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A Web-based Interactive Problem Solver for Enhancing Learning in Engineering Mechanics

Gregory G. Kremer, Hajrudin Pasic, Bhavin V. Mehta
Ohio University

Abstract

Many entry-level engineering students arrive at the Engineering Mechanics courses deficient in the rigorous problem solving skills that are required for success in the engineering curriculum. Additionally, many students have difficulties visualizing the motions and evaluating the physical realism of their numerical results. The standard lecture/homework/exam course setup does not compensate for these student deficiencies, leading to a situation where some students just “get through” the engineering mechanics courses without developing a real “feel” for dynamics. Further, the focus of Engineering Mechanics textbooks on simplified problems that can be solved by hand does not truly prepare students to solve real-world dynamics problems. We believe that a student-centered learning environment would be a valuable addition to entry-level engineering courses, and that this learning environment should be problem-based for motivational purposes, should involve interactive visual displays of inputs and outputs to improve visualization skills, and should stress active learning paired with forced reflection to increase student understanding of good problem-solving methods. This paper describes an ongoing process of course and curricular review that has resulted in the development of a web-based learning environment (the Interactive Problem Solver) to supplement traditional instructional methods in an undergraduate Dynamics course. The Interactive Problem Solver, which is still under development, is being designed 1) to help students learn (and practice) rigorous problem solving skills, 2) to help students develop an ability to understand and evaluate mathematical models and results in the context of physical reality, and 3) to provide a forum for instructors to evaluate the impact of various features of a learning environment on student learning of tasks (problem solving skills) and concepts.

I. Introduction

One of the benefits of ABET EC2000 which will be realized long before most schools actually go through the new accreditation procedure is that it forces departments to do a critical review of their courses and curricula. In the Mechanical Engineering Department at Ohio University we are in the process of an internal review of our curriculum and courses, including reexamining course objectives and conducting student and faculty assessments of how well the current courses fulfill the learning objectives.

The Engineering Mechanics classes (Statics and Dynamics) serve as the gateway into the engineering curriculum, and as such they have a large impact on an engineering student’s academic success. It is our experience that students often arrive at the Engineering Mechanics courses unprepared, in need of extra assistance in the area of problem solving (See Table 1).

Table 1: Rigorous problem solving skills for Engineering Mechanics
1. General or standard problem solving procedure 2. Visualizing the physics of a problem 3. Creating free-body diagrams & mathematical models of physical events 4. Assessing whether or not calculated results are physically meaningful

Since most students are still academically immature when they enter the Engineering Mechanics courses (usually as freshman or sophomores), it is not enough just to tell them about good problem solving skills and then expect that they will use the skills. The students' deficiencies must be addressed using methods that pedagogical research has shown to be effective at this stage of their development. According to the report "Making Quality Count in Undergraduate Education" [1] and other generally accepted sources [2], teaching methods for students at this level should have the characteristics listed in Table 2.

Table 2: Desirable Characteristics of Teaching Methods and Materials
1. **Student-centered –** with individualized instruction designed to meet the needs of students with different learning styles and skill levels [3]
2. **Active –** the student must not be given the solution but must struggle and work through the solution step-by-step, receiving guidance only at the proper times
3. **Problem-based –** "real-world" problems should be used to motivate and drive the learning, with *just-in-time* instruction provided when the student is ready for it [4]. Also, problem sequencing should be performance based.
4. **Formative –** learning involves successive approximations to the target mental representation, so timely and focused *process-centered* feedback should be provided to help students identify specific learning needs and enable the learning required to meet those needs
5. **Reflect/Re-perform** - students should be required to look back at their solution method, compare it to that of an expert, and re-perform tasks that they could have performed better. Ideally, this gives students the chance to see processes and to think about what they are doing, to see new ways of approaching problems, and to correct their errors and replace bad habits with good ones [5]

Based on our review of the Engineering Mechanics courses and our review of academic research, we developed the goals listed in Table 3 for our Engineering Mechanics courses. We believe that early intervention to prepare and motivate engineering students is a key factor in improving engineering education and retention of *at-risk* students. Similar to the initiative to incorporate design throughout the curriculum for instructional and motivational purposes, one of our goals is to introduce real-world problems in early engineering courses for motivational purposes and to focus attention on the development of problem solving skills applicable to real-world problems. Also, because of the continuing trend towards the use of technology for solving almost all engineering problems in industry (and the fact that businesses are beginning to demand web-savvy employees), we believe it makes sense to have students learn problem solving skills in the mode that they will be using those skills, i.e. on a networked computer.

Table 3: Goals and Objectives
Primary goal: to improve the overall quality of our engineering graduates by identifying and addressing the educational problems of entry-level engineering students Related Objectives: 1) improve student problem solving skills 2) improve the retention rate in the engineering program 3) improve the preparation of students for future engineering courses **Secondary goal:** to apply results from educational research to the engineering curriculum using the best available technology to better serve students with limited faculty time and resources. Related Objectives: 1) take advantage of the strengths of the WWW for implementing educational materials 2) improve learning via interactive, student-centered, problem-based learning opportunities 3) develop tools and procedures which allow efficient outcomes-based assessment

The objectives listed in Table 3 for implementing results from educational research may require some explanation. First, there is the question of the world-wide-web (WWW). One of the dangers with the increasing availability of technology is the temptation to develop applications because they are possible, not because they are needed. We have chosen to develop a web-based learning environment to improve students' problem solving skills not just because the tools and technology are available to do it, but because for this application the advantages of being web-based far outweigh the disadvantages, especially with respect to access, distribution, and evaluation. Details of this decision are discussed in a later section of this report.

Second, there is the question of how the level of interactivity of the learning environment effects student learning. Interactivity is one of the current buzzwords in multimedia and internet-based software applications, and everyone seems to agree that interactivity is a key feature in an effective computer-based learning environment. However, in reality there is a wide disparity in the types of activities that are called interactive, and there is a lack of research on determining the impact of various forms of interactivity on student learning. This interactivity question highlights a third issue, the need to develop tools and procedures that allow efficient outcomes-based assessment. Due to EC2000, it is now more important than ever to design assessment directly into educational materials, which is the strategy that we are using in developing the interactive problem solver.

II. Teaching the Skills and Procedures Necessary for Solving Engineering Mechanics Problems

According to the theory of experiential learning, to learn a behavior you must practice it. In other words, *if we expect students to solve problems, we should teach them about problem solving.* Also, research to determine effective instructional systems has shown that knowledge is strengthened by practice, that failure in solving a problem triggers new learning, and that motivation is primarily derived from success in solving problems [2].

Problem-based learning (PBL) will not necessarily increase knowledge acquisition relative to traditional instructional methods, but it likely will improve the students' ability to solve problems. PBL has been used in medical study to increase clinical competence, and studies have shown that students prefer the PBL method to traditional methods, they report increased motivation, and test results show there is virtually no difference in the amount of knowledge acquired [6]. Other studies have shown that providing learning experiences in which students applied principles in a variety of different problem situations led to high performance in knowledge of principles and facts, and a significant improvement over the control group (that was taught the principles but not in a problem-solving context) in the ability to apply the principles to new problem situations [7]. Finally, research results indicate that through trial and error with feedback, and with the assistance of a tutor (computer–based or human) that provides knowledge, hints, examples, and practice, students engaged in problem-based instruction acquire automatic processing and recognition skills, improved conceptions of problem structures, and metacognitive skills to control problem-solving procedures [8].

Based on this academic research and our own experience, we believe that an instructional strategy based on problem-based learning is appropriate to teach the skills and procedures for solving Engineering Mechanics problems. With this baseline, we investigated the software and instructional materials currently available to build a problem-based learning environment in Engineering Mechanics. Even though there are good examples of software and educational tools available for Engineering Mechanics, to the best of the authors' knowledge the current tools do not address problem-solving skills in a direct way. The best features of the current tools are those based on improved utilization of technology, including:

1. the use of animation/visualization software such as Working Model® to graphically display or "animate" the mathematical solutions in order to help students make a connection between the equations and real physical motions. A example of this is Multimedia Engineering Dynamics [9], which is designed to help students learn Engineering Mechanics concepts by incorporating an improved visual representation of the problem situation and giving the student the capability to explore using Working Model ® simulations.
2. the use of multimedia resources to improve the presentation of course content (i.e. to have dynamic rather than static presentation of material).
3. the use of computational software such as MATLAB® to eliminate the need for solving equations of motion by hand and to provide the capability to easily create simulations [10].

The use of equation solvers and visualization software provides some benefits, but these tools do not truly help the student learn how to go from a problem statement (or a physical situation) to a correct free-body diagram (FBD) and mathematical model. This is an area where many students need help, as evidenced by the following quote from Norton's Machine Design text: "Most errors in force analysis occur because the FBD is incorrectly drawn". Therefore, we have begun to develop a learning environment designed to provide a structure for effectively teaching problem-solving skills and focusing student attention on the importance of evaluating results with respect to physical reality.

III. Types of Learning Environments and Assessments of their Effectiveness

Designing effective learning environments that improve student learning and reduce faculty workload has been a goal of many educators throughout history. Starting with Programmed Instruction in the 1960s, the learning environments have progressed in parallel with technology through Computer-Assisted Instruction (CAI, alternately known as CBI, CAL, or online education) and multimedia presentation to the current web-based learning environments. Programmed instruction used sequenced questions, mostly multiple choice, designed to build upon each other and in the process help a student learn the key issues in a topic or a subject. A programmed instruction package was designed to be all-inclusive and teacher-friendly, containing review questions and appropriate test questions, clearly defined learning objectives, target audience, and expected time to complete, and results of an evaluation study demonstrating the effectiveness of the instructional package [11].

Computer Assisted Instruction (CAI) replaced programmed instruction as computers became affordable and widely available, and there are now a large number of examples of its use from pre-kindergarten through graduate-level education. There are probably as many different forms of CAI as there are different forms of presenting material in a traditional classroom, with the common thread being that the learning environment is programmed in software and is used by a student working at a computer. As computer processing speeds and available memory have increased, CAI has broadened to include multimedia, or audio and visual presentations of material integrated with the CAI learning environment. The results of evaluation studies to determine the effectiveness of CAI are somewhat lacking, but are improving as more schools and school systems develop a history of using the technology. For example, a new study of the use of CAI in elementary schools in West Virginia (Boone County) shows that CAI is effective in enhancing learning in Math and English. Dr. Mann, from Columbia teachers college, studied all factors that have led to West Virginia's improved national test scores (up from 39th nationally to 11th) and found that instructional technology was responsible for 1/3 of the gains. There was a direct correlation between the amount that students used the available CAI and higher test scores[12]. Additionally, a Wall Street Journal Special report from November 1997 investigated a decade's worth of CAI experience in schools to formulate "Ten Hard Lessons on Computers in Schools". The general conclusion was that computers can significantly improve learning when used correctly, and several specific "lessons learned" are that struggling students often get more out of computers than higher performers, computers don't diminish traditional skills, and computers are a tool (not a subject) and need to be integrated into the lessons of other subjects. These results are interesting and encouraging for CAI, but the key for our future course and curriculum decisions is that all over the nation, students in grade school and high school are being exposed to CAI as one of a number of complimentary instructional techniques. Therefore, future college students will be familiar with various forms of CAI and may expect it, prefer it, or even demand it.

Many decisions must be made in the design of a computer-based learning environment. Key among them is how much control to give the student, or conversely how much structure to impose on the environment. Most entry-level engineering students are not prepared to make intelligent pedagogical decisions, even when it comes to their own education. Highly structured environments keep students engaged in activities that can lead to learning, and they provide immediate feedback to student mistakes to keep students on the right path and reduce potential frustrations and floundering. However, having some control over the learning environment is a motivating factor for students and it allows them to study things that are most interesting to them and learn to explore productively. The highest level of instructor control in a computer-based environment is coaching, which involves choosing tasks, modeling how to do them, providing hints and *scaffolding*, diagnosing problems and giving feedback, challenging and offering encouragement, and structuring the way to do things. Scaffolding refers to providing focused help to students at critical times as they carry out a task - in other words giving only as much help as is needed and only when it is needed. Like the structured environment, scaffolding helps students accomplish tasks they could not complete on their own, and it can be reduced or eliminated as students become more expert so they eventually become independent of the assistance[5].

Numerous studies have shown that students given one-on-one tutoring from an instructor have far superior final achievement compared to students in a conventional teaching environment[13]. In one such study, the average tutored student had achievement levels above 98% of the students in the control class [14]. Unfortunately, personal tutoring carries a high cost and is not feasible in most cases. Therefore, many computer-based learning environments have attempted to replicate the tutoring experience, resulting in an entire category of intelligent tutoring systems (ITS). It appears that the key factors in the success of good personal tutoring that should be replicated by an ITS are reinforcement, encouragement, constant feedback, and a process of reflection and correction. Although intelligent tutoring systems have been in existence since the early 1980s, controlled evaluations are scarce. Results from the evaluations that do exist show that these tutors do accelerate learning and produce equal or greater outcome performance compared to control groups [13].

Now that the internet has progressed beyond being a mere phenomenon to the point where it has changed traditional practices in communication, business, and commerce, CAI is being supplemented (and eventually may be replaced) by web-based learning environments. The recent explosion of web-based educational tools indicates that web-based software has matured to the point where exciting and useful web-based tools can be developed. However, making an instructional tool web-based just for the sake of being web-based is not only useless but is often detrimental. Web-based implementation offers clear advantages in some areas and interesting opportunities in several other areas. Among the advantages are improved access to materials (available 24/7), improved communications and timeliness of feedback, and easier distribution of software updates and corrections. Opportunities, or features that are likely to be beneficial if used correctly but for which there is not yet sufficient proof of their effectiveness, include building a connected learning community that enables collaboration, incorporating virtual reality into the educational experience, creating an educational environment, providing a hyperlearning experience, and providing an interactive learning experience [15].

Because of its short history, there are only limited assessment studies available for web-based applications. One recent study showed that a group of Mechanical Engineering students taught about visual modeling using web-based instruction had a higher average grade performance than the group of students receiving traditional classroom instruction [16]. In the recent book “Business @ The Speed of Thought”, Bill Gates argues that all businesses need to create a digital nervous system in order to survive in the new information age. His point is that having data about customers available in digital form opens up new possibilities for data mining to identify trends and evaluate the effectiveness of various programs and initiatives. The same argument can be made for academics, because the availability of digital data will open up new possibilities for evaluation and assessment of web-based educational tools and techniques. One of the current limitations in assessment is its cost in time and resources. Integrating assessment tools into a web-based application that directs the results in digital form to a database pre-programmed for data analysis can make assessment an automatic step in the educational process, leading to better and more frequent assessment.

Throughout the progression from programmed instruction to web-based instruction and beyond, the correct way to view technology is as an enabler. Technology makes new things possible, but the instructional methods must be based on sound educational and pedagogical research or the educational tool is doomed to failure, regardless of the technology. Based on the academic research and our own experiences, we chose to implement a learning environment with a structured tutoring framework (a number of steps that must be completed) to teach the problem solving procedure, but to give students control over picking the details of the problems they solve (for example selecting a vehicle from the showroom), and freedom to explore tangential to the main framework (to create "what if" scenarios). The imposed structure will likely be relaxed or eliminated as the student progresses. Full-scale coaching and/or a developing a true ITS is very expensive, so we have chosen to implement a streamlined scheme focused on providing structure, encouragement, and scaffolding for select tasks. We are incorporating the collection of assessment data directly into the design of the learning environment, for formative assessment of our learning environment design and to establish the benefit of computer-based and web-based tutoring in general.

IV. The Web-based Interactive Problem Solver

As indicated throughout this paper, we are developing a web-based learning environment called the interactive problem solver (IPS) in response to the findings of an ongoing course and curricular review. The IPS website (under construction) is http://www.ent.ohiou.edu/~dynamics/. We will attempt to describe its features in this paper by showing and describing the structured framework being used to tutor students in problem-solving skills. This first version of the IPS is designed as a supplemental educational tool for a standard undergraduate Dynamics course. The IPS framework is an adaptation and implementation of the instructional characteristics described in Table 2 that are likely to be most effective for entry-level students. In this structured environment, the problem-solving format is learned directly, while Dynamics facts and concepts are learned incidentally. Another feature of the IPS worth emphasizing is that it uses "real-world" problems selected specifically to motivate and drive the learning. Additionally, each learning module (or series of related problems) will attempt to show the connection of Engineering Mechanics with background material (such as vector analysis) and advanced topics (such as machine design) for further motivation.

The general framework is divided into two parts, the creation of a mathematical model to describe a physical situation as shown in Table 4a, and the solution of the model and evaluation of that solution as shown in Table 4b. There will be hypertext links to explain each step and give an example of how to complete the step. At each step some sort of student input is required. The types of input used by the IPS are as unconstrained as possible, leading to a truly interactive learning experience in which the students own input is evaluated, rather than having the student always select from a certain number of choices. The IPS functions like a tutor by evaluating each student response and giving information as needed (scaffolding) to guide the student without actually giving the solution. The IPS also uses a "gate-keeper" methodology in an attempt to get the student to understand the solution method and apply it correctly (in effect master the topic) before advancing to the next step. The immediate feedback provided by the IPS will indicate to the students their areas of weakness that require more study (either online or offline), thereby allowing them to use their study time more efficiently. This is important because students can't (or don't) really learn until they know what they don't know and they have some reason to learn it (in order to complete an assignment). The structured framework imposes a forced solution method in which students are rewarded for doing things right, not just for getting "close enough". This environment forces reflection and re-performance of tasks until they are completed correctly. In addition to giving immediate feedback to the student, the IPS is being designed to track each student's progress and to alert the instructor to specific areas of confusion that can be addressed individually or in class.

Even though the framework seems rigid, there is a lot of flexibility within each step due to the "Open Input" fields, and there are opportunities for exploration once a solution has been found. The open input creates a challenge for our team, since there are many valid ways to approach any problem. However it is this flexibility, combined with the just-in-time delivery of information and the opportunity to work at any pace that allows the IPS to meet the needs of students with different learning styles, learning rates, and levels of understanding.

V. Assessment and Evaluation

We have mentioned assessment and evaluation throughout this paper, but its overall importance warrants a special section. Assessment is an area of both current and future work. We have developed a student survey (and have already administered it to students in Dynamics class) to establish a baseline of data before the IPS is offered, and we are continuing to work on appropriate assessment questions and tasks. We plan to use surveys and evaluations (that are an integral part of the IPS) along with focus groups and pre and post tests to determine what help is most needed and how effective the IPS is in providing this help. Currently the determination of the needs of entry-level engineering students is focused at Ohio University, but eventually we would like to extend this effort to other universities.

The IPS evaluation team is interdisciplinary, representing the fields of psychology, instructional technology, and education. The team members are particularly qualified to develop and lead the evaluation for this project because of their experience in both evaluation and information technology. The evaluation plan uses a mixture of quantitative and qualitative (descriptive/anthropological) methods as appropriate for both formative and summative evaluations as described in Table 5. Ultimately, we plan to compare perceived (survey) and actual (pre/post test) learning, determine if problem solving improves in an offline setting for students who have completed training on the IPS, and determine the impact of various aspects of interactivity on student learning. We will benchmark the IPS against traditional learning environments (lecture), models of excellence in CAI and ITS (for example the winners of the NEEDS Premier Award for excellence in engineering education software), and the best examples we can find of web-based applications.

Table 4a: Interactive Problem Solver General Framework: Part 1, Create the model
Legend "Open" input field, either free format or with specified format (The student must enter a symbolic or numerical result for the program to evaluate) "Limited Selection" input field, or multiple choice (The student must select one or more of the alternatives presented) "Point and Click" to select an object, place a force vector, etc.

After logging in to the web site containing the Interactive Problem Solver (IPS), the student will be presented with a visual and textual description of a vehicle dynamics problem and will be asked to analyze the physical situation to determine some required information. The steps that the IPS will require the student to complete for a rigorous problem solution are outlined below.

1. **Define the problem based on the physical situation and the required information**
   a. **Classify nature of problem**
      Ex: Statics, Kinetics, Kinematics, or Dynamics.
   b. **Classify nature of motion**
      Ex: Particle motion, Rigid body rotation, General plane motion, Equilibrium etc.
   c. **Identify special cases & simplifying assumptions**
      Ex: Constant acceleration, Conservative forces, Rolling contact (no slip), etc.
   d. **Identify the primary unknown(s)**

2. **Create the diagram(s) appropriate for your planned solution method**
   a. **Choose the system(s) whose motion/equilibrium needs to be studied in order to find efficient solution.**
      Ex: If a contact force between two bodies is to be found, one of the bodies must be considered as a system separate from the other body. If contact forces are not required, both bodies may be treated as a single system.
   b. **Create Free Body Diagram (FBD) for each system.**
   c. **Establish the coordinate system(s).**
   d. **Identify any secondary (new) unknowns introduced by the selection of the system and the creation of the FBD.**
   e. **Count the total number of unknowns (1d+2d).**

3. **Create a mathematical model consistent with your planned solution method**
   a. **Based on the nature of problem, nature of motion and nature of external forces in the FBDs, choose the principle(s) to be used to find the unknowns.**
      Ex: Use Newton's second law to find reaction forces, or use Work and Energy principle to find velocities if external forces depend on displacements, etc.
   b. **Write the governing equations corresponding to the principle(s) chosen in 3a and input them (symbolically) for evaluation.**
   c. **Check for agreement between the total number of unknowns (2e) and the total number of equations (3b)**
   d. **If needed write additional kinematics and/or constraint equations for the system**
      Ex: If the total number of unknowns (2e) is less then the total number of equations (3b) additional kinematics/constraint equations are needed.

Table 4b: Interactive Problem Solver General Framework: Part 2, Solve and Evaluate Solution
4. <u>Solve the mathematical model</u> **a. Solve symbolically (for the general case) and input the symbolic result and its units.** **Equation(s) for unknown(s):** ☐ **Units for unknown(s):** ☐ Note: IPS will substitute units for the known variables and those entered by the student for each unknown into the mathematical model and will display the resulting dimensions. **b. Review the dimensional homogeneity of the mathematical model and results.** ○ Ex: The display of the dimensions for the equations will indicate if the dimensions input for the unknown quantities are compatible with the other dimensions in the equations. The student will be given the choice of accepting the dimensions or modifying them. **c. Solve numerically, for the specific case, and enter the numerical result(s)** ☐ Note: The IPS will substitute the numerical result(s) into the mathematical model and will display the resulting numerical values for all equations. **d. Review the numerical homogeneity of your mathematical model and results.** ○ Ex: The display of the back substitution of the numerical results into the equations will indicate if the numerical results satisfy the equations. The student will be given the choice of accepting the numerical results or modifying them. **5. <u>Check if the solution is physically realistic by:</u>** **a. Comparing its magnitude to expected or predicted results, to results for similar problems, and to physical constants (i.e. number of g's of acceleration)** ☐ **b. Reviewing the graphical display of results on the FBD** ○ Ex: The IPS will show force vectors on the FBD with relative size indicative of magnitude and arrows showing direction. The student may choose to accept the results or modify the mathematical model to make the solution more physically realistic. **c. Exploring the mathematical model in more depth** ○ Ex: Reviewing a simulation of selected results for a selected range of variable values Ex: Reviewing an animation of selected results (for example the motion of the physical object) for a selected range of variable values

Table 5: Key Evaluation Types and Evaluation Data
Evaluation Type: Formative evaluation of the Interactive Problem Solver with respect to its features and user interface **Data:** a) Incorporate data collection into the design of the IPS to measure usability, motivational impact, perceived effectiveness, etc. b) conduct observational and interview studies **Evaluation Type:** Formative & Summative evaluations with respect to the goals, objectives and expected outcomes **Measure:** a) programmatic retention rates (for all students, for women, and for minorities) b) student performance in the engineering mechanics courses c) performance in future engineering classes & the Fundamentals of Engineering exam d) content *pre* and *post* tests with a control group e) self-assessment ability, and self-efficacy*

* Self-efficacy, the confidence to perform similar tasks in the future, is predictive of future task choice and persistence in the face of difficulty, which may affect retention.

Computer-based and web-based learning environments have a distinct advantage when it comes to assessment. Because they deal with digital data which can be easily stored, manipulated and evaluated, these environments can create a permanent record of student performance, requests for assistance, effectiveness of feedback types, etc. On a more theoretical level, using a structured problem-based instructional format allows information relative to the process of learning to be recorded to document continuous changes in knowledge, skill, and understanding as the student encounters problems of increasing complexity.

VI. Conclusions & Recommendations

This paper describes our efforts to design a learning environment to help entry-level engineering students develop improved problem-solving skills. As an integral part of this project we will test the hypothesis that a structured web-based learning environment can be effective in helping entry-level engineering students develop rigorous problem solving habits which persist beyond the learning environment.

Even though many useful educational tools have been developed in the last ten years to assist with teaching engineering mechanics, the available tools do not address some of the most important needs of entry-level engineering students (they often just allow students to change inputs and observe responses), their integration into an overall educational strategy is ad hoc, and they often increase rather than decrease the work load for the instructor. The advantages offered by the IPS are in three main areas. First, the IPS is a World Wide Web (WWW) based educational tool, so it has advantages in terms of access, communications, etc. Second, the IPS will be a self-contained educational package, so no additional effort is required from the instructor for implementation. The other advantages of the IPS are its unique emphasis on rigorous problem solving (from problem formulation through verification of results), its unified approach to Engineering Mechanics (treating Statics as a special case of Dynamics), its advanced level of interactivity, and its integration of assessment directly into the learning environment.

Future plans include extending the IPS to include more topics and tasks both in Engineering Mechanics and throughout the curriculum to give students a better idea of the big picture and to show relationships between previous material (vectors, calculus, differential equation solvers) and future courses (machine design, kinematics and dynamics of machinery, design projects). Additionally, we advocate teaching engineering mechanics with appropriate analysis software so that students can focus more on setting up problems, creating mathematical models for “real-world” systems, and understanding and evaluating results, and less on solving systems of algebraic equations by hand. Excellent educational software already exists in these areas (for example AUTOLEV ®, MATLAB ®, etc.), and we will investigate integrating our web-based environment with these packages.

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GREGORY G. KREMER
Gregory Kremer is an Assistant Professor of Mechanical Engineering at Ohio University. His area of expertise is Mechanical Systems Design, and he has extensive industrial experience in this area. Dr. Kremer received his B.S. degree in Mechanical Engineering from Rose-Hulman Institute of Technology in 1989 and his Ph.D. degree in Mechanical Engineering from the University of Cincinnati in 1998.

HAJRUDIN PASIC
Rudy Pasic is a Professor of Mechanical Engineering at Ohio University. Dr. Pasic has over 20 years of experience teaching engineering mechanics, has written four textbooks on Engineering Mechanics, and has won awards in the field of Applied Mechanics. Dr. Pasic received his Ph.D. degree in Mechanical Engineering from Stanford University in 1979.

BHAVIN V. MEHTA
Bhavin Mehta is an Associate Professor of Mechanical Engineering at Ohio University. His areas of expertise include CAD/CAE/CIM, artificial intelligence and virtual reality, and web-based implementations. Dr. Mehta received his Masters degree in Chemical Engineering from Ohio University in 1988 and his Ph.D. in Interdisciplinary Engineering from Ohio University in 1992.