On-Line Resources Supporting PSI (Keller Plan) Instruction in Remedial Mathematics and Algebra

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Abstract:

This paper discusses the on-line resources that have been developed to support PSI (Personalized System of Instruction), also known as the Keller Plan, instruction in remedial mathematics and algebra. The paper will focus on the new component, MUSolver, that was added for the Fall 2002 semester. MUSolver is a package of seventeen (17) applications, nine of which are directly related to remedial mathematics instruction that accept input from the student (i.e., student enters the problem to be solved) and dynamically solves the problem in a step-by-step process.

This paper contains the following sections:

1. Institutional Setting
2. PSI (Keller Plan)
3. Key Features of MUTester
4. MUSolver Component
5. Software Distribution
6. Current Problems -- Future

Institutional Setting:

Monmouth University is a private, comprehensive, teaching university enrolling approximately 4500 students of which 3200 are full-time undergraduate students. The University is located in the central shore area of New Jersey – about 55 miles south of New York City.

The Mathematics Department has thirteen full-time faculty members. The Mathematics Majors program at the University enrolls over 60 full-time equivalent students; a significant number of those students are dual-majors – mathematics and education. As with most institutions of today, a substantial part of the teaching responsibility of the Mathematics Department is directed toward instruction for non-majors with many in the non-science disciplines. The largest single group serviced by the Department consists of those students majoring in programs within the School of Business Administration.

The Mathematics Department has a computer laboratory with 30 computers, a laboratory classroom with 12 computers and a digital video projection system, and access to four general purpose classrooms with instructor computers connected to digital video projection systems. All computers in the Mathematics Department are pentium III class or higher units; all the laboratory and classroom computers are running the WinXP operating system; while faculty are running either the Win2K or Win XP operating system. The main software products used by the department are: MS Office Productivity Suite, Maple 8.0, MiniTab, Geometer's SketchPad, InteractiveDE, Advanced Grapher, Matlab, and Euphoria.

The network in the Mathematics Department is supported with a Win2K Domain Controller which also

serves as a file and print server and a Win2K Terminal Server. The Terminal Server provides access to the department resources from the Internet.

The University is a wired campus like most universities today. At Monmouth, this includes connections to all campus buildings, to each room in the residence halls, and to special locations in each of the off-campus temporary housing units. At the present time, the University is completing a plan to wire all classrooms with video and data and to install computer-supported digital video display units that are connected to the campus network. There are currently 27 computer laboratory/classrooms. Eight percent of the University classrooms have permanently-installed digital video display units.

PSI (aka Keller Plan -- described in [5]):

The PSI mode of instruction dates back to the late 60s. It became know as the Keller Plan in 1968 with the publication of the paper, *Good-bye, Teacher* [1] by Fred Keller (1899-1996), a Behavioral Psychologist at Columbia University. The key aspects of the teaching method espoused in that paper were:

1. Students progress through the course at their own pace.
2. Unit mastery required before proceeding to other units.
3. Lectures and demonstrations intended for motivation rather than information.
4. Stress on written word and teacher-student communication.
5. Individual tutoring with personalized instruction.

Over the years, there have been as many variations on the theme as there have been faculty using the ideas. A recent search of the web has discovered that a course containing only a two-week self-study component was called a "Keller" course. Most of the research studies over the past thirty years tend to support the following points:

1. Students favor the method over standard lecture/recitation format.
2. Content learning as measured by various means (control groups, standardized exit exams, and longitudinal outcomes analysis) equals or exceeds traditional courses.
3. Students who normally perform at the lower or middle level, learn significantly more in PSI courses.
4. Students report that they learn more in PSI courses.
5. Students report putting more time and effort into the PSI courses.

A general survey of the research results can be found in an article by Kulik, Kulick, and Carmichael [2].

In early PSI days, the most difficult part of a Keller course was managing the tests and tracking student progress. The author taught several courses in the PSI mode during the early 1970s, but became disillusioned, not with the concept, but with the overwhelming amount of time and effort that went into the management part of the process. With the technology of today, the management of the process has become the simplest component.

Several years ago, the author developed a web-based system of practice problems [3] to support several courses in mathematics. During the spring 2000 term, the author expanded that system to include a testing component [4] and during the spring 2002 term the solver component was added. The complete system is called *MUTester*.

Key Features of MUTester (described in[6]):

MUTester contains three components: a Practice Problem Component, a Testing Component, and a Demonstration (or Solver) Component. Students are able to access the components from any web-

connected station, whether on campus or off.

The Practice Problem Component was patterned after the "RUReady Problems" at the University of Arizona. The problems are designed to provide students with a baseline of expectations on a specific topic. By working through the problems, students are able to evaluate their own readiness for the examinations.

The problem database for Math050 contains over 800 problems divided into 22 different categories of problems. There are no constraints on the number of problems that can be associated with a single category. The system is dynamic so that problems can be added to and deleted from a category at any time. The tests are randomly generated from problems in the categories and can contain problems from several different categories.

The system is capable of presenting problems in *gif* format, encoded *html* text, plain *ASCII* text, or any combination. Long-term plans are to transition the presentation format to the MathML - XML technology.

The Testing Component can be used in conjunction with a specific set of practice problems that have been made available to students, or with a separate set designed exclusively for the testing feature.

The basic features of the Practice Problem and Testing Components are to:

1. Provide for web accessibility through Internet Explorer or Netscape 4.0 or higher browsers.
2. Support dynamic additions and deletions to the test-set database.
3. Support a variety of modes at the problem-presentation level.
4. Provide access to individual student progress records.
5. Support dynamic test creation from a problem set that can be assigned to a given student or to an entire class.
6. Provide an authorization mechanism for test administration.
7. Support faculty-level administration.
8. Support both multiple choice answers and single-answer, free-format style answers.

The Demonstration (MUSolver) Component, described in more detail below, consists of a collection of computer programs that dynamically solve in an annotated, step-by-step manner, a student-entered problem. The Solver system contains solution procedures for seventeen different mathematical concepts.

MUSolver Component:

At the present time, the Solver System contains seventeen different programs that relate to different mathematical concepts. The concepts range from simple addition of fractions to the antiderivative of polynomials. Nine of those topics relate to the topics found in the noncredit, remedial mathematics course Math050. The complete set of topics includes:

1. Arithmetic of Fractions -- Evaluation of two fractions with the four fundamental binary operations: +,-,*,/.
2. Expression Evaluation -- Evaluate an expression involving the fundamental operations: +,-,*,/,^ (exponents) with integer values.
3. Ratios and Proportions -- Set up and solve problems involing ratios and proportions.
4. Percentage Problems -- Set up and solve problems involving percentage.
5. Linear Equations -- Solve a linear equation in one variable.
6. Equation Line -- Find the equation of a line when two data elements are known.
7. Solve Two Equations -- Solve a system of two equations in two unknowns.
8. Factor Trinomial -- Factor a second degree expression involving only integers.

9. Quadratic Formula -- Solve a second degree equation using the Quadratic Formula.
10. Polynomial Arithmetic -- Perform fundamental operations (addition, subtraction, and multiplication) on polynomials.
11. Elimination -- Solve a system of 3 by 3 equations using the Elimination Method and Back Substitution.
12. Gauss Elimination -- Solve a system of 3 by 3 equations using Gauss Elimination Method.
13. Linear Programming -- Solve a 3 constraint by 3 variable Linear Programming Problem using the Simplex Algorithm.
14. Derivative Integer Exponents -- Find the Derivative of functions with integer (+ and -) exponents.
15. Product and Quotient Rule -- Find the Derivative of functions of the form uv or u/v.
16. Power Rule -- Find the Derivative of functions of the form u^n.
17. Antiderivative (Indefinite Integral) -- Find the Antiderivative of functions with integer coefficients and exponents.

MUSolver is intended to provide worked-out solutions in a step-by-step manner along with appropriate commentary. The system is designed to illustrate a specfic process rather than a *be all - end all* for a given type of problem. General purpose computer algebra systems, like *Maple* and *Mathematica*, have been developed for that purpose.

Subject to some restrictions, e.g., integers coefficients in the solving linear equations procedure, the system is dynamic; dynamic in that a user enters a problem of choice.

The programs have been written in "Client-side Java Script" and work well in Internet Explorer (5.0 or higher). Most appear to work in Netscape; however, they have not been fully tested in Netscape, since the Mathematics Department at Monmouth has standardized on Internet Explorer as the browser for content presentation.

Since the purpose of MUSolver is to demonstrate a process, most calculations are done in terms of fractions and displayed as factions, rather than decimals numbers. In general, it is easier to follow the flow of operations when fractions are displayed rather than a resulting decimal number. The difficulty with fraction representation is that students have trouble relating to the magnitude of fractions, e.g., 39/231.

Appendix A is a screen shot of the procedure that displays the equation of a line given two bits of information: two points or a point and the slope.

The system has extensive data verification and check procedures. It provides warning messages when incorrect on insufficient information is entered. For example, data points for the line procedure must be in the form "x1,y1"; two numbers separated by a comma. Further, two points must be entered or one point and the slope. Any other combination will produce a warning message and will require the user to correct the data entry.

Software Distribution:

The current version of the software is available at no charge and can be downloaded from the web site "http:mathematics.monmouth.edu/musolverzip/". It is copyrighted software and should be treated as such. The free use comes with the desire that suggestions for improvement would be provided to the author. Finally, it is expected that the author will be provided free access to any derivative work.

Since the programs use 'asp' files on the server side and javascipt on the client side, the application must

be accessed through an IIS compatable web server. The zip file mentioned above contains a set of installation instructions and the application software in the proper directory structure. Generally, the installation involves just unzipping the file and copying the MUTester directory with all the subdirectories to a web server. The web administrator might have to establish an alias to the phyiscal location of the root directory of the application -- the MUTester directory.

Current Problems:

At the present time, the majority of the feedback concerns the length of the commentary. That is, some feel that the commentary is too lengthly and too much for students to read. As a result, plans have begun to develop a shorten version -- a version containing "just the facts." Users would have the option of selecting the short version or the verbose version for the display.

The other suggestion that has been made is to include some graphical display; for example, display the graph of intersecting lines as well as the coordinates of the intersection point. That feature is currently being developed and will be in the form of a Java applet.

Conclusion:

In general, we feel that the resource has benefited students in the remedial Math050 course.

Reference:

1. Fred S. Keller, *Goodbye Teacher*, Journal of Applied Behavior Analysis, 1968, 79-89.
2. James Kulik, Chen-Lin Kulick, and Kevin Carmichael, *The Keller Plan in Science Teaching*, Center for Research on Learning in Teaching, University of Michigan.
3. Richard Kuntz, *A Web-Based System to Support Practice Problems in the Classroom*, 12th International Conference on Technology in Collegiate Mathematics (ICTCM), 1999.
4. _____, *A WEB-Based Testing System for Introductory Mathematics Courses*, 33nd Annual Conference Association of Small Computer Users in Education (ASCUE), 2000.
5. ____, *Using a Web-Based Testing System to Support PSI in Remedial Mathematics*, Joint Mathematics Meetings, 2001.
6. ____, *A WEB-Based Testing System for Introductory Mathematics Courses II*, 34th Annual Conference, Association of Small Computer Users in Education (ASCUE), 2001.

Appendix A