The Access to Algebra Project of the Appalachian Math Science Partnership

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Access to Algebra is a project within the AMSP technology program. Its primary purpose is to serve as an R&D platform for instructional technology and technology-supported models for teacher professional development.

Synopsis:

Secondary math teachers at multiple rural high schools work with small numbers of their students as the students take a University of Kentucky college algebra course. The teachers participate in a weekly seminar on the course progress and content.

The secondary students follow the same syllabus on the same schedule using the same text, doing the same homework, and taking the same open-response, commonly graded examinations as an on-campus, comparison cohort of college students.

The professional development is deemed successful to the extent that the students earn university college algebra credit.

Questions

- Is the course taken by the secondary students “equivalent” to that taken by the on-campus students?

- Is the associated PD “effective”?
  - Are the secondary students “successful” in comparison to a on-campus comparison group?
    - Is their success (or lack thereof) associated with the PD program

Some Implementation Details

- Under IRB requiring student, parent, counselor approval for participation.
- First semester teachers limited to 4 students
- Not a distance learning course. Students work with their teacher in a format determined by the teacher and school
  - e.g: after school, in regular class, independent study
- AMSP pays for texts, duplication costs, teacher stipends
- University of Kentucky waives all tuition and fees, registers students after the fact, and offers students with passing grades the option of accepting the credit with that grade.
  - University president sends each student his/her transcript and a note of congratulations to the teacher, parents, and administrators.
- "Success" = student is offered credit and accepts

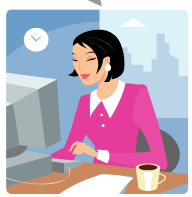
Evaluation/assessment

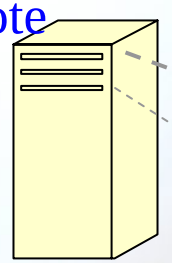
- Formative evaluation of content and technology is provided through direct feedback from teachers to developers.
- Formative project evaluation is provided by student homework and examination scores relative to those of the comparison groups and through weekly seminars.
- The primary summative assessment parameter for the PD program has been the success of the participating teachers' students in earning college algebra credit.
- The program does not formally measure changes in teacher content knowledge. Theses are inferred by observation and objective measures of student success.

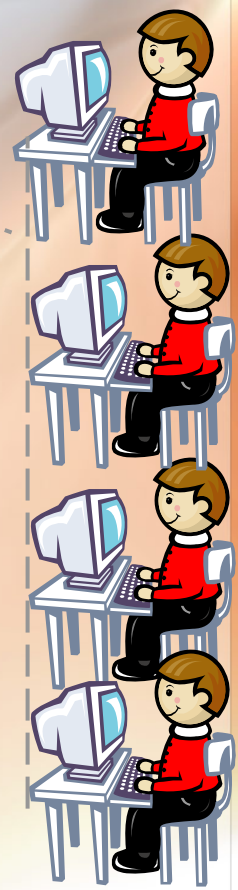
Weekly online teacher seminars parallel on-campus staff meetings, include on-campus instructors, are facilitated by teacher-leaders.

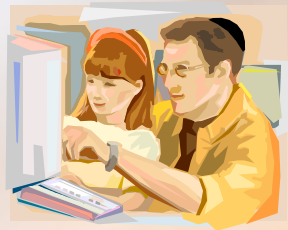
Central site for IT services for on-campus and remote students

Same common online homework and common exams for K12 students and comparison cohort of on-campus students









Local instruction includes classroom instruction, after-school group meetings, tutoring, independent study

Topics:

- The actual course
- The technology
  - Examinations
- Some preliminary data and outcomes
- Not everything works
- An unexpected spinoff
- Next steps

About the course ..

Text: *College Algebra* by Avinash Sathaye

- Author is UK Math Professor and distinguished researcher
  - No previous work with AMSP or other sponsored outreach programs
- Open source
  - Complete LaTeX source freely adaptable to local needs
  - Softbound copy typically less than $20
  - can be used as supplement for other classes,
  - can freely shared with colleagues, students
- Covers substantial amounts of material, and is written in a style, that is generally not familiar to secondary math teachers

Text is updated annually and contributing teachers are credited in the preface

The member of the summer 2005 development team members were:

Andrea OBryan of East Jessamine High School, Jessamine County, Ky; **Charlotte Moore, and Sharon Vaughn** of Allen Central High School, Floyd County, Ky; **Karen Heavin, Marcia Smith, and Mark Miracle** of West Jessamine High, Jessamine County, Ky; **Cheryl Crowe and Susan Popp** of Woodford High School, Woodford County, Ky; **Clifton Green** of Owsley County High School, Owsley County, Ky; **Gina Kinser** of Powell County High School, Powell County, Ky; **Jennifer Howard** of Magoffin County High School, Magoffin County, Ky; **Joanne Romeo** of Washburn High School, Grainger County, Tn, **Lee Alan Roher, Paul Eakin, Ken Kubota, and Carl Eberhart** of the University of Kentucky; **Lisa Sorrell and Teresa Plank** of Rowan County Senior High School, Rowan County, Ky; **Patty Marshall** of Johnson Central High School, Johnson County, Ky; **Roxanne Johnson** of Wolfe County High School, Wolfe County, Ky; and **Sarah Stinson** of Paul Laurence Dunbar High School, Lexington, Ky.

The college algebra program continued during the academic years 2007-2008 and 2008-2009.

Teachers who have joined the Access to Algebra Team:

Scott Adams of Rockcastle County High School, Rockcastle County, Ky. **Teresa Combs** of Knott County High School, Knott County, Ky. **Brent West** of Corbin County Independent High School, Corbin County, Ky.

Studies the interplay between algebra and geometry with particular attention to the geometric information in coefficients of algebraic expressions.

Emphasis on a few, primary tools:

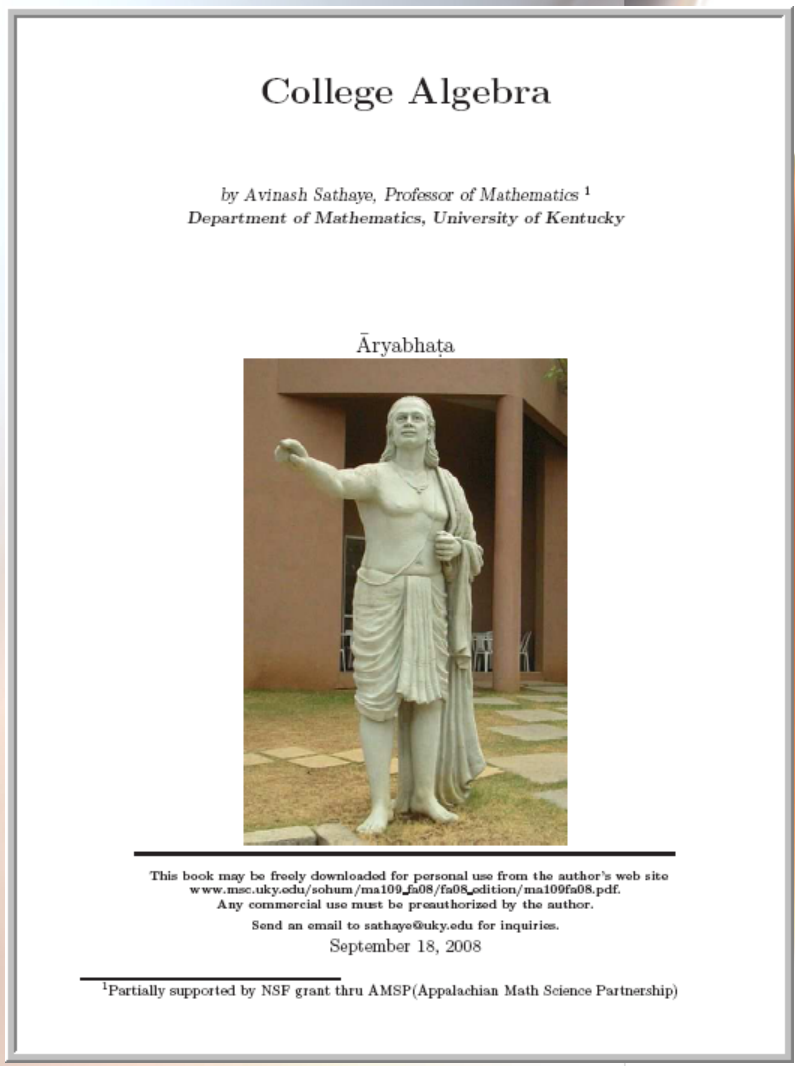
- Euclidean Algorithm
  - -Aryabhata Algorithm

- Parametric equations

- Cramer's Rule

- Complex numbers

- Binomial Theorem and Tangents



College Algebra

by Avinash Sathaye, Professor of Mathematics [1]
Department of Mathematics, University of Kentucky

Āryabhaṭa

September 18, 2008

[1]Partially supported by NSF grant thru AMSP(Appalachian Math Science Partnership)

Aryabhata Algorithm Example:

Calculate the gcd and lcm of 124 and 56

$$\begin{bmatrix} & 1 & 0 & 124 \\ & 0 & 1 & 56 \end{bmatrix}$$

124=56*2 + r3

$$\begin{bmatrix} & 1 & 0 & 124 \\ -2 & 0 & 1 & 56 \\ & 1 & -2 & 12 \end{bmatrix}$$

65 = 12*4 + r4

$$\begin{bmatrix} & 1 & 0 & 124 \\ -2 & 0 & 1 & 56 \\ -4 & 1 & -2 & 12 \\ & -4 & 9 & 8 \end{bmatrix}$$

$$\begin{bmatrix} & 1 & 0 & 124 \\ -2 & 0 & 1 & 56 \\ -4 & 1 & -2 & 12 \\ -1 & -4 & 9 & 8 \\ -2 & 5 & -11 & 4 \\ & -14 & 31 & 0 \end{bmatrix}$$

GCD

LCM

124*5 -11*56 = 4 (the GCD)

-14*124 + 31*56 = 0

14*124=31*56 = 1736 (the LCM)

$$\frac{124}{56} = \frac{31}{14}$$

Question 10

The fraction $\frac{308,712}{334,248}$ is not in lowest terms since both the numerator and denominator are even. So $\frac{308,712}{334,248}$ and $\frac{154,356}{167,124}$ are fractions that represent the same rational number, r. Find the fraction in "lowest terms" which represents r. That is, write $r = \frac{A}{B}$ where A and B are both positive and have no common factor other than 1.

$A =$ [ ] $B =$ [ ]

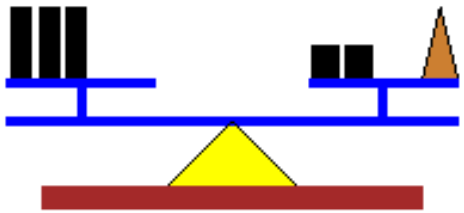
Remember not to include commas in your answers.

	1	0	308712
0	0	1	334248
-1	1	0	308712
-12	-1	1	25536
-11	13	-12	2280
-5	-144	133	456
	733	-677	0

733*308712 = 677*334248

Answer = $\frac{677}{733}$

Question 16



Larry has a balance, a large collection of 43 gram weights and another large collection of 37 gram weights. He also has a golden object which is supposed to weigh exactly 6 grams and he wants to check the weight. Complete the following Aryabhata table

minus quotient	Answer 1	Answer 2	Remainders
	1	0	43
	0	1	37

and use part of it for a recipie to place weights of one type on one side of the balance and weights of the other type on the opposite side so that the scale will perfectly balance if the weight of the object is correct. To do this, one would place [ ] of the 37 gram weights in the left pan and [ ] the 43 gram weights in the right pan.

Solution:

-6*43+7*37=1

6*(-6*43) + 6*(7*37) = 6*1

-42*37 + 36*43 = 6

36* 43 = 6 + 42* 37

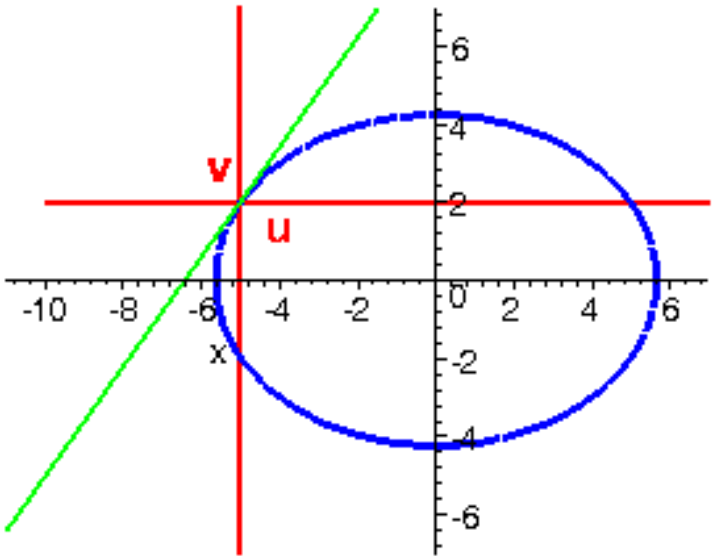
	1	0	43
-1	0	1	37
-6	1	-1	6
-6	-6	7	1
	37	-43	0

The Binomial Theorem and Tangents to algebraic curves

If C is the plane curve defined by f(x,y) = 0 and (a,b) is a point on C then the equation of the tangent line to C at (a,b) is the linear form of the "Taylor series" expansion of f(x,y) about (a,b).

For polynomial, and even rational expressions, *this has nothing to do with calculus*. The classical approach, going back in modern notation at least to Baskarachaira (1114-1185) (and likely to Aryabhata (476-550)) requires only the binomial theorem for positive non-negative, integral exponents in the case of polynomial expressions and the geometric series for rational expressions.

Question 1



The graph of the ellipse E, with equation $9 \cdot x^2 + 16 \cdot y^2 - 289 = 0$ is shown. The vertical line is the graph of x = -5 and the horizontal line v is the graph of $y = 2$. Their intersection $P(-5, 2)$ is on E (i.e. is a solution to the equation). As in section 10.1 pf the text, substitute $x = u - 5$, $y = v + 2$ to get $9 \cdot u^2 - 90 \cdot u + 16 \cdot v^2 + 64 \cdot v = 0$ which is the equation for the ellipse in terms of u, v.

(i) In terms of u, v the equation of the tangent line to E at P is [ ] $\cdot u +$ [ ] $\cdot v +$ [ ] $= 0$.

(ii) In terms of x, y the equation of the tangent line at P is $y =$ [ ]

Solution:

$$9x^2 + 16y^2 - 289 = 0$$

$$9(u-5)^2 + 16(v+2)^2 - 289 = 0$$

$$9u^2 - 90u + 16v^2 + 64v = 0$$

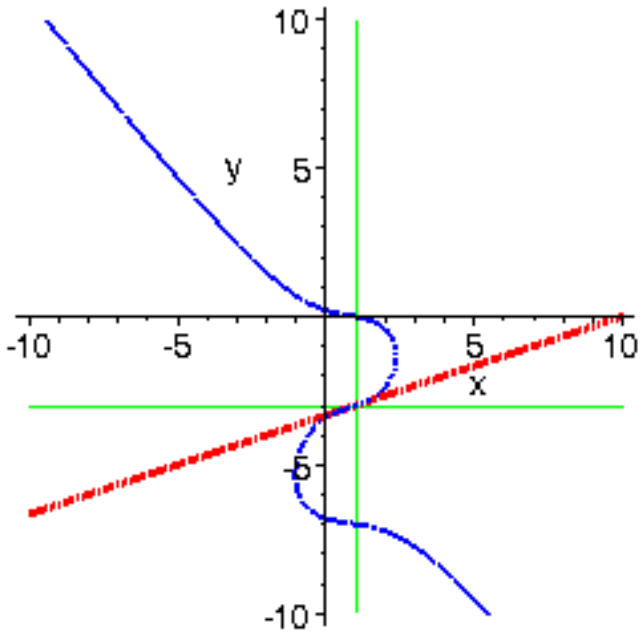
$$-90u + 64v = 0$$

$$-90(x+5) + 64(y-2) = 0$$

$$-90x - 578 + 64y = 0$$

$$y = \frac{45x}{32} + \frac{289}{32}$$

Question 6



Solution:

$$-8x+5+5x^2-2x^3-y^3-10y^2-21y=0$$

$$-8u+60+5(u+1)^2-2(u+1)^3-(v-3)^3-10(v-3)^2-21v=0$$

$$-4u-21v+60+\text{higher order terms}=0$$

$$-4(x-1)-21(y+3)=0$$

$$-4x-59-21y=0$$

The point $P(1,-3)$ lies on the graph of $-8\cdot x+5+5\cdot x^2-2\cdot x^3-y^3-10\cdot y^2-21\cdot y=0$. If, as in section 10.1 of the text, make the substitution $x=u+1$, $y=v-3$ in this equation to produce an equation for the graph, expressed in (u,v) coordinates.

(i) The (u,v) coordinates of the point P are ([ ] , [ ]).

(ii) In (u,v) coordinates the equation for the tangent line to the graph at P is

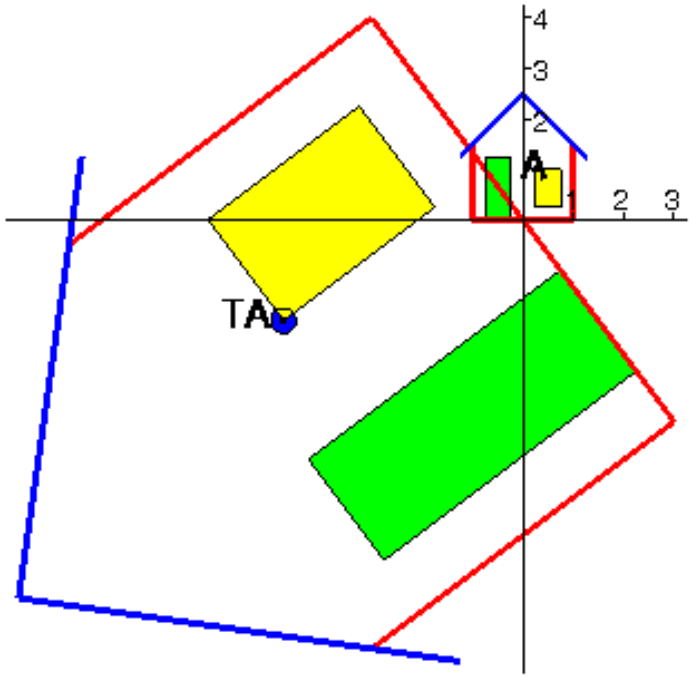
[ ] $=0$.

(iii) In (x,y) coordinates the equation of the tangent line is [ ] $x+12y+$ [ ] $=0$.

Hint

Complex numbers, their arithmetic, and the complex plane (as an obvious extension of the number line) are covered. The representation of multiplication by a complex number as a rigid rotation and scaling of the plane is treated as a natural extension of scaling the number line by real numbers. The presentation of the "imaginary" unit, i, as counterclockwise rotation of a quarter circle together with the equivalence of 180 degree rotation and multiplication by -1 makes $i^2 = -1$ "obvious" and removes the "imaginary" from complex numbers.

Question 3



The transformation T maps the plane onto itself by multiplication by a complex number. That is, there is a complex number $C = a + ib$ such that for any point $P(x, y)$, $T(P)$ is the point corresponding to the complex number $C \cdot P$. For a particular complex number C the transformation T takes the smaller house in the diagram to the larger one. The point $A = \left(\frac{1}{4}, 1\right)$ (the upper left corner of the window) on the smaller house is taken to the point $T(A) = \left(-\frac{19}{4}, -2\right)$ on the larger house.

The complex number $C =$ [ ]

The small house is rotated [ ] degrees counterclockwise and expanded by a factor of [ ]

Solution:

$$T(A) = C\,A$$

$$A = \left(\frac{1}{4}, 1\right) = \frac{1}{4} + i$$

$$T(A) = \left(-\frac{19}{4}, -2\right) = -\frac{19}{4} - 2\,i$$

$$-\frac{19}{4} - 2\,i = C\left(\frac{1}{4} + i\right)$$

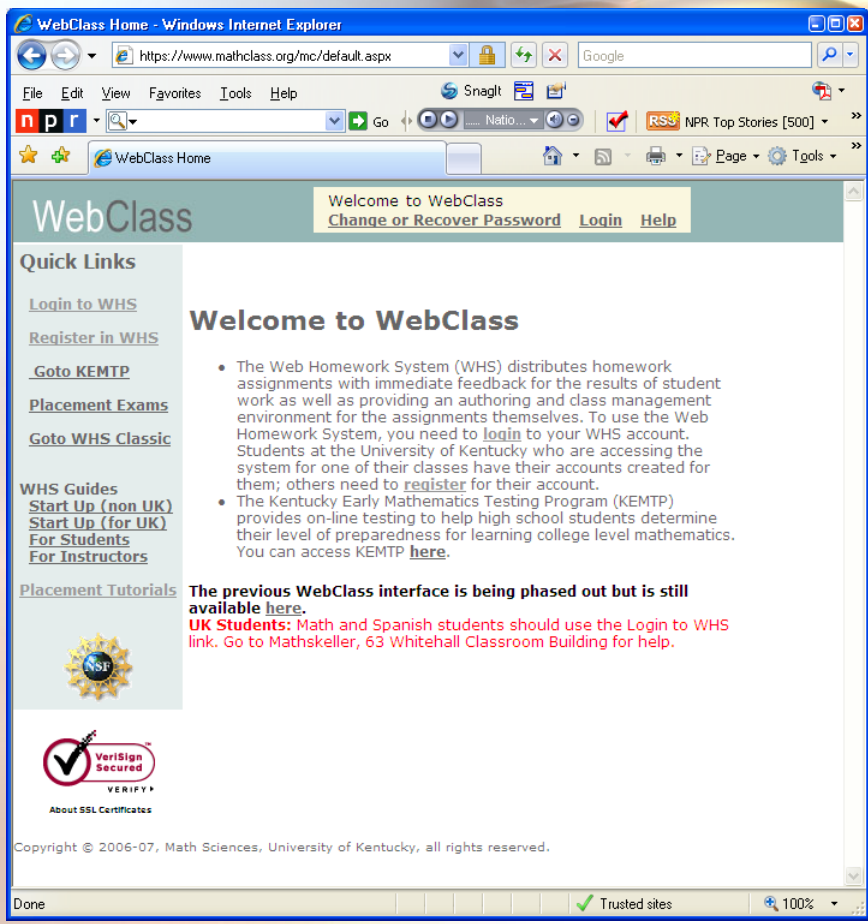
$$C = \frac{\frac{1}{4} + i}{-\frac{19}{4} - 2\,i} = -3 + 4\,i$$

$$\|C\| = \sqrt{(-3)^2 + 4^2} = 5$$

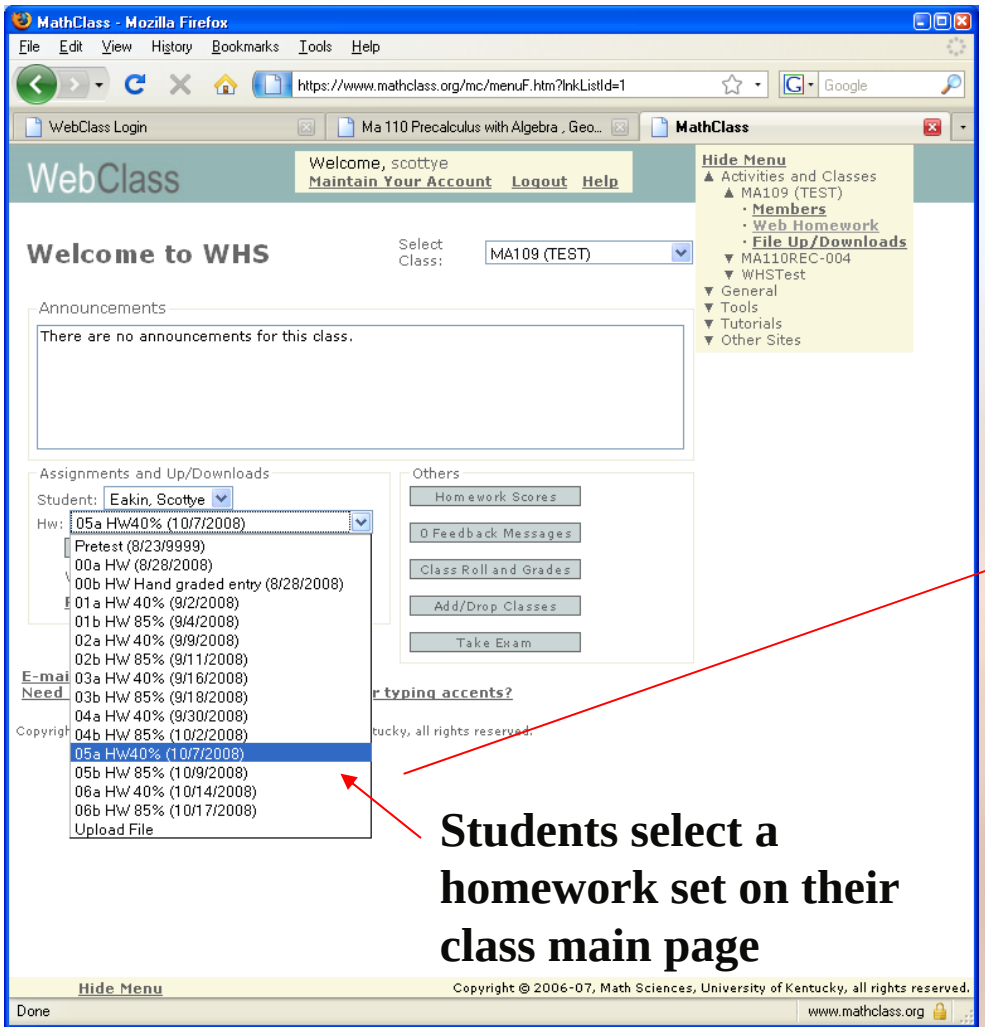
$$\theta = \arctan\left(\frac{4}{-3}\right) + \pi = 126.8698 \text{ deg.}$$

The technology..

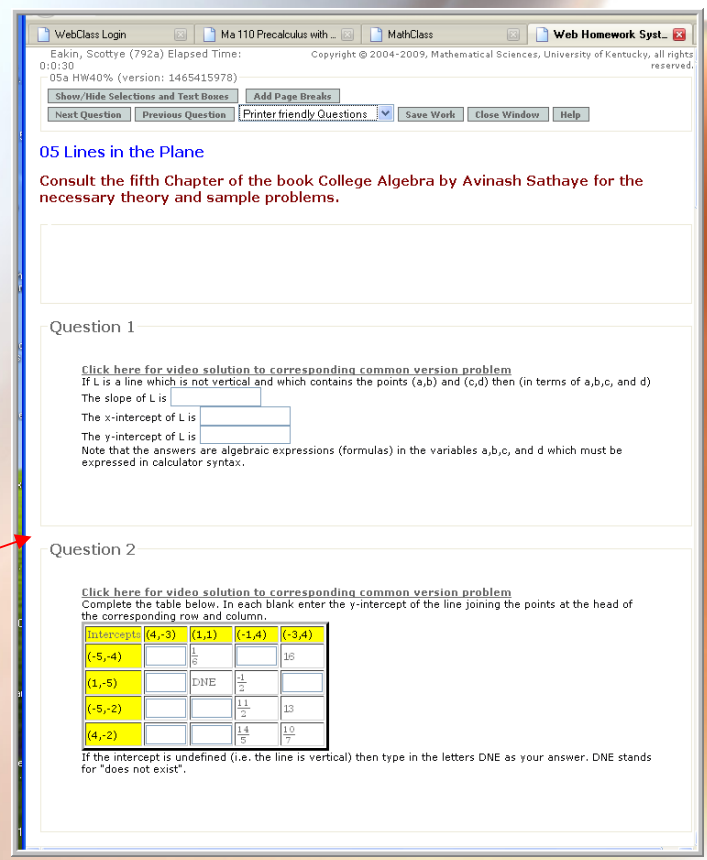
Webclass is a very large, open source instructional support system that has been developed, largely with NSF support over the last ten years. It is optimized to support the collaborative development, coordinated implementation, and the free dissemination and adaptation of mathematics instructional materials, courses, and curriculum.



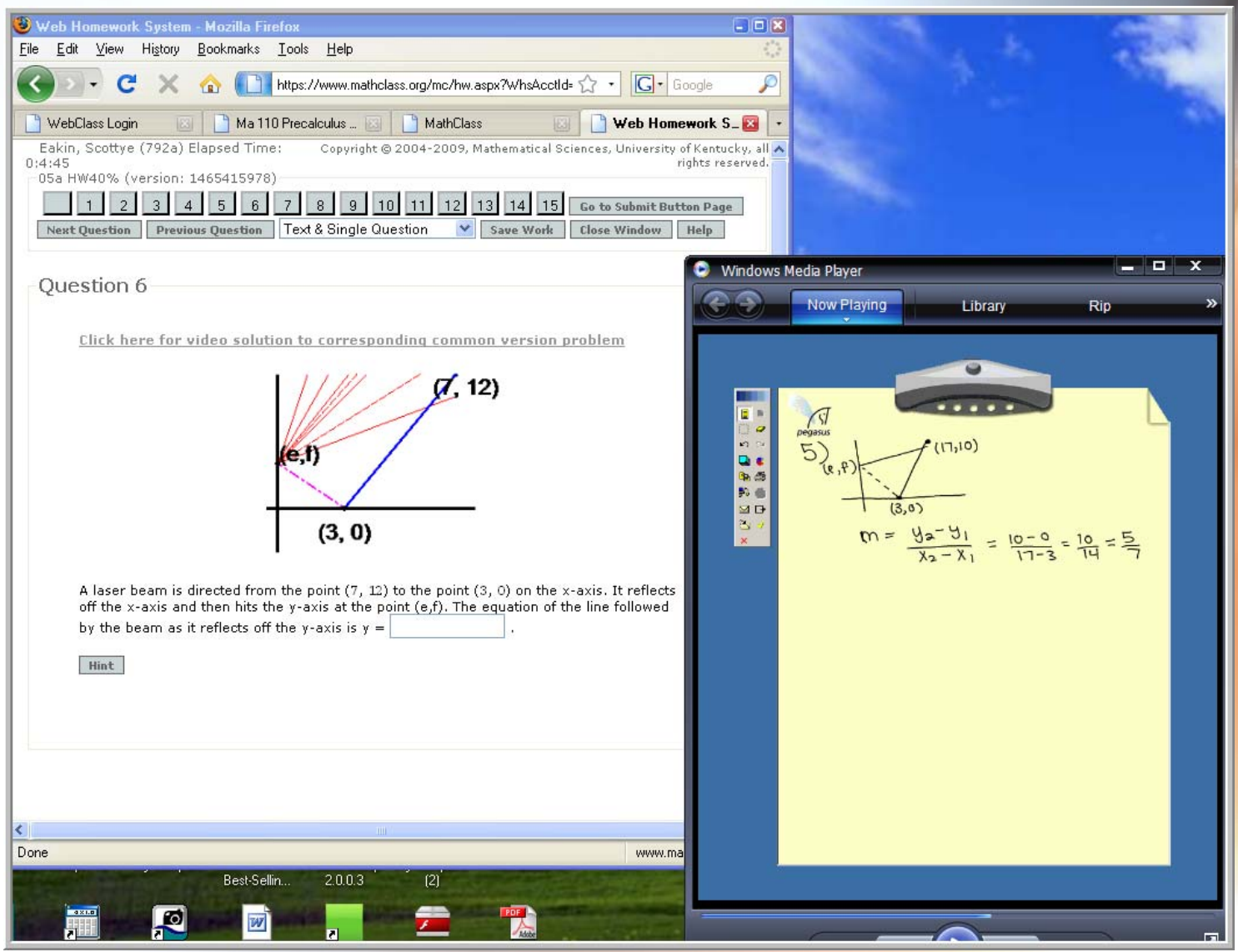
Each student is in a “class”. Classes can are organized into courses which are defined by common syllabus, text, homework, and tests. Each Access to Algebra teacher is the “instructor” of a class whose members are his or her students who are in the program.

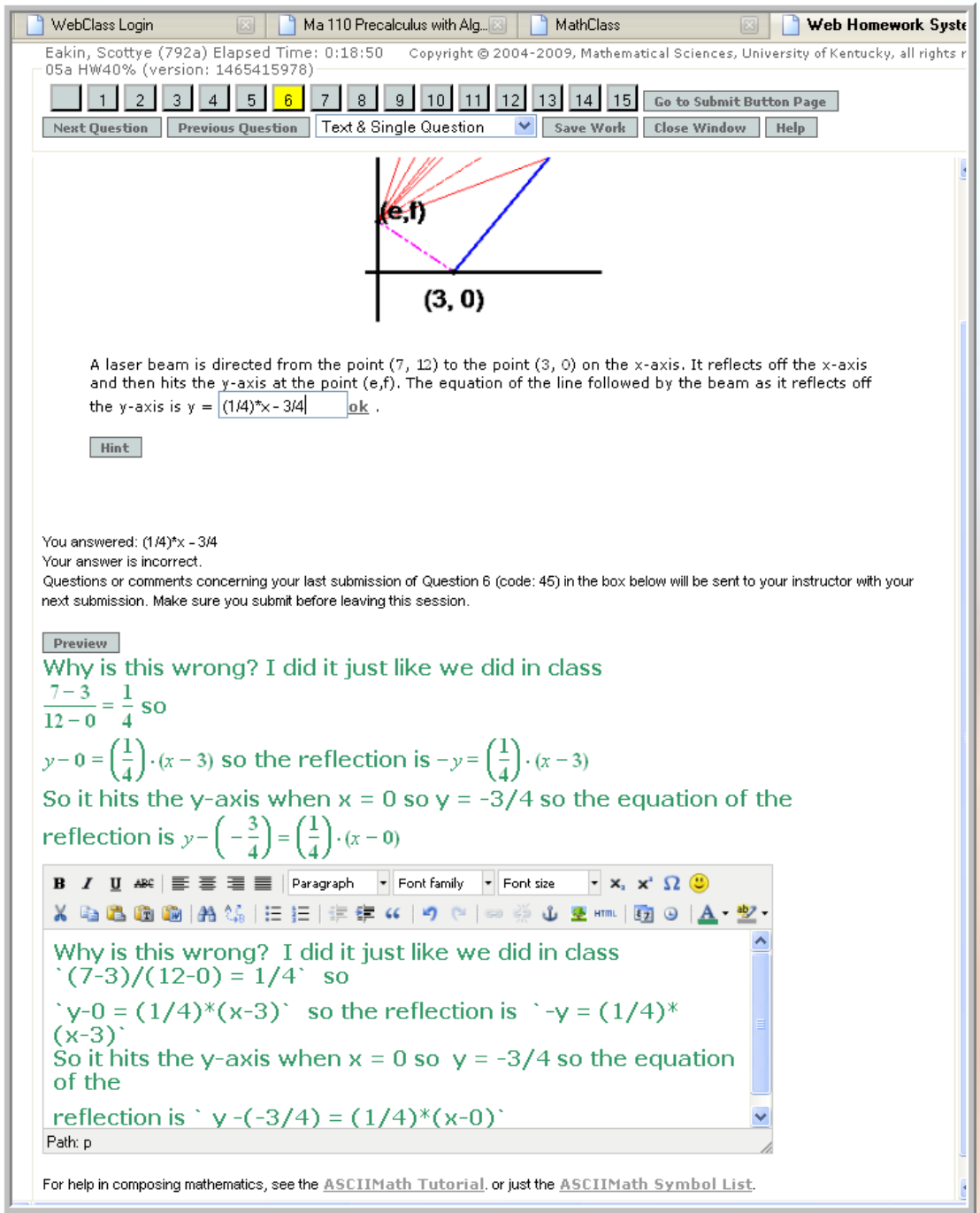


Students select a homework set on their class main page



Many problems have associated video solutions that were made by AMSP-sponsored pre-service math teachers

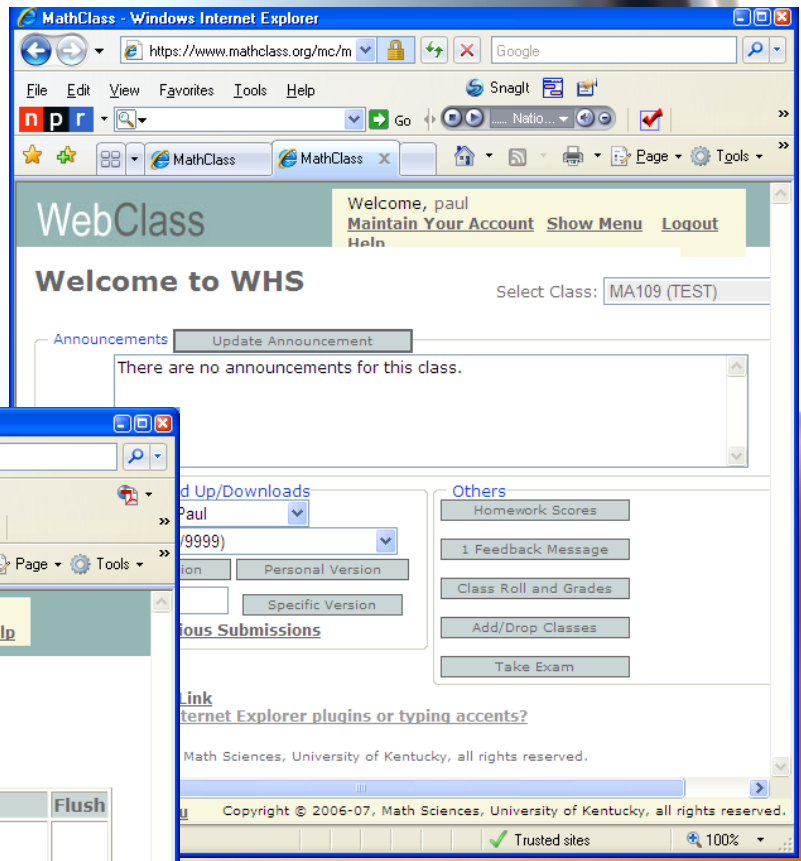


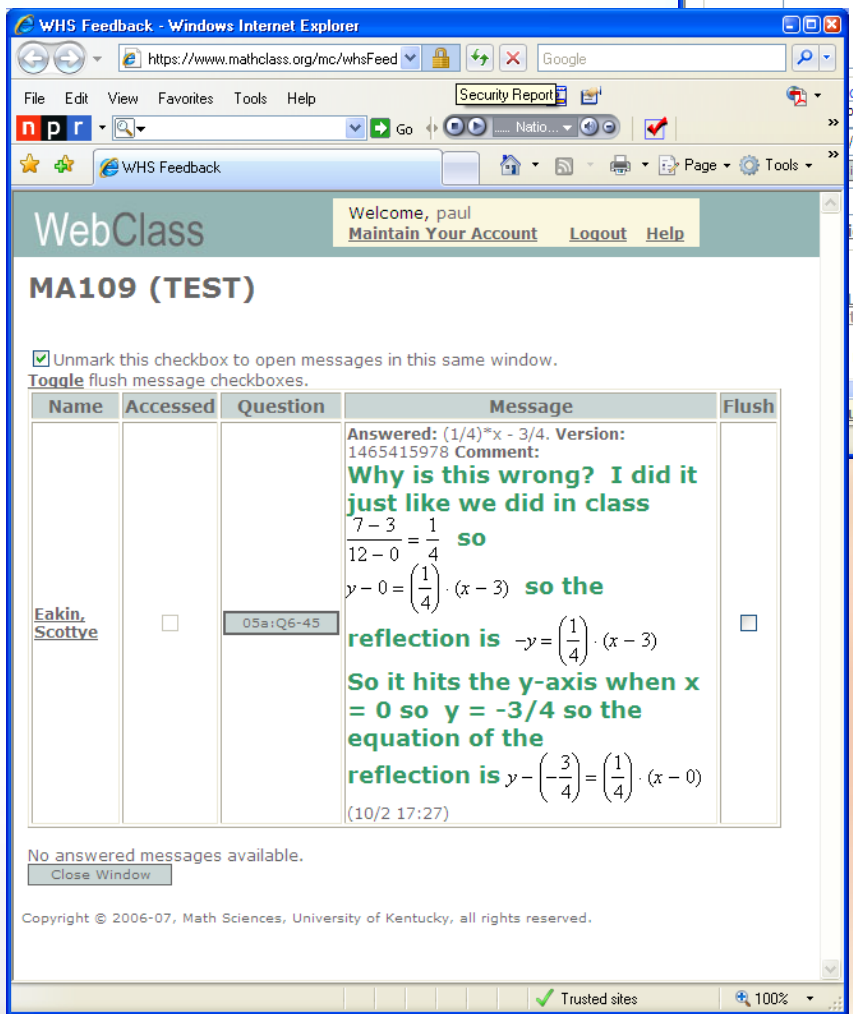


After the machine checks a submitted answer, the student can send a "feedback" message to the instruction staff.

An intuitive grammar supports formatted math

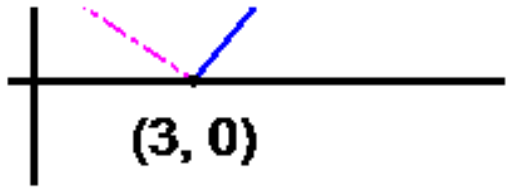
All submitted messages are tabulated in a web page for the instructors and assistants





Instructor receives the exact statement of the problem as seen by the student – together with the expected answer and the allowable error.

MA109 (TEST)



A laser beam is directed from the point (7, 12) to the point (3, 0) on the x-axis. It reflects off the x-axis and then hits the y-axis at the point (e,f). The equation of the line followed by the beam as it reflects off the y-axis is y = (1/4)*x - 3/4 .

Hint

The correct answer including error bound is: 0.05;3*x+9

Eakin, Scottye	☐	05a:Q6-45	is $-y=\left(\frac{1}{4}\right)\cdot(x-3)$ So it hits the y-axis when x = 0 so y = -3/4 so the equation of the reflection is $y-\left(-\frac{3}{4}\right)=\left(\frac{1}{4}\right)\cdot(x-0)$ (10/2 17:27)

Why is this wrong? I did it just like we did in class

$\frac{7-3}{12-0}=\frac{1}{4}$ so THE PROBLEM IS THAT YOU CALCULATED THE SLOPE WRONG. IT IS $\frac{y_2-y_1}{x_2-x_1}$

$y-0=\left(\frac{1}{4}\right)\cdot(x-3)$ so the reflection is $-y=\left(\frac{1}{4}\right)\cdot(x-3)$

So it hits the y-axis when x = 0 so y = -3/4 so the equation of the CHECK YOUR ARITHMETIC TOO

reflection is $y-\left(-\frac{3}{4}\right)=\left(\frac{1}{4}\right)\cdot(x-0)$

(10/2 17:27)

Preview

B I U ABC | Paragraph | Font family | 4 (14 pt)

`y-0 = (1/4)*(x-3)` so the reflection is `-y = (1/4)*(x-3)`

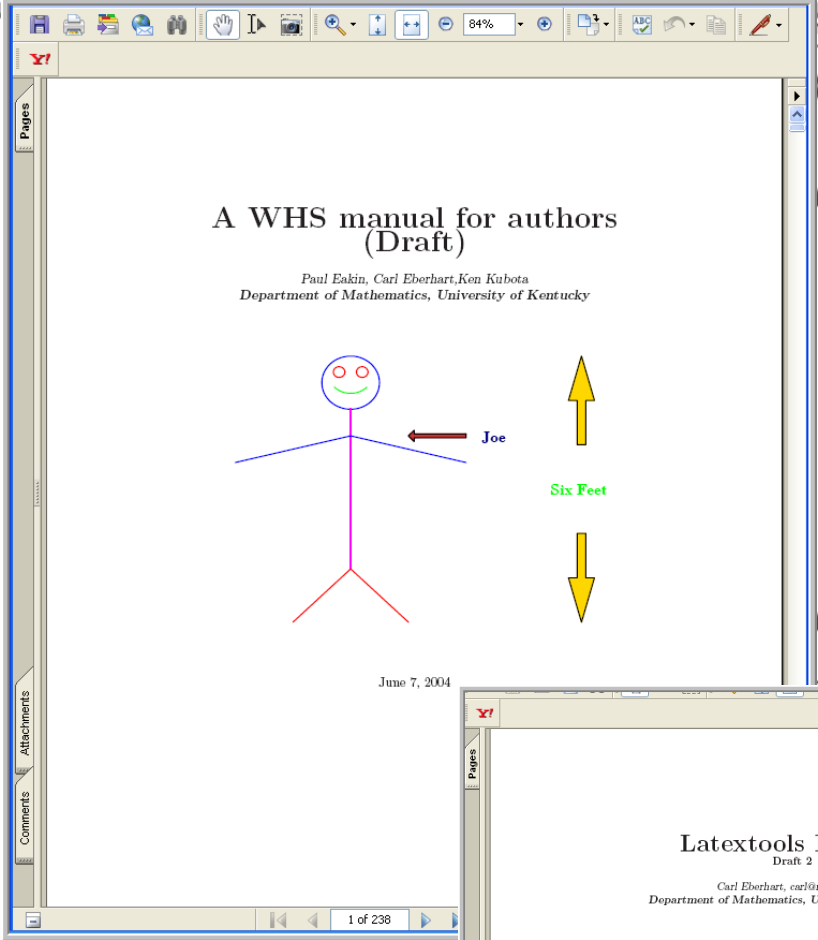
So it hits the y-axis when x = 0 so y = -3/4 so the equation of the CHECK YOUR ARITHMETIC TOO

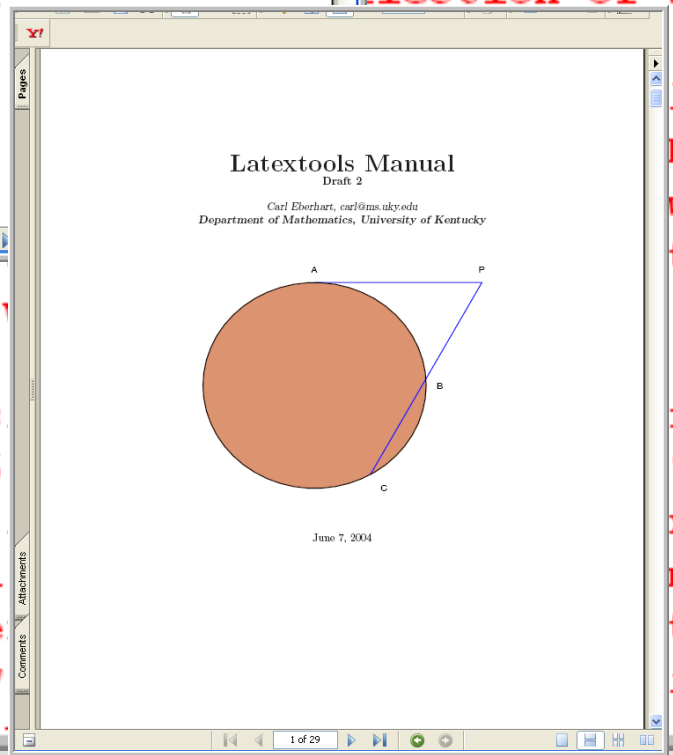
Path: p » strong » font » font

Record Response | Mark as Read without Responding

The instructor or an assistant can edit the student question. The response is routed back to the student. The feedback number on instructor page is decremented and that on the student page in incremented

Testing ..



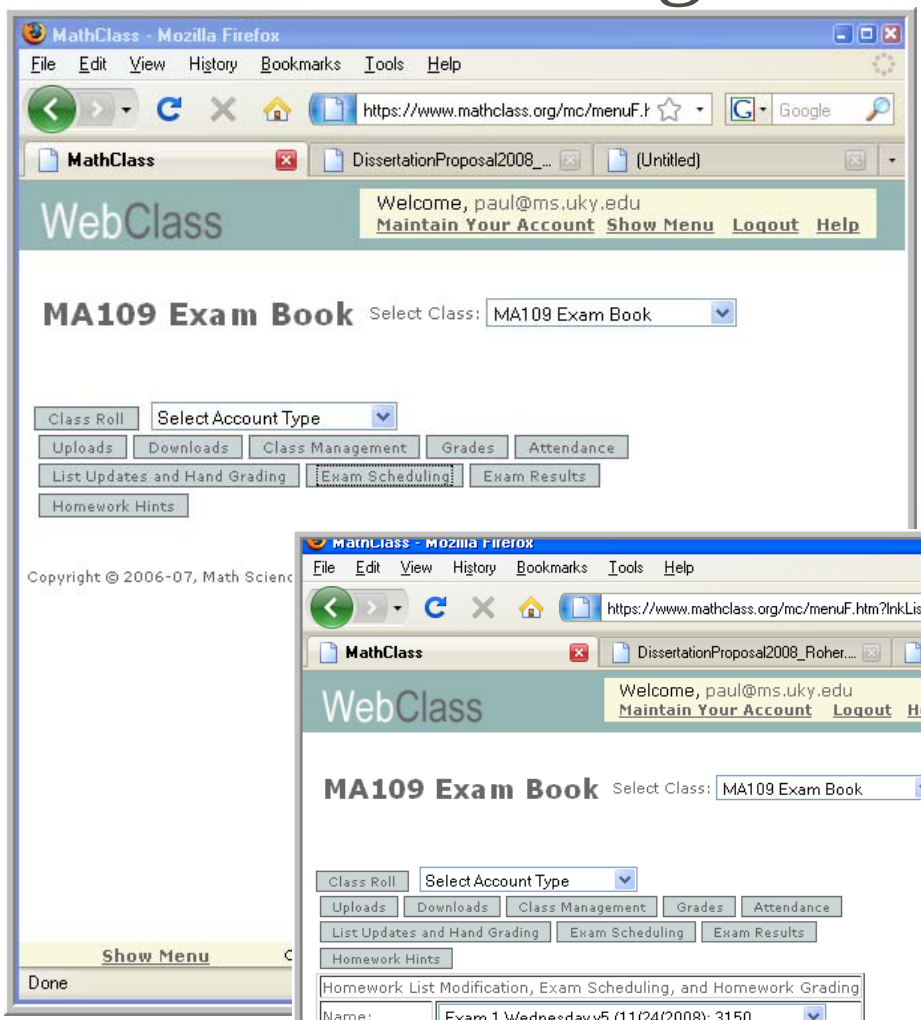


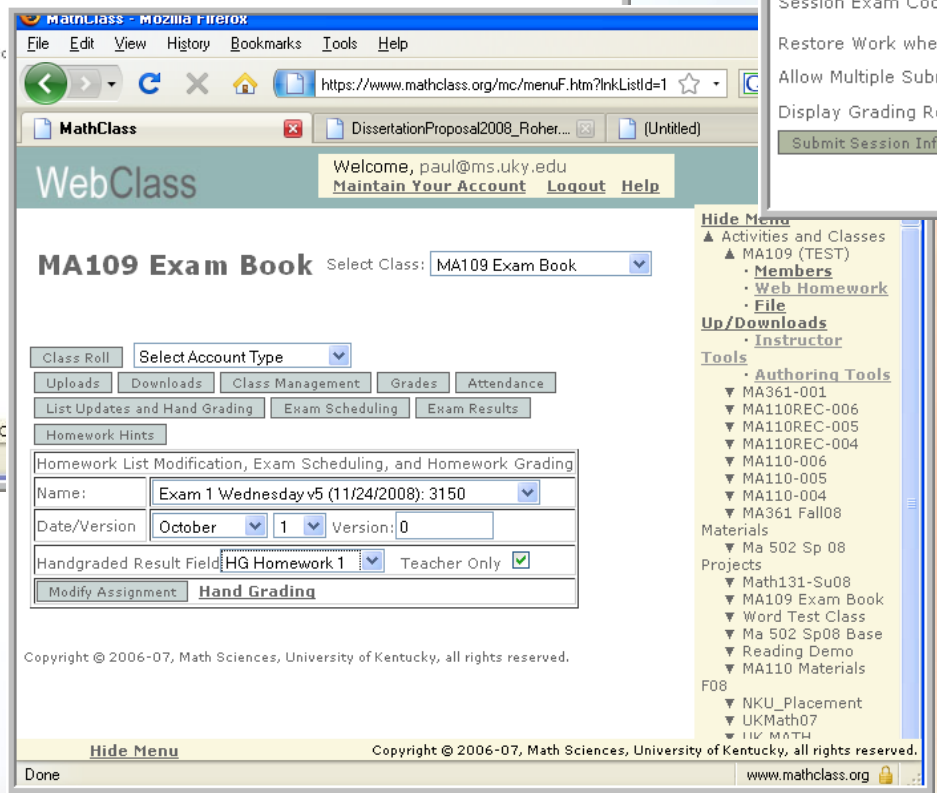
Homework problems are Maple procedures which produce versions of problems complete with diagrams that reflect the problem data. The same code can spawn both Mathml and LeTeX. This is the basis of the Access to Algebra testing system

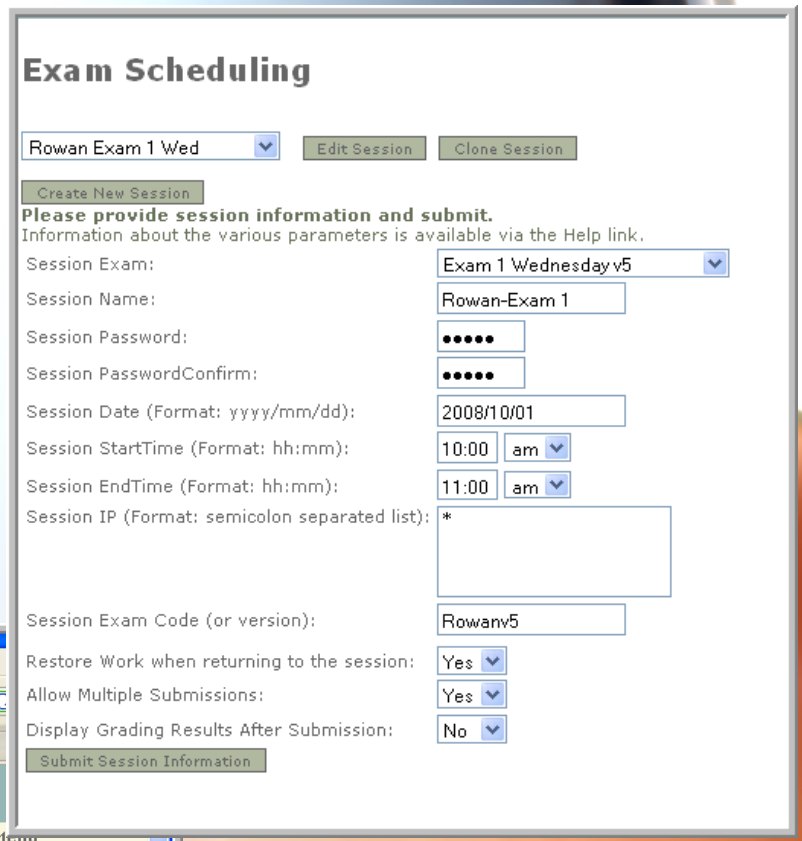
Examinations:

- Tests are initially produced as if they were ordinary homework but are installed in a separate, secure environment.
- Pdf versions are produced from the same code. Local and remote teachers access these over secure channels and duplicate them to produce classroom exams.
- Remote students complete their “paper and pencil” exams and are then given time to submit their solutions through an environment much like the feedback system. This is done under the supervision of the teacher who retains the original.
- The electronic versions are “hand graded”, along with the on-campus exams by the on- campus instructors. Students (and teachers) typically have their results within 48 hours – often the next day.

Exam Scheduling tools





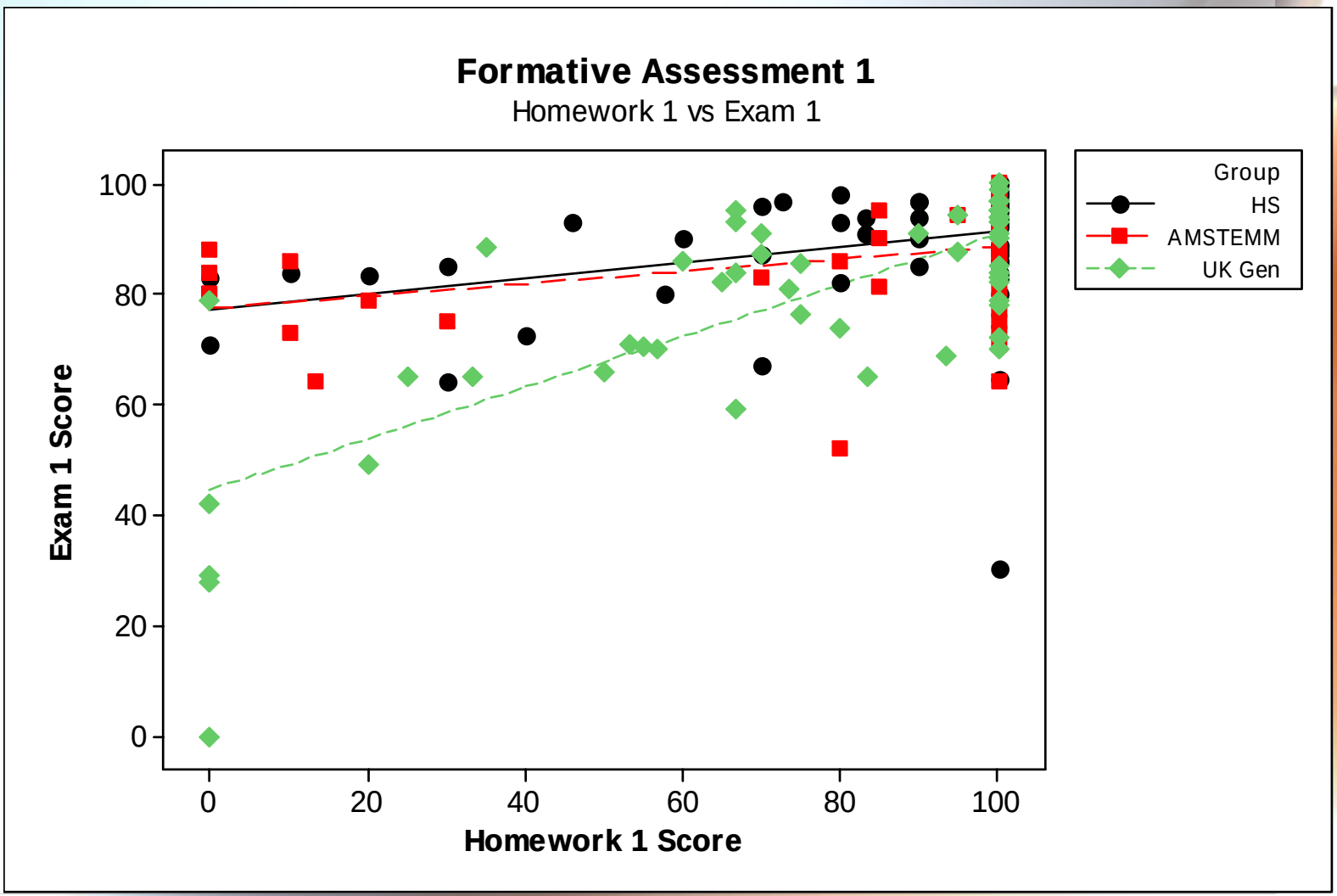


Some data and outcomes

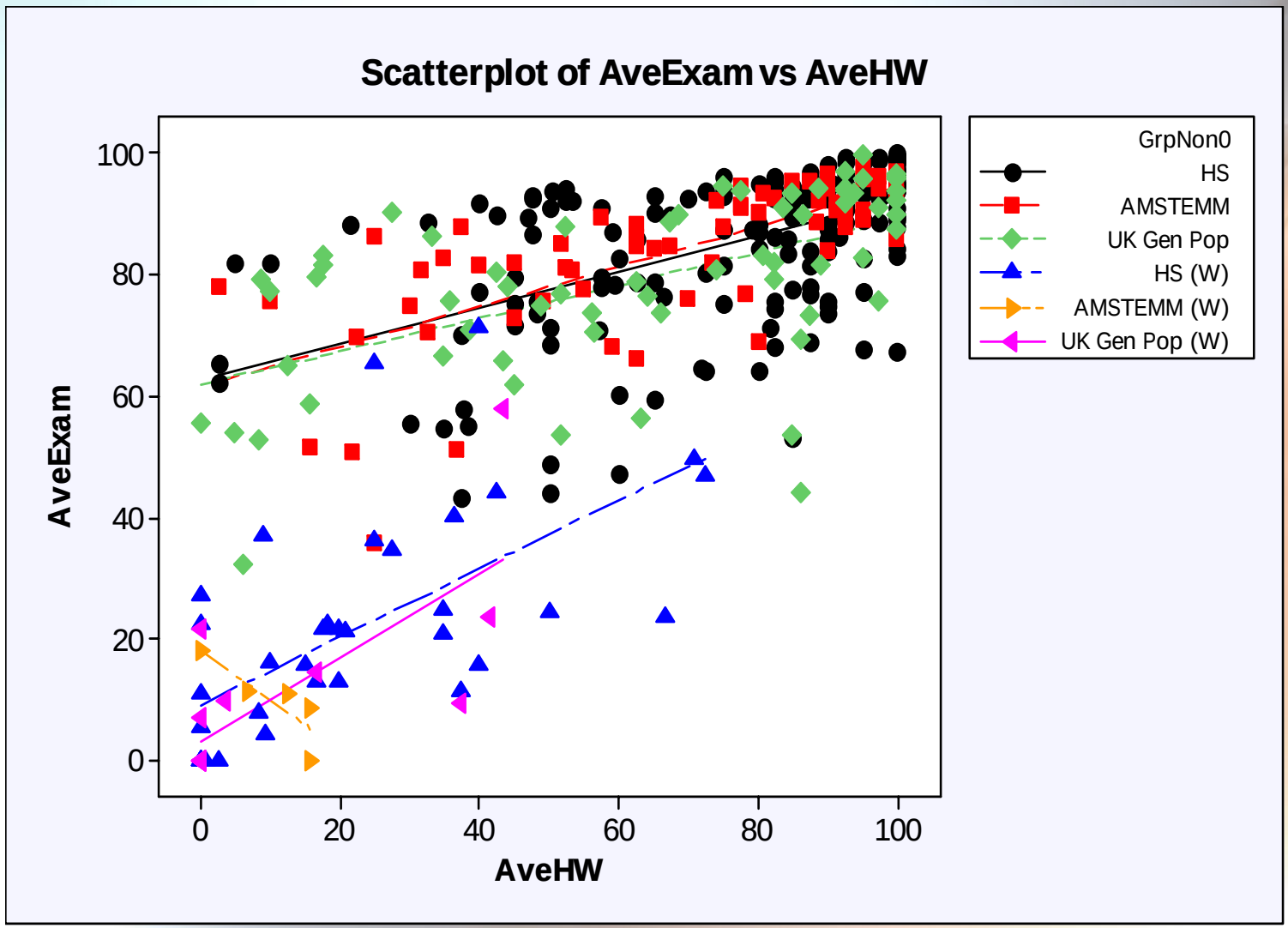
The (primary) On-campus Comparison Cohort

- Students From an NSF STEP program at UK
- Focus on Appalachian and Minority Science, Technology, Engineering, and Mathematics Majors (AMSTEMM)
- Majority from Appalachian Kentucky
- Motivated, well-supported
- Demographics largely reflect those of the Access to Algebra students

Representative Formative Evaluation Data:
Student scores on exam 1 vs online homework participation
Spring 2007



Homework vs Test Average
Fall 2007- Spring 2008



Grade distributions: Fall 07-Spring 08

	A	B	C	D	E(F)	W	total
College Students 2007 Fall	16 39%	12 29%	5 12%	4 10%	1 2%	3 7%	41
Secondary Students 2007 Fall	27 43%	12 19%	6 10%	4 6%	3 5%	11 17%	63
Secondary Students 2008 Spring	26 34%	13 17%	12 16%	7 9%	4 5%	14 18%	76
Percentages are rounded to the nearest integer, so rows may not total 100%							

Note: AMSTEMM did not have a section of MA109 in Spring 2008.

Student success vs PD participation

F 06

Teachers	Total	Total Enrolled HS Students	HS Students receiving College Algebra credit	Success Rate
Systematic Participation	9	28	26	93%
Non-systematic Participation	5	14	3	21%*

S 07

Systematic Participation	11	21	19	90%
Non-systematic Participation	3	9	3	33%*

F 07

Systematic Participation	3	27	20	74%
Non-systematic Participation	5	40	25	62.5%

S 08

Systematic Participation	4	28	19	67%
Non-systematic Participation	5	48	32	67%

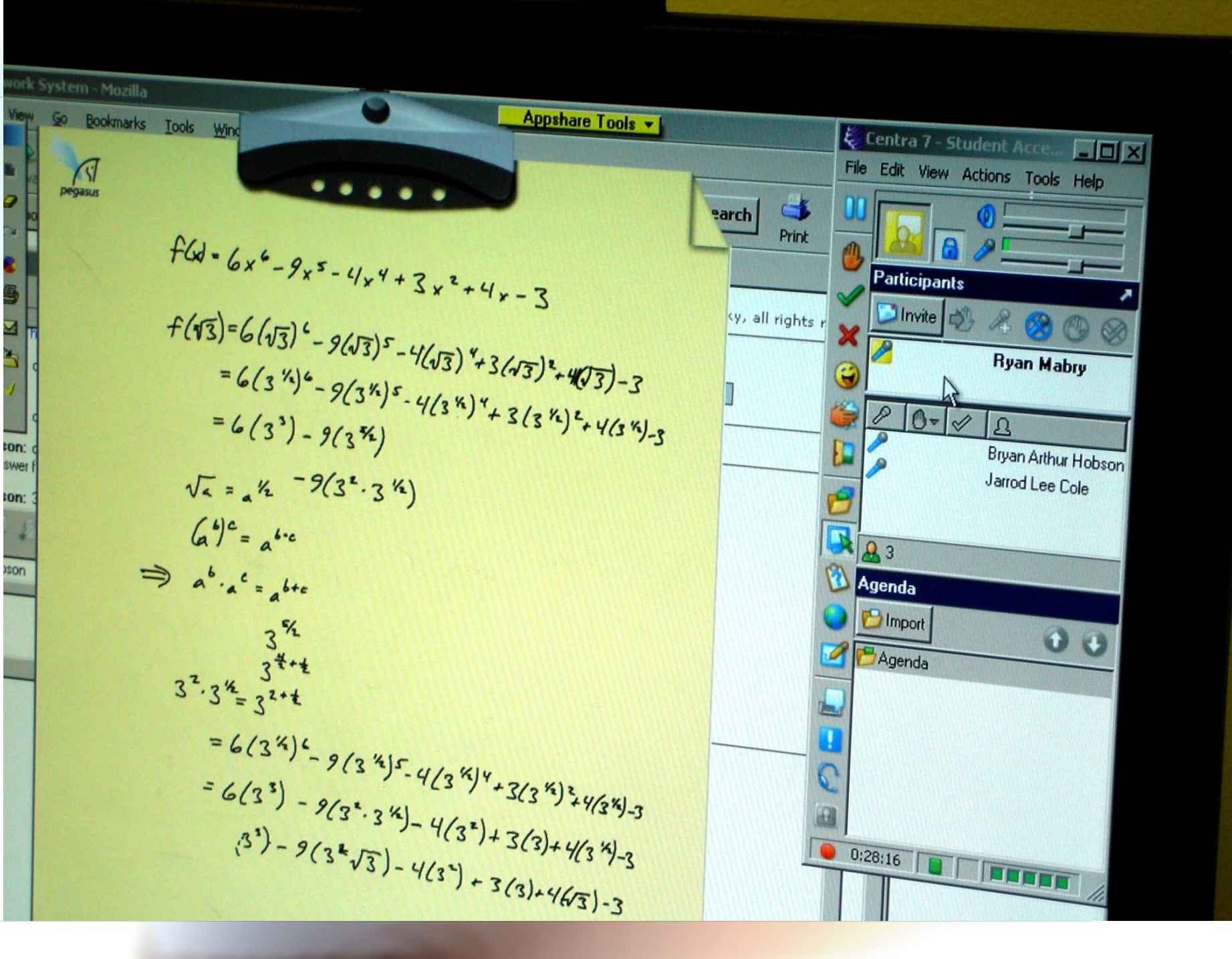
* = skewed by outlier

Most S07-S 08 are repeating from previous semester

Not everything has worked ..

Online tutors:

If you build it they might not come..


Appshare Tools
Centra 7 - Student Acce...
File Edit View Actions Tools Help
Participants
Invite
Ryan Mabry
Bryan Arthur Hobson
Jarrod Lee Cole
3
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pegasus
$f(x) = 6x^6 - 9x^5 - 4x^4 + 3x^2 + 4x - 3$
$f(\sqrt{3}) = 6(\sqrt{3})^6 - 9(\sqrt{3})^5 - 4(\sqrt{3})^4 + 3(\sqrt{3})^2 + 4(\sqrt{3}) - 3$
$= 6(3^{1/2})^6 - 9(3^{1/2})^5 - 4(3^{1/2})^4 + 3(3^{1/2})^2 + 4(3^{1/2}) - 3$
$= 6(3^3) - 9(3^{5/2})$
$\sqrt{a} = a^{1/2}$
$(a^b)^c = a^{b \cdot c}$
$\Rightarrow a^b \cdot a^c = a^{b+c}$
$3^{5/2}$
$3^{\frac{4}{2}+\frac{1}{2}}$
$3^2 \cdot 3^{1/2} = 3^{2+\frac{1}{2}}$
$= 6(3^{1/2})^6 - 9(3^{1/2})^5 - 4(3^{1/2})^4 + 3(3^{1/2})^2 + 4(3^{1/2}) - 3$
$= 6(3^3) - 9(3^2 \cdot 3^{1/2}) - 4(3^2) + 3(3) + 4(3^{1/2}) - 3$
$(3^3) - 9(3^2\sqrt{3}) - 4(3^2) + 3(3) + 4(\sqrt{3}) - 3$

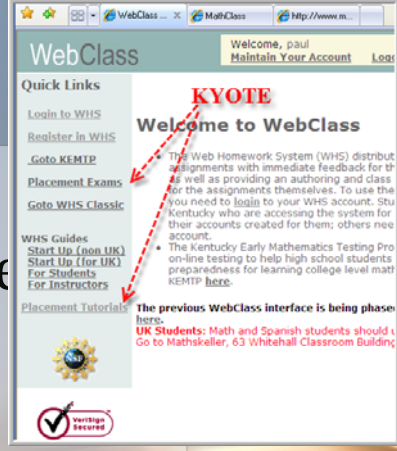
We could not get online tutors to work!

- Technology worked exactly as expected.
  - No technical glitches
- Tutors were excellent
  - Outstanding math majors and pre-service math teachers
  - Well prepared
  - Articulate
- Scheduling was not a problem
  - Regularly scheduled hours
  - Individual appointments as requested
- Facilities and access were not a problem
  - Schools given extra computers
  - Students given personal sets of equipment
    - Pen, headset, video camera
- Students simply went to their teachers for assistance and ignored the tutors
  - Backhanded positive measure of success of the PD program

Unexpected “bonus”:

A spontaneous statewide partnership driven by a new, open source tool

The KYOTE Online Placement System



- Feb 2007: at a state math meeting Ken Kubota was casually asked about the feasibility of a secure online placement system by colleagues at several other universities.
  - He was just completing the design of the Access to Algebra secure testing system
- March 2007: an informal meeting of a group of math faculty and administrators met to discuss placement exams. This became the "statewide placement group". UK adapted the Access to Algebra system and made it freely available to everyone.
- March 2008: The **K**entuck**Y** **O**nline **TE**sting program (KYOTE) is fully operational with college readiness, college algebra, and calculus exams.
- Summer 2008: Northern Ky University and 18 school districts form partnership bases on school administration of the exams.

Slides from a July 08 talk by a KY higher Ed official

Working on Two Fronts: Improving Delivery and Early Intervention to Reduce the Need for Remedial Education in Kentucky

NASH
P-16 Summer Institute

July 20-22, 2008

Dr. Dianne M. Bazell
Assistant Vice President,
Academic Affairs
dianne.bazell@ky.gov

Kentucky Council on Postsecondary Education
http://cpe.ky.gov

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What It Is

KYOTE: Kentucky Online Testi

- 3 assessments: developmental (pre college algebra; college calculus
- Developed by mathematics faculty f public four-year institutions, severa community/tech colleges, and some
- Free-of-charge to students and insti

How It Developed (2)

- **Appalachian Math and Science Project (AMSP-UK)** – NSF-funded P/D for K-12 math/science teachers
  - On-line instruction and P/D applicable to other subjects (currently Spanish)
- **"Access to Algebra" (UK)**
  - On-line P/D embedded in academic year
  - Open-source on-line courses and textbooks

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What a Statewide Placement Assessment Provides

- A cross-institutional placement instrument—consistent more nuanced, usable for **accelerated as well as developmental placement**
- Another venue for pre-college diagnosis and intervention
- Basis for developing transitional courses for HS seniors AND assigning accelerated students to challenging (college-level) courses and college calculus
- **Way to assess effectiveness of developmental ed**

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Next Steps

- **Regional initiatives:**
  - NKU + 18 area superintendents give transitional algebra course to seniors not on track for college-readiness. Passing KYOTE guarantees credit-bearing course placement at NKU.
  - EKU + Madison County: KYOTE administered beginning in 8th grade with summer interventions given to students not on track for college-readiness.
- **Statewide initiatives:**
  - KCTCS use of KYOTE as additional option (with COMPASS) for entering students
  - KDE use of KYOTE resources to develop transitional senior year math courses in pilot districts

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http://apps.cpe.ky.gov/bazell/NASH072108-workingontwofronts.ppt

Next steps

- Adaptation of the college algebra text to produce an “algebra I/II” version to serve as a platform for:
  - A program that secondary teachers can run to develop middle school colleagues to the level of teachers of algebra I and II
  - A parallel remedial program for postsecondary
  - Collaboration with UTC
- Study of factors promoting systematic participation in embedded professional development of this type and relationship to student achievement
  - AMSP sponsored doctoral research
- Inclusion of full synchronous conferencing in the WHS system
  - Removes last commercial product and makes the entire system open source
- Completion of PD infrastructure needed for technology dissemination
  - release versions of manuals for authoring and system operation, user guides
  - courses for users and developers
- Release version of WHS
- Expansion of KYOTE system
- Collaboration with KY community colleges on adaptation of Access to Algebra format for faculty PD and course transfer.
  - Initial effort with linear algebra
  - Impacts community college to university transition

Dissemination:

- * Roher, L. A. H., & Kinser, G., (2008, March). ***Creating a professional learning community for secondary mathematics teachers through embedded professional development using online meetings***. Presented at the annual Society for Information Technology and Teacher Education, Las Vegas, NV.
- Eakin, P., & Roher, L. A. H., (2007, October 29). ***A model for embedded professional development for secondary mathematics teachers***. Presented at the 2007 Quality Teacher Summit, Frankfort, KY.
- Roher, L. A. H., Zehnder, S., & Kinser, G. (2007, October 19 & 20). ***Professional learning communities communicating online in real time***. Presented at the annual meeting of the Kentucky Council of Teachers of Mathematics, Georgetown, KY.
- Roher, L. A. H., (2007, October 15). ***Embedded professional development for math teachers: College credit in college algebra for secondary school students***. Presented at the inaugural meeting of Mathematics and Science Symposium, Knoxville, TN.
- Roher, L. A. H. (2007, February 25). Access to algebra: ***Comparative study of high school math students using distance learning at readiness with college algebra classroom students***. Electronic proceeding for the Tenth Special Interest Group of the Mathematical Association of America on Research in Undergraduate Mathematics Education, San Diego, CA. Available at http://cresmet.asu.edu/crume2007/papers/roher.pdf.
- Roher, L. A. H. (2007, February 25). ***Access to algebra: Comparative study of high school math students using distance learning at readiness with college algebra classroom students***. Presented at the 2007 Tenth Special Interest Group of the Mathematical Association of America on Research in Undergraduate Mathematics Education, San Diego, CA.
- Roher, L. A. H., & Aossey, C. A. (2006, September). ***Centra - Online mathematics meetings.*** Presented at the annual meeting of the Kentucky Council of Teachers of Mathematics, Georgetown, KY.