and quadratic functions. The last chapter deals with solving quadratic equations.
- CORD, GLENC, ML, and SW first introduce linear equations and ways of solving them, then examine lines, slopes and equations from a linear function perspective. From there, they discuss solving linear equations through tables and graphs.

Remarks on textbook adoption in Texas

From well designed education standards to anticipated student learning outcomes, many factors play roles in the process and build up the complexities and uncertainties. Among them are the two crucial episodes: textbook selection and classroom implementation. Compared with the algebra curriculum standards in other states (such as California), the one in Texas has a greater emphasis on function-based knowledge and skills. This lays a good foundation for educators and administrators across Texas to be aware of, understand, and implement function-based algebra. The reality, however, doesn't seem to be as promising. As shown in the structural analysis, none of the ten Algebra I textbooks officially adopted in Texas and surveyed above has a function-based structure, which makes implementing function-based algebra a much harder, if not completely impossible, task.

Mathematically speaking, the biggest advantage of function-based structure has much to do with its potential in unifying the two themes of equations and functions, since the majority of equations that students have to deal with in secondary school algebra can be related to a general function relation. This is especially true for linear and quadratic equations. The cell phone charge problem at the beginning of this article is a good example. With equation-based or mixed structure, however, the two themes of equations and functions may still be presented as isolated. For example, in some textbooks, linear equations of unknowns are introduced in early chapters, and actually arise from functional contexts. But they are never reviewed and connected to those linear functions that are defined and studied in later chapters.

When it comes to algebra teaching and learning in thousands of classrooms across the state, it would be reasonable to imagine that there are greater diversity and thus stronger deviation from the desired function-based algebra standards and student outcomes.

The new round of textbook adoption in Texas has been launched and will be completed in the next two years. The author believes that the adoption would be more successful in the long run in terms of teaching practice and student learning, if textbook publishers and mathematics educators, administrators, and policy makers in Texas are better informed of the fundamental differences between the two types of algebra curricula and different textbook structures, and utilize such knowledge in making important algebra curricular decisions.

This makes particular sense for the fact that, when the emphasis on functions and relations become a fashion, many publishers attempt to integrate the function concept, modeling and problem solving activities, and use of graphs and numerical tables into their algebra-related products. Some of those integrations may be just superficial and will not yield genuinely function-based materials and subsequent function-based algebra instructions. Details of the textbooks need to be examined in terms of whether function-related concepts and methods provide the foundation for modeling, analyzing and solving problems in the entire content. ■

Xuhui Li., *<lixuh@msu.edu>*
Division of Science and Math Education,
Michigan State University

DEPARTMENT

CAMT 2006

Navigating Mathematical Understanding Through Research

July 20 – 22, 2006

CAMT 2006 will be held July 20-22, 2006, at the George R. Brown Convention Center in Houston, Texas. The Program Chair is Janet Vela of ESC Region IV. Program information will be available online next spring (probably late March) at:

http://www.tenet.edu/camt/

Many favorite speakers such as Kim Sutton, Randy Charles, Cathy Seeley, Marcy Cook, Steve Leinwand, and many others are returning in 2006. There will also be a strong strand on sessions for teachers of English Language Learners (ELL). Math-A-Rama will be all three mornings, STEPS will be two full days.

We will be using an easy online registration process for the first time in spring 2006. Look for information via your email. ■

DEPARTMENT

TCTM E-mail Communications

Timely announcements are sent to our membership using e-mail.

If you have an e-mail address, please be sure it is on file and up-to-date with TCTM. If you do not have an e-mail address, please let us know by indicating this on your membership application. We will attempt to contact you via postcard if there is a crucial issue at hand. TCTM members that have e-mail and have not received e-mail messages from the president, Cynthia Schneider, in the last six months, should contact her immediately at *<cschneider@satx.rr.com>* or by phone at 512-475-9713. Also note: if your server is not accepting our messages due to security, we would like to work with you on this issue. ■

Voices From the Classroom

Fraction ID

Objective:

Students will use deductive logic to name a fraction.

Materials:

Fraction tents
Fraction ID Question Cards
Fraction ID recording sheet

Procedure:

This is an activity for 3-5 students.
To determine who goes first:

- Shuffle the Fraction tents and place face down.
- Each player draws 1 tent.
- The player with the fraction value closest to zero plays first.
- Play continues to the right.

To play:

(1) Shuffle the Fraction ID Question Cards and place face down in the center of the game area.
(2) Shuffle the Fraction tents and deal one tent to each player face down.
(3) Each player sets up their tent so that the other players can see it but they can't.
(4) Player #1 draws a Fraction ID Question Card. Reads it to the other players and answers the question based on the fractions that player #1 can see (remember, player 1 can NOT see their own fraction).
(5) The other players now know something about their own fraction and should record that information on their Fraction ID Recording Sheet.
(6) Steps 4 and 5 are repeated with the next player.
(7) When a player thinks they know their fraction, they say: "Fraction ID My fraction is ___ and in the order of least to greatest value is the ___ term." Confirmation is given by the other players.
(8) If this player is correct, they are declared 1st place winner. Play continues with the other players. The next player to correctly Fraction ID will be the 2nd place winner and so on until all fractions have been identified.

Example Fraction ID Recording Sheet

What I've Learned About My Fraction

Numerator:	Denominator:	My Fraction

My fraction is _________ and in the order from least to greatest is the ______ term.

Example Fraction ID Question Cards

(1) How many fractions are less than one?	(2) How many fractions are equal to one?
(3) How many fractions are greater than one?	(4) What is the sum of all the numerators?
(5) How many denominators are prime?	(6) How many times do you see the digit 1?
(7) How many times do you see the digit 2?	(8) How many times do you see the digit 3?
(8) How many times do you see the digit 4?	(8) How many times do you see the digit 5?
(11) How many fractions have an odd denominator?	(12) How many fractions have an even denominator?

Fraction Tents are available online along with this entire activitiy, located at

http://www.tctmonline.net/

2005 Award Recipients

TCTM Leadership Award

Barbara "Basia" Hall

Honored for her service in mathematics education in Texas to improve professional development and empower teachers to provide the best teaching environment for all students, **Barbara "Basia" Hall** of Houston ISD received the 2005 TCTM Leadership Award. She was recognized for her contributions to the improvement of mathematics education in Texas at the 2005 CAMT luncheon in Dallas.

TCTM E. Glenadine Gibb Achievement Award

Barrie Madison

Honored for her service in mathematics education at the state and national level to empower teachers to provide the best teaching environment for all students, **Barrie Madison** of Lewisville ISD received the 2005 E. Glenadine Gibb Award from the Texas Council of Teachers of Mathematics. She was recognized for her contributions to the improvement of mathematics education in Texas at the 2005 CAMT luncheon in Dallas.

TCTM CAMTership

Four $300.00 CAMTerships were awarded this past summer by TCTM. We would like to extend our congratulations to **Jennifer A. Miller** of Clear Creek ISD, **Thuy-Anh Do Le** of Austin ISD, **Maureen E. Allan** of Austin ISD, **Jessica D. Jacobs** of Irving ISD, and **Elizabeth R. Brown** of Austin ISD. All recipients volunteered two hours of their time at CAMT and attended the annual TCTM Business Meeting and Breakfast as guests of TCTM. If you have been teaching for five or fewer years, look for the CAMTership application in this *Texas Mathematics Teacher*. The CAMTership is intended to encourage beginning teachers to attend CAMT by helping cover part of the expenses associated with attending the conference.

TCTM Mathematics Specialist Scholarship

Four Texas students were awarded the $1500 TCTM Mathematics Specialist Scholarship for 2005-06.

Leah Dahms

The University of Texas at Austin

Student teaching in Austin ISD

Courtney Owen

Baylor University

Heather Freeman

Abilene Christian University

Carrie Simonton

Tarleton State University

Student teaching in Mineral Wells ISD

TCTM CAMTership Application

Deadline : May 31, 2006

Eligibility: Eight $500 CAMTerships will be awarded to teachers with five or fewer years teaching experience. Previous winners are not eligible. Winners will be determined by random drawing of names and will be notified by telephone or email after June 1, 2006. Winners will be asked to volunteer for two hours at CAMT and will be TCTM's guest at our breakfast Saturday morning, where the checks will be presented. Good luck!

Name:	Last	First	Middle
Address:	Number and street		Apt. number
	City	State	Zip Code
Contact:	( ) Home Phone	( ) Cell Phone	Email Address
Workplace:	District and Campus		ESC

Are you a member of TCTM?	Y / N	Have you attended CAMT before?	Y / N
How long have you been teaching?		What grade(s) are you currently teaching?	

Send your completed application to:

by mail: **Cynthia Schneider,**
234 Preston Hollow,
New Braunfels, TX 78132

by fax: **(512) 232-1855**
ATTN: Cynthia Schneider

by email:
<cschneider@satx.rr.com>

Texas Council of Teachers of Mathematics
Executive Board 2005 - 2006

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Norma.Torres-Martinez@tea.state.tx.us

When does YOUR membership expire?

Note the expiration date on your mailing label.
Use the membership form inside to renew before that date.

Texas Council of
Teachers of Mathematics

Member 2005- 2006

NAME ___________________________

Texas Mathematics Teacher
234 Preston Hollow
New Braunfels, TX 78132