Individualized Assignments and Assessment through Automated Grading

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Computation Lab – CS 121, 122, 123 Course Goal and Themes

- For science, mathematics and engineering students to become proficient with an industrial grade tool including symbolics, numerics, visualization and scripting that they can use for engineering computation
- Design, Exploration, and Simulation
- Required of all freshmen engineering students (~950/year)

Motivation for Learning Approach

- Recent literature* re-iterates the value of our key strategies:
  - Value of a quiz based learning experience
    - "interleaving of worked example solutions and problem-solving exercises"
    - "use quizzing to promote learning, re-expose students to information"
    - "use pre-questions to introduce a new topic"
  - Value of an extended learning experience (3 semesters instead of a single term)
    - "space learning over time"

*H. Pashler, P. Bain, B. Bottge, A. Graesser, K. Koedinger, M. McDaniel and J. Metcalfe, Organizing instruction and study to improve student learning: A practice guide (NCER 2004-2007).

MapleTA Question Parameterization

Algorithm Edit

```
$ovenTemp = range(350,450)
$startTemp = range(68,85)
    $delta = $ovenTemp-$startTemp
     $coef = range(80,98)/100
 $doneLow = 260
$doneHigh = 280
  $formula = maple("$ovenTemp-$delta*$coef^t")
 $lowTime = maple("fsolve($doneLow      = $formula,t)")
$highTime = maple("fsolve($doneHigh     = $formula,t)")
$midTemp = $deltaf2+$startTemp
 $midTime = maple("fsolve($midTemp      = $formula,t)")
     $qml = maple("MathML[ExportPresentation](T = $ovenTemp-$delta*$coef^t)")
      $eq = maple("T                    = $ovenTemp-$delta*$coef^t")
```

Case Study - Least Squares

- Overview of the Least Squares Algorithm
  - Produces a "best fit" linear expression in the form
    - Dependent variable = a + b * Independent variable for a list of ordered pairs [independent, dependent]
  - Curve fitting is taught in Computation lab at Drexel
    - CS121 – Least Squares (Ideal Gas Law)
    - CS123 – Spline curve fit
  - Curve fitting is utilized in Drexel's freshman engineering design lab sequence
    - Exponential curve fit to model capacitor charge and heating profiles
    - Linear curve fit to correlate actual versus measured distances for robot light sensors

Course Objectives

- Technical
  - Using an interactive CAS for mathematical computations
  - Setting up and using mathematical models
- Programming
  - Assignment, looping, conditionals, functions
  - Simple Data Structures – lists, tables, sequences, expressions
- Software engineering
  - Developing scripts
  - Testing
  - Troubleshooting
  - Learning from documentation
  - Communicating technical material

MapleTA Overview

- Web-based quiz system with Maple backend
  - Class and roster management with provisions to create, conduct and report / store results for individual quizzes
  - Instantaneous feedback, hints, multiple attempts
- Allows for the following types of question creation
  - Multiple choice, matching, true/false
  - Computed solutions to word problems
  - Free form answers checked against patterns and via Maple computation
- Can "individualize" tests at the student level
  - Different parameter values for the same problem
  - Different questions for the same concept

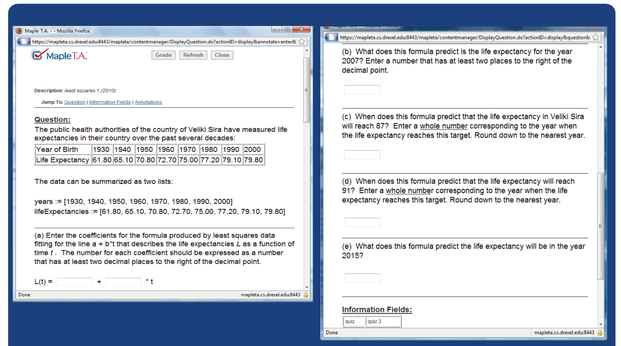
MapleTA Question Selection

Question Name: Parameter ver2

Script Parameters
What is a parameter in a script?

- Typed characters such as parentheses or square brackets that bound pieces of an expression
- Variables that you assign at the beginning of a script
- Equations used in the description of a problem
- The things that don't change between different versions of a problem
- None of the above

We populate the question with randomly selected options from a pre-established list of correct and incorrect options. The Maple TA script calls combinat[randperm] to randomly select elements from a list.



Course Organization

- 1 credit hour per term, 3 terms (30 weeks)
- Separate from calculus (math content lags behind one term)
- Meet 2 hours in weeks 2,4,6,8 in lab
- Automated quizzes (Maple TA, web based) in weeks 3,5,7,9 (on-line, any time)
- Proficiency exam in week 10 (Maple TA, proctored – 36%)
- ~30 sections with ~32 students each. (~950/ year)
- Staff: 1 or 2 senior instructors, 4 or 5 instructors, 15+ undergrad assistants

Example – MapleTA Quiz Problem

MapleT.A. Grade Refresh Close

Description: *Potato Problem - Hot Potato 3 (2010)*

Jump To: Question | Information Fields

Question:

Computing the time to bake potatoes
From Problem 38, chapter 1 review, Anton, Calculus 8th edition.

An oven is preheated and then remains at a constant temperature. A potato is placed in the oven to bake. Food scientists have measured the rise of temperature of a baking potato. They have found that the temperature T (in degrees Fahrenheit) of the potato can be described by the relation given by the equation

$$T = 448 - 379\,0.97^{t}$$

where t is the amount of time (in minutes) after the potato is put in the oven.
In Maple "1 dimensional (keyboard entry)" syntax this formula is written as

T = 448-379*.97^t

The potato will be considered done when its temperature is anywhere between 260 and 280 degrees Fahrenheit.
(a) Enter two numbers that are the start and end times of "doneness". Enter an number with decimal point. Your answer will be graded as correct if you are within .1% of the answer computed by Maple.

Doneness begins at *t* = _____ minutes after the potato is put into the oven.

Doneness ends at *t* = _____ minutes after the potato is put into the oven.

(b) How long does it take for the difference between the potato's starting temperature and the oven's temperature to be cut in half? Enter an approximate value (with decimal point) correct to within .1% of the correct time (as calculated by Maple).

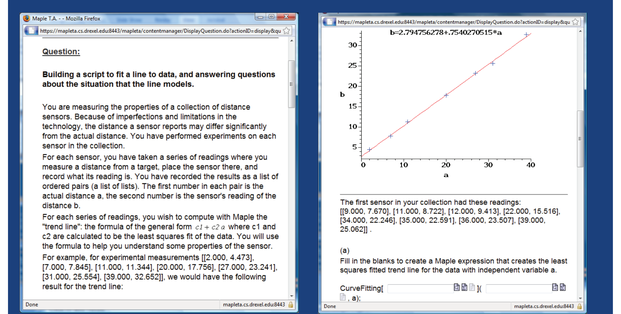
It takes approximately _____ minutes for the potato's temperature to get half way from its starting temperature to the oven's temperature.

Hints Edit

Hint 1: You can copy and paste the "1 d" version of the equation from the web page into Maple, and it should accept it just as if you've typed it in from the keyboard.
Hint 2: For all parts of this question, Maple TA is programmed to accept any answer that is within .1 % of what it calculates as the correct answer.
Hint 3: The solve operation on the equation you set up here will have a decimal point answer ... because there is a decimal point in the equation itself.
Hint 4: To do several similar calculations in a row, you can copy and paste the sequence of actions to repeat them. Edit the copies so that they do something slightly different. Then select the whole area with the mouse and use the Edit->Execution->Selection menu item at the top of the Maple window and Maple will do all the operations at once. This can save typing. However, typing in the variations of the equation to solve for (a) and (b) and solving them individually will also work.

How Is Maple Used In Questions?

- Generation of MathML for display of math expressions
- Occasional formula manipulation to insert parameters into models
- Solvers invoked heavily for checking and for generation of problems/correct answers
- Integer and floating point random numbers (*RandomTools*), random permutation of lists of items (*combinat[randperm]*)
- Module feature to store extended computations as a library loadable into a Maple TA question
- Plotting to show answers and/or illustrate problems
- Generation of animations, either through Maple TA *mapleplot* call to maple animation, or through pre-animated gifs
- List manipulation/selection



What goes "beyond the envelope" in Maple TA?

- Connection between Maple TA script engine and Maple engine is too narrow -- often you want to return several values and it isn't easy.
- Student input can't include full fledged Maple programming because Maple TA assumes input is in HTML. Thus inputs with "<" and ">" can be problematical.
- Data limitations in results returned by Maple make it difficult to display or compute large animations on the fly -- they can be computed quickly enough, but Maple TA can't receive it.
- No technology for code assignments.

Computation Lab Learning Approach

- Current Computation Lab teaching model
  - Introduce the concept
  - Formally teach / master the key principles
  - Test effectiveness of the learning experience
  - Re-enforce the imparted knowledge
- Note that all phases of this approach employ quizzes to facilitate the learning process

Case Study - Least Squares

- How we can measure the effectiveness of meeting the objectives for the LS concept
  - Measuring initial learning experience
    - Pre-lab quiz results – no current data on LS problem
    - Lab verification score – nearly 100% success rate for 3 person teams
  - Measuring retention between 1st encounter and end of term
    - Fall, 2010 – post-lab quiz (874 students) – 87.0%
    - Fall, 2010 – end of term proficiency exam (551 students) – 81.2%
  - Measuring longer term retention
    - Fall term, 2010 – post-lab quiz (874 students) – 87.0%
    - Winter, 2010 – review problem in post-lab quiz (802 students) - 86.3%

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