Math Activities for Interdisciplinary Studies

Presentation for AMATYC Conference 2002
Phoenix, Arizona, November 17, 2002
Central Arizona College
Aravaipa Campus

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For more information see our web site at www.cardells.net

A LEARNING COMMUNITY: "Coming Together Where the Waters Meet"

Central Arizona College (CAC), Aravaipa Campus
Fall 2001 (www.geocities.com/lcomavc)

How does one learn? There must be more exciting and meaningful ways to carry on this enterprise called higher education! A second question: What methods or environments best foster persistence and retention? We are a team of three, Shay Cardell, Professor of Mathematics, Maren Wilson, Professor of Anthropology/Social Sciences, and Flint Anderson, Director of Student Services and Adjunct Faculty, Sociology, Philosophy.

We deconstructed traditional approaches, developing and implementing an alternative model for orientation, academic assessment, advisement, and instruction for non-traditional and developmental students. By exploring our own experiences, listening—really listening—to students, and reviewing pertinent literature, we asked what are the essential elements for a creative learning environment.

We wanted new students to experience at the very beginning of their college life the **best** of what an institution of higher education can offer: a collaborative, project- and theme-based learning environment that promotes critical thinking and exploration, without the constraints of time or faculty domination; a learning community that challenges instructors to step out of traditional roles, to work intensely as one member of a team, willing to venture into arenas where they surrender control.

1. Socio-Economic Context

The Aravaipa Campus is located in the San Pedro River Valley, a rural area in the heart of Arizona's copper country. Once a boom industry, U.S. copper mining is in a severe recession; this has resulted in the complete closure of BHP Copper, the area's largest employer. 2400 miners were laid off. Historically, no formal education was necessary to enable one to earn a good income working in the mines.

Approximately 50% of the area population are of Mexican/Yaqui descent. Over 40% identify themselves as Roman Catholic. Less than 8% of current students' parents have earned a college degree. Almost 50% are from families with annual incomes of $30,000 or less.

Compared with students at other public two-year institutions, twice as many students at Central Arizona College (CAC) need remedial help in math, science, reading, and writing. They also report less confidence in their academic ability, computer skills, math and writing ability. Two-thirds spent five hours or less a week studying or doing homework in high school, while half of those at other institutions report doing five hours or less. Twice as many CAC students report never talking with teachers outside of the classroom.

The cohort of twenty-seven students which began the semester in the Learning Community (LC) reflect even more challenging demographic status (the numbers in the parentheses represent full-time CAC students and other two-year public institutions respectively):

- 25% (51, 66) have used a personal computer.
- 50% (31, 23) spent six to 10 hours a week in last year of high school socializing with friends.
- 83% (55, 18) spent three to 10 hours a week watching TV

- 25% (12, 3) spend over 20 hours a week doing household/childcare activities.
- 42% (26, 8) listed the inability to find a job as important in deciding to go to college.
- 17% (33, 49) have not attended an art gallery or museum.
- None (27, 14) listed a mentor/role model encouraging them to attend college.

2.

3. The Concept

A partnership of student services and instruction, the three instructors created a nine-credit learning community that met Mondays and Wednesdays from 10:00 to 3:30 p.m. for sixteen weeks with an hour off for lunch. Each student could earn four credits of math (MAT 81, 91, or 121), three credits of anthropology (ASB 201 Indians of the Southwest), and two credits of college success skills (CPD 111).

Through the spring and summer of 2001, new students were given the option to sign up for the nine-credit block rather than taking the ASSET academic assessment tests (math, reading, and composition). Those choosing the LC would experience academic assessment as an ongoing process in which they actively participated. Seventeen new students enrolled. Fourteen who had previously been assessed but were not successful in one or more developmental courses were also included in the class.

No formal examinations were administered. But there were quizzes to check students' progress, especially in math. Each student maintained a portfolio that constituted 60% of his/her final grade. The remaining 40% were determined by attendance/participation.

Students self-selected a group with which they would work for the entire semester. Each collaborative group was responsible for a major research project and presentation.

1) The Content

The theme for the semester, "Coming Together Where the Waters Meet," refers to the confluence of two desert riparian near the Aravaipa Campus. In this area are multiple pre-historic Indian sites, a former military fort, as well as the location of the infamous Fort Grant Massacre in 1873. We would explore many facets of this unique environment. The semester was divided into historical segments: prehistoric, early historic, current, and future times.

Activities included archeological dating, a survey of plants along the San Pedro River, visiting Native American ruins and natural/historical museums, an ecological simulation game (Fish Banks), Internet and other library research, guest speakers, group presentations, videos, tree ring dating, a microbacterial and salinization lab, extensive writing exercises, and daily "plus delta" evaluations of activities/projects.

4. Initial Outcomes

Of the 27 who registered and attended, 24 completed the semester, an 88% persistence rate, compared to 69% for CAC in Fall 2000. 83% of the LC participants, compared to 69% for CAC, continued classes in the subsequent spring semester. Participants ranked their overall experience in the learning community 8.7, on a 10-point scale ("didn't like at all" to "liked it very much"). They would recommend the instructors to others (9.4), and would encourage this experience for others (8.6).

Flint Anderson

Learning Community Objectives

Students will:

1. Develop critical thinking and writing skills.
2. Understand college procedures and bureaucracy.
3. Acquire good study skills.
4. Make connections between subject areas.
5. Develop an appreciation for life long learning.
6. Construct their own knowledge and reality.
7. Experience hands-on and real world applications.
8. Understand systems thinking: interdependence, long-term results, and unintended consequences.
9. Extend knowledge horizons beyond their immediate community.
10. Feel valued as individuals.
11. Develop mutual respect.
12. Appreciate and value diversity.

Math Objectives

Students will:

1. Communicate using meaningful and relevant mathematics.

1.1 Identify and interpret mathematical information found in real life applications.

1.2 Collect accurate real world data from a variety of areas other than math

1.3 Use number sense and estimation to verify the correctness of answers

1.4 Communicate mathematics information verbally through discussions, writing, **and presentations.**

2. Use multiple approaches to solve mathematics problems

2.1 Represent functions in numerical, algebraic, graph, language, and physical model formats.

2.2 Use inductive and deductive logic to analyze mathematical patterns, create rules, and argue their validity.

2.3 Identify and apply alternative approaches of interpretation, argumentation, and evaluation to specific situations involving mathematics.

3. Experience math as a laboratory discipline

3.1 Create mathematics projects based on laboratory research.

3.2 Analyze mathematical data from hands-on laboratory experiences

3.3 Identify the limits and constraints of data accuracy

3.4 Work as a member of a scientific team to design and perform experiments in which scientific data is collected and analyzed.

4. Use technological tools to solve math problems.

4.1 Use a calculator to analyze data and functions

4.2 Use computer spreadsheets and math software to solve problems

4.3 Use sensors and measurement instruments to collect data

5. Analyze system behavior using mathematical models

5.1 Create mathematical models of systems

5.2 Identify composite functions within systems and determine the effects of changing system parameters.

5.3 Make predictions about systems based on current trends.

Transfer and General Education courses at Central Arizona College consist of a four semester, four credit hours per semester, sequence:

MAT081 Basic Arithmetic
MAT091 Introduction to Algebra
MAT121 Intermediate Algebra
MAT151 College Algebra

The fourth course, MAT151 College Algebra is transferrable to the universities. Course descriptions and contents follow:*

Basic Arithmetic:

Students who will take only one math course need practical math, so this course contains a variety of topics in math useful for business and vocational areas. Topics include the following:

- Problem Solving
- Integers
- Fractions
- Decimals
- Estimating
- Using Calculators and Computers
- Accuracy and Precision
- Rate, Ratio and Proportion
- Percent
- Measurement
- Area and Volume
- Pythagorean Theorem
- Similar Triangles
- Using Formulas
- Solving Equations
- Statistics

Introduction to Algebra

The first semester in Introduction to Algebra, introduces mathematical tools and functions through measuring, collecting, and analyzing data; linear and quadratic systems of equations; and expressing math concepts. Topics include the following:

- Pattern recognition
- Reasoning
- Number Sequences
- Properties of Numbers
- Using Calculators and Computers
- Solving Equations
- Measurement
- Accuracy and Precision
- Scientific Notation
- Data Collection and Analysis
- Functions
- Graphing
- Linear Functions
- Modeling Linear Functions
- Direct and Inverse Variation
- Exponents
- Quadratic functions

*These lists include only those concepts that are introduced during each course. All topics are cumulative and applied in subsequent courses.

A Partial List of Math Activities from the Aravaipa Learning Community 2002

Activity and Math Concept

1. Measurement - Fractions, Decimals
2. Scale Drawing - Measurement, Ratio
3. Radioactive Carbon Dating
    - Geological Features - Exponential Decay
    - Anazazi Artifacts - Exponential Decay
4. Cause and Effect - Systems Thinking, Exponential Feedback Loops
5. Riparian Plant Survey
    - Tree Diameter - Circle Circumference and Diameter
    - Percent Canopy Cover - Percent
    - Height of Canopy - Ratio
6. Anazazi Land Use - Area, Population Density
7. Soil Salinization Lab - Density and Concentration, Volume
8. Fish Banks Ecology Simulation - Number Sense and Estimation, Systems Thinking
9. Tree Ring Dating - Ratio, Linear Model, Solving Equations
10. Population Growth - Exponential Growth, Scientific Notation
11. Limits to Growth - Logistical Functions
12. Temperature Lab - Exponential Decay
13. Camp Grant Massacre - Linear Model
14. Depth of Mine Shaft - Quadratic Function
15. Ranch Management - Statistics, Systems Models
16. Seismic Testing - Ratio, Equations
17. Preparing an Archeological Dig Site - Measurement, Pythagorean Theorem
18. Finding Height from Bones - Ratio, Linear Model, Equations
19. Field Trip to Archaeology Site
    - Measuring a Ball Court – Measurement
    - Estimating Site Population – Measurement, Estimation
    - Height of a Building – Measurement, Similar Triangles, Ratio
20. Ecological Footprints – Measurement, Area, Volume, Ratio
21. Measuring a Million – Measurement, Scientific Notation, Area, Volume, Ratio
22. Recording a Site – Angles, Measurement, Graphing
23. Site Transformation – Pythagorean Theorem, Measurement, Graphing
24. Weaving – Algebraic Expressions, Patterns, Number Properties, Measurement, Equations, Ratio
25. Measuring Pots – Circles, Measurement, Using Formulas

1. Find a number with a cause -effect relationship ("A Function").
2. Translate the relationship into 5 math languages.
3. Predict a result.
4. Use the math to discover an interesting conclusion.
5. Communicate your results clearly.

Five Math Languages
1. Words
2. Table
3. Graph
4. Equation
5. System Dynamics Model

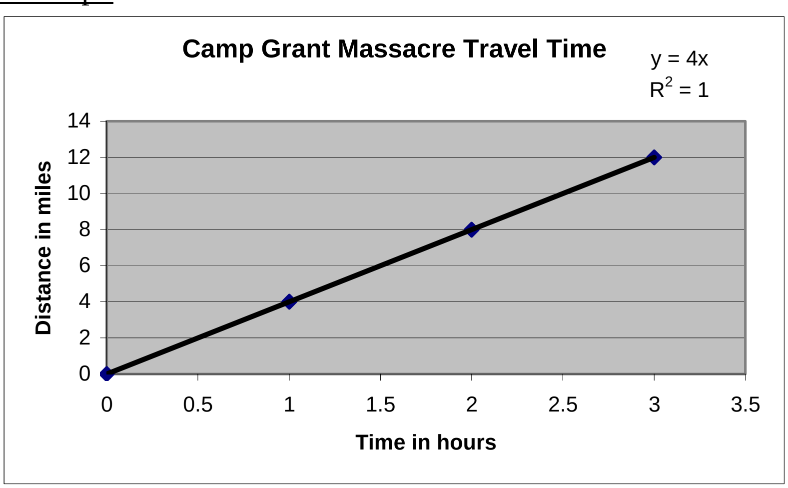
Example

1. Words: Traveling to the Camp Grant Massacre, the group of attackers left Ft. Lowell in Tucson traveling on horseback at an average rate of 4 miles per hour.

2. Table:

Time in hours (T)	Distance in miles (D)
0	0
1	4
2	8
3	12

3. Graph:

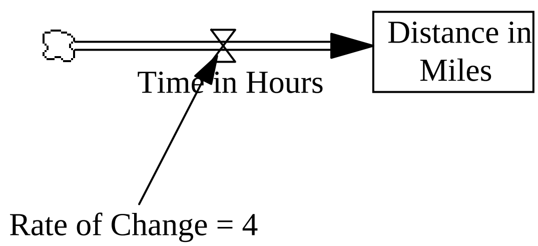


4. Equation:

D = 4 T

T = time in hours
D = distance in miles

5. Systems Dynamics Model:



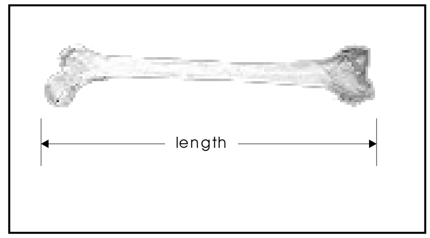
Prediction: After 12 hours the attackers will have traveled 48 miles. Camp Grant is a distance of 70 miles from Ft. Lowell by the Reddington Route, so it will take them 70/4 = 17.5 hours of traveling to reach Camp Grant.

Conclusion: Seventeen hours is a long time to travel in one day. The attackers will probably need to camp overnight on the way to Camp Grant.

Finding Height from Bone Length:
An Activity Integrating Archeology and Mathematics

The femur is a long bone in your upper leg that stretches from the hip socket to the knee. The length of the femur can be used to estimate a person's height.

Objectives:
Use metric measurement to measure the length of a bone.
Read a table to choose an appropriate formula.
Use a formula to estimate height from bone length.



Materials:
Metric ruler or tape measure.
Human femur bones or replicas cut from cardboard.

Procedure:
1. Measure the length of your specimen in centimeters.

2. Use the information found on the bone about the sex, and race of the individual to choose an appropriate formula from the chart.

3. Use the formula to calculate the probable height of the individual.

Bone	**Race**	**Male Equation**	**Female Equation**
Femur	Caucasoid	2.32 * length + 65.53	2.47 * length + 54.10
Femur	Negroid	2.10 * length + 72.22	2.28 * length + 59.76
Femur	Mongoloid	2.15 * length + 72.57	Not available

Results:
Length of bone in centimeters _________________

Race ____________ Gender ___________

Formula used _______________________________________

Estimated height of person in cm ______________________

Questions:
1. What is the estimated height of person in inches (there are 2.54 cm in an inch)
____

2. What is the estimated height of person in feet (there are 12 inches in a foot)
____

Additional Activities:

I. Adjusting the Estimate for Age

Most people older than 30 years have skeleton changes that decrease their height.
To adjust for the loss of height associated with aging, use the following equation:
Adjustment = 0.06 * (age - 30) cm. Then subtract the adjustment value from the height of the person.

If your specimen were from an individual of age 55 years, what would the estimated height be? Find out how much height your individual would have lost and subtract it from your height estimation. _________________

II. Testing a formula

Procedure:

1. Measure the length of your partner's humerus bone in centimeters. The humerus is the large bone that extends from the elbow to the shoulder socket.

2. Calculate your partner's height using the formulas in the table below.

3. Measure your partner's actual height.

Bone	**Race**	**Male Equation**	**Female Equation**
Humerus	Caucasoid	2.89 * length + 78.10) 4.57 cm	3.36 * length + 57.97) 4.45 cm
Humerus	Negroid	2.88 * length + 75.48) 4.23 cm	3.08 * length + 64.67) 4.25 cm
Humerus	Mongoloid	2.68 * length + 83.19) 4.16 cm	Not available

Results:

Length of bone in centimeters _________________

Race ____________ Gender ___________

Formula used ______________________________________

Estimated height of person in cm ______________________

Actual height of person in cm. ______________________

Questions:

1. What is your potential height range? (Subtract the error from your height estimate and then add the error to our height estimate.) ___________________

2. How does your estimate compare with your actual height?

3. How might the accuracy of the estimate be improved?

III. Making Your Own Formula
Procedure:
1. Measure in centimeters the objects in the Table 1.

2. Add your results to the class chart (Table 2) on the blackboard.

3. Graph the relationship between the length of each bone and the height of the person.

4. Using a linear regression, find an equation for the relationship of the length of each bone to a person's height. Make separate equations for males and females. Write your results in Table 3.

Results:

Table 1. Your Own Measurements

Object	**Size**
Length of thigh (femur)	
Knee to ankle (tibia)	
Elbow to shoulder (humerus)	
Wrist to elbow (radius)	
Total Height	

Table 2. Class Chart - Length of each person's bone in centimeters

Student Name	Gender	Femur	Tibia	Humerus	Radius	Total Height

Table 3. Equation for height from bone length

Object	Male Equation	Female Equation
Knee to ankle (tibia)		
Length of thigh (femur)		
Wrist to elbow (radius)		
Elbow to shoulder (humerus)		

Questions:

The formulas you used for finding height from femur and humerus lengths were created by Dr. Mildred Trotter, a physical anthropologist.

1. How does your formula compare with the Dr. Trotter's formula? Explain any differences.

2. How could you be more accurate in developing your formula?

References:

Dead Men's Tales Scientific American Frontiers Teaching Guide

Forensic Science, Helen Brand, Hunter College High School, New York, NY, http://renoir.vill.edu/~ysp/Teacher/Webpages/Forensics/forensic.html

Lab 5: Age and Stature Estimation, Dr. Darlene Applegate, Western Kentucky University, www.wku.edu/%7Eappleda/forensic/lab5.html

OsteoInteractive Website, University of Utah, http://medstat.med.utah.edu/kw/osteo/osteology

Prediction, Mathematical Models with Applications, Science and Engineering Module, The Concord Consortium, http://www.tenet.edu/teks/mmacd/curric/pr/prtg.htm

Finding Height from Bone Length:
An Activity Integrating Archeology and Mathematics
Answer Sheet

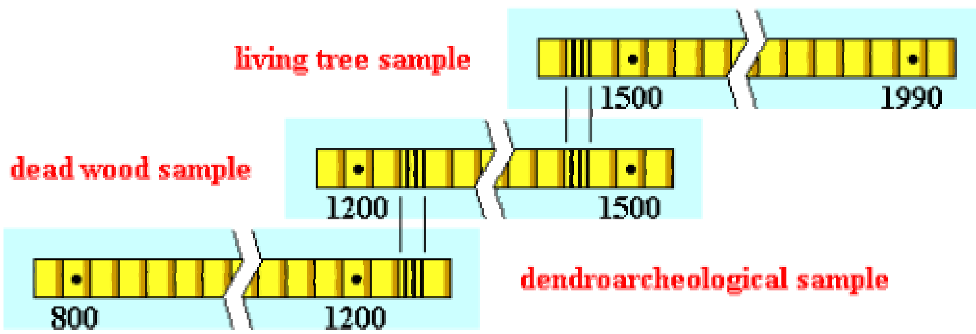
Bone	Length of Bone in cm	Height of Person in cm
1	41	155
2	40	159
3	43	163
4	47	170
5	53	181
6	55	191
7	44	160
8	52	186
9	49	179
10	54	189

Tree Ring Cross-Dating Exercise

1. Go to the web page http://tree.ltrr.arizona.edu/skeletonplot/introcrossdate.htm
2. Read the instruction pages.
3. Try counting the rings on the conifer tree ring sample where every tenth ring is marked to see if our count agrees with theirs.
4. Notice how to detect locally absent and false rings.
5. Try cross dating by using skeleton plotting.
    1) Begin with 11 rings
    2) Set the Sensitivity at 2
    3) Set the Absolute Value at 2
    4) Leave the rest of the settings at their default values.
    5) Click on Restart a New Core
    6) For every small tree ring make a mark on the graph. Smaller rings have taller marks. If a sample has fewer than two small rings it may be too difficult to date. Click on Restart a New Core to see a new sample.
    7) When you have finished marking your graph, click on Master to see the master chart.
    8) With the mouse pointed to the top section of your graph, slide your graph along the master to find the dates that match. For a better match you may want to change the height of all the marks on the master by changing the Abs Value setting.
    9) Write your answer for the dating period from the master chart numbers. e.g. 1971 to 1981.
    10) Click on Answer to check your answer.
    11) Practice makes perfect. Be sure you practice enough to acquire speed and accuracy so you can date real tree rings at the next class.

Linear Model: Tree Rings

1. Measure each tree ring.
2. Make a data table.
3. Draw a graph of the radius vs. time
4. Draw the Line of Best Fit
5. Find the average rate of change of the radius.
6. Find the equation for the radius vs. time
7. Predict the radius of the tree after 22 years.
8. Solve the equation for time.
9. When will the radius be 100 mm?
10. When the radius is 100 mm what will the diameter be in cm?



Tree Ring Number (Year)	Width in mm	Radius of Tree
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

5. Rate of Change of Radius

6. Equation

7. Radius after 22 years

8. Equation solved for time

9. Time when radius will be 100 mm

10. Diameter in cm when radius is 100 mm.