How To Assess or How Not to Assess … That is the Question

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Abstract

Many innovations are taking place in engineering classrooms across the nation. But how do we decide if an innovation is achieving the desired outcomes? Most engineering faculty members are interested, even eager to make improvements in the way engineering concepts are taught in their courses. But many, if not most, have little or no experience in formal educational assessment. Hopefully our experiences in assessing a new innovation incorporated into the large enrollment statics course at Penn State during the Fall of 2004 can offer some help to others. The innovation, called "MechANEX," is a set of software modules and matched, bench-scale laboratory exercises aimed at seven key statics concepts. The assessment consists of a combination of pre-tests, post-tests, on-line surveys, and phone interviews. Discussed are details of the proposed assessment plan and the logic behind the individual assessment instruments employed. Preliminary results are also provided.

Introduction

In the fall of 2004, an innovation was incorporated into an existing introductory statics course at Penn State (EMCH 011). The innovation consisted of a set of software and laboratory exercises involving key concepts related to the course. Because this innovation had not yet been utilized in the classroom in its completed form, a comprehensive plan to assess and evaluate the effectiveness of the innovation was appropriate.

Frequently, the purpose of educational assessment is to provide feedback to an instructor about what is working in the classroom so that changes can be made in order to improve student learning. In addition, administrators, as well as other faculty, could be keenly interested in assessment results to determine if the innovation should be continued in the course. Ultimately, the purpose of assessment is to determine whether or not the intended goals of the innovation have been met. Therefore, the planning stage for the assessing any innovation must first begin with the goals and objectives of the innovation. Once these goals and objectives are clearly identified, preferred means of gathering information related to these goals and objectives can be determined.

The purposes of this paper are to provide a description of one such assessment plan for an engineering educational innovation, and to assist others who might want to assess similar course level innovations. Details of the MechANEX project are first described to provide context followed by a discussion of the assessment plan used during the fall 2004 semester. The challenges encountered during this particular project are also summarized. Finally, preliminary results of the assessment project are provided and discussed.

MechANEX Project Details

'MechANEX' is a mini-laboratory combining comprehensive software analysis modules and matched, bench-scale verification experiments to improve and enrich a sophomore-level engineering mechanics course in statics.[1] Developed as an extension of the "AN/EX" (ANalysis and EXperiment) laboratory[2,3] used by civil and architectural engineering students in junior-level structural engineering courses, MechANEX combines a tailor-made, easy-to-use, statics analysis software package with fully configured, bench-scale experimental setups designed for use with existing AN/EX laboratory equipment. The MechANEX system was designed for students to begin each assignment by using the software to check their hand-calculated results for the assigned pre-lab problem. When the hand calculations and software results match, students perform the associated lab experiment and compare the resulting experimental data with the existing analytical results. Students complete each MechANEX module by using the software to study a more involved and application-oriented post-lab problem, varying analytical parameters in the context of a 'real-world', design-type problem without the burden of repetitive and lengthy hand calculations.

This pre-lab hand calculation and related computer assignment, hands-on laboratory experience, and post-lab computer-oriented design assignment sequence was developed to accomplish four pedagogical objectives.

A. Students develop a deeper understanding of core course concepts by in-depth study of representative engineering problems using a customized software analysis package. Any mechanics student can gain greater understanding of targeted course concepts by solving additional complex problems or by varying parameters and reworking assigned homework problems. Unfortunately, most students cannot afford (or do not wish to spend) the extra time required to accomplish these activities. The MechANEX analysis package alleviates much of the mathematical burden these types of exercises entail, thereby saving time and allowing for more in-depth conceptual exercises.

B. Students realize that verifications of software solutions are essential. While an analysis package can save time and allow for in-depth study, students can easily place too much blind trust in "black box" computer solutions. Most introductory mechanics courses do not include a formal laboratory component, so the issue of independent, experimental verification is not typically addressed. MechANEX allows students to study problems using a three-pronged verification approach, requiring comparison between hand calculations, computer solutions, and experimental results. Differences between analytical and experimental results demonstrate that while the analytical models in statics are idealized, they provide good approximations of reality.

C. Students gain insights into their own personal misconceptions regarding important course topics. One expectation of the first part of each MechANEX assignment is that hand calculations produce the same results as the software solutions. By presenting a series of pertinent intermediate values used to calculate the final answer, each MechANEX module aids students in troubleshooting their hand calculations when results do not match. Even when the discrepancy between software results and hand calculations is nothing more than a sign error, this checking process can help students to recognize fundamental misconceptions they might have with respect to a particular course concept.

D. Students gain a greater appreciation for the multidisciplinary nature of statics. Most students view the introductory mechanics course as mostly an extension of physics and math with very little relevance to the work they will do as a 'real engineer'. In addition, most students view different engineering disciplines as being stand-alone, rather than overlapping fields that share and employ the same fundamental mechanics concepts. The MechANEX analysis package, particularly through the post-lab exercises, allows students to solve a number of problems from a variety of engineering disciplines, allowing students to experience a wide range of multidisciplinary mechanics applications.

Separate MechANEX modules have been developed around the following seven core statics topics: (1) Moment About an Axis; (2) Equivalent Force Systems; (3) 2-D Equilibrium; (4) Mechanical Systems; (5) 3-D Equilibrium; (6) Friction; and (7) Area Moments of Inertia. Each of the seven MechANEX modules for statics involves a pre-lab exercise, a lab experiment, and a post-lab exercise. In the pre-lab exercise, students complete a typical 'homework-style' problem by hand, which they check by analyzing the same problem using the windows-based MechANEX software. Each pre-lab exercise serves three purposes: (1) students practice the analytical steps covered in class by solving the problem by hand; (2) students become familiar with the MechANEX software module in an organized, tutorial-like manner; and (3) students are able to identify flaws in their personal understanding of the course topic when their manual calculations and the software computations do not check, compelling them to troubleshoot their own mistakes.

Following the pre-lab exercise, each lab exercise provides a physical connection to the analytical techniques discussed in class and introduces students to the reality that analytical and experimental techniques both have their inherent limitations. Each post-lab exercise enables students to develop a deeper understanding of important course concepts by having them perform a more in-depth, application-oriented exercise intended to reinforce the practical relevance of targeted course concepts. Throughout, the MechANEX software enables students to perform analytical and experimental tasks successfully during lab exercises and expedites the solution of multiple versions of the same physical problems during post-lab exercises.

MechANEX modules have been intentionally designed with flexibility in mind such that numerous options exist at the discretion of individual instructors, for incorporating MechANEX software and lab assignments into existing statics courses. The following specific details of the Fall 2004 MechANEX incorporation represent just one of many possible scenarios for implementation. The trials conducted during the Fall 2004 semester involved a course enrollment of over 450 students taught in a lecture/recitation format. The faculty member (Dr. Masters) conducted lectures one day a week for 150-170 students at a time. During the other two class meetings each week, the students met in groups of roughly 45 with a graduate teaching assistant where representative sample problem were solved and discussed. At the start of the fall semester, six of the seven software modules were deemed ready for testing. However, subsequent errors detected in the software made it possible to fully implement only five of the seven MechANEX modules.

For this MechANEX trial, several decisions were made to keep student time devoted to the course within reasonable limits. First, the traditional list of required homework problems was reduced to allow time for students to complete each set of pre-lab and post-lab software assignments. This was deemed an appropriate trade-off because each pre-lab assignment requires the solution of several 'traditional homework style' problems. Second, each student was required to participate in the hands-on laboratory activity for only one, rather than all, of the assigned MechANEX modules. As a result, a new set of approximately 100 students entered the lab every two to three weeks to conduct an experiment. These MechANEX lab sessions were conducted outside of the scheduled class period to allow extra time (75 minute lab session vs. 50 minute class period) and to accommodate smaller groups at the four existing lab stations (maximum of four students per group times four lab stations, or a maximum of 16 students assigned to any one lab time slot). Lab sessions were scheduled at various times throughout the week to allow students several choices of times and days to accommodate their individual schedules. Each one of the 12 sections of students was assigned a specific experiment, thus ensuring by the end of the trials that roughly equal numbers of students would have performed each lab experiment.

Assessment Objectives and Guiding Questions

An assessment plan should be guided by the goals and objectives of the course innovation. In this case, the written objectives above provided a guide for the assessment plan. However, these objectives needed to be written as questions that could be answered through various types of measurements. Therefore, the assessment activities of the Fall 2004 trials were targeted at answering six key questions related to the above A through D MechANEX objectives:

1. Are students' analytical skills enhanced as compared to those who did not use MechANEX? (Objective A)

2. Do students have a better understanding of the limitations of computer models as compared to reality? (Objective B)

3. Do students have a better physical sense of how things behave – e.g., the effects of forces and moments? (Objective C)

4. Do students see that the course content is really related to engineering and do they see the relevance of the statics course content to their future engineering work? (Objective D)

5. How does student perspective regarding the relevance of the subject influence motivation to study the course content? (Objective D)

In addition to these assessment objectives, the decision to have each student participate in only one laboratory experiment prompted another question: Does participation in the laboratory exercise have a significant effect on answers to Questions 4, 5 or 6?

The questions above imply the use of a summative assessment. In other words, these questions focus on the outcomes and impacts of using MechANEX in the statics course. However, the authors also had interest in pursuing questions relating to formative assessment, or gathering information relating to the changes that needed to be made to the MechANEX exercises and the corresponding course curriculum. Therefore, a final question for assessment was, "How can the MechANEX exercises and the version of the statics course employing MechANEX be improved?"

Mapping Questions to Measurement Techniques

The above questions were used to create a map of how and when each question would be answered. The assessment plan consisted of a mixed-methods approach, employing both qualitative and quantitative methods of data collection.[4,5] Using both qualitative and quantitative methods can result in obtaining the most complete picture of the effects of the innovation through triangulation. As Frechtling & Sharp note, "The validity of results can be strengthened by using more than one method to study the same phenomenon."

When using mixed-methods designs, attention must be given to the order with which the methods are performed. In this assessment plan, a sequential explanatory approach was employed, in which the quantitative data collection and analysis was performed first followed by the more qualitative data collection and interpretation.[6] This type of assessment plan was selected to enable further exploration through follow-up interviews of issues and concepts that emerged from the quantitative surveys..

The assessment questions were broken down into issues relating to student achievement and attitude. Each of the above assessment objectives was mapped into an assessment plan, as shown in Appendix A. Student achievement was measured by student performance on pre- and post- tests of statics knowledge and concepts. Two instruments were used to test each student's conceptual knowledge at the beginning and at the end of the course. The Math Statics Baseline (MSB) Test[7] was administered to provide a comparison with Penn State statics students from previous semesters. The newly developed, more comprehensive Statics Concept Inventory[8] was also administered to gain this type of data on a wider range of course topics. Additionally, students provided perceptions of their understanding of statistics through surveys and interviews. Student attitude was measured by online surveys and follow-up interviews.

The course instructor and an external assessment specialist participated in designing the surveys and interview protocols. The questions were chosen such that student responses to the assessment questions would help to identify more clearly the impacts of the MechANEX innovation. The survey consisted of both Likert-type scales and open-ended questions. Dynamic questions were used so that students received different questions based on their responses to previous questions. For example, when a student responded "yes" that they had participated in a particular MechANEX laboratory exercise, he/she was given an additional set of questions targeting the laboratory experience, while a student who answered "no" would not receive the laboratory questions.

Assessment Challenges

This project generated specific challenges regarding the assessment. Of particular concern in the assessment was the large number of students enrolled in the course (n=468). Based on logistical issues regarding data collection and data analysis with such a large population of students, all surveys were administered online, rather than in class. The surveys were created using a program called Perseus[9] and were sent electronically to students enrolled in the course. Using online data collection helped to reduce the amount of class time devoted to administration and also reduced the time required for data analysis. The Perseus program easily converted data into a format in which data analysis could occur. An additional advantage with the online surveys was the use of dynamic questions. This would not have been feasible with pencil-and-paper surveys.

However, online data collection does have some disadvantages.[10] First, when administering surveys online as compared to face-to-face, often response rate is often a concern. Students are less likely to complete a survey sent to them electronically, than when the survey is administered using pencil-and-paper format during class, while they are a captive audience of the survey administrator. Therefore, for this study, a small amount of extra credit was used as an incentive for students to complete the survey. With this incentive, the response rate for the first survey was 337 or 72%. The response rate for the second survey was 388 or 83%.

Although the survey and the MSB test were administered online, some parts of the assessment needed to be performed during class time. The Statics Concept Inventory pre- and post-tests of content knowledge were administered during class for several reasons. First, since this test takes longer to finish than the MSB, students would be more likely to complete the test if given during class. Second, using class time could ensure that students were not using outside resources to complete the tests. In order to aid data analysis, students were asked to bubble in responses on scan sheets, which were easily converted into an Excel spreadsheet format for data processing.

In addition, informed consents from the students were collected during class time. This was done as a way to increase participation rate and ensure that the data from the pre- and post-tests could be utilized, even if students chose not to complete the online surveys. A total of 420 students agreed to participate in the research study (90%).

As the famous saying goes, “the plans of mice and men often go awry.” Soon into the semester, it became apparent that the assessment plan had to be modified. Originally, the plan included three online surveys during the semester administered at 5 weeks, 10 weeks and 15 weeks (at the end of the semester during finals week). In between the surveys, the plan was to analyze the survey data and choose a sample of students to participate in interviews. However, the first survey, being slightly delayed, was made available for a 2 week period starting in the 6th week of the semester. By the time the survey closed during the 8th week of the semester, it was nearly the originally scheduled time to send out the second survey. Therefore, a decision was made to delay the second online survey until the 12th or 13th week of the semester and eliminate the third survey. In addition, the authors were unable to analyze the large amount of survey data very quickly. The data from the open-ended questions was especially voluminous, and is still being analyzed. Due to time constraints, the interviews had to be postponed to the spring semester. As of February, 2004, the interviews are currently being scheduled.

Another challenge for the assessment plan was the difficulty in identifying a control group with which to compare results. Based on the unified format across all sections of the course at Penn State, it was not feasible to segregate selected sections out of participation in the MechANEX exercises. Therefore, no true control group was obtained. However, in an attempt to find some comparison groups that could help to better understand the impact of the innovation, concept test data will be collected from students who are taking the statics course in the spring of 2005 without the MechANEX exercises. This comparison group, in addition to MSB test results from previous statics courses where MechANEX was not used, will possibly provide a measure of the impact MechANEX can have on improving student understanding of key statics concepts. However, there are some threats to the validity of our conclusions, such as significantly different course format (smaller sections with no graduate teaching assistants) and a variety of instructors. With the difficulty of obtaining a true experimental design, comparisons between these two groups of students must be interpreted with caution.

Preliminary Results and Conclusions

Due to the large nature of this study, much of the data analysis is still ongoing. As of February 2005, all survey data and course tests had been administered. Interviews are currently being planned. The data analysis for the concept tests is still being performed. For the survey data, all frequency data and descriptive statistics have been performed for each item. Content analysis of the open-ended questions has also been completed. Although there is still significant data analysis to perform, some preliminary results are available at this point in time, particularly involving the course surveys. These results follow, as they relate to each question for assessment.

As mentioned above, a total of 337 students completed the first survey. A total of 388 students completed the final survey. Of the students who completed the first survey, 267 (79%) were male and 70 (21%) were female. Of the students who completed the second survey, 315 (81%) were male and 73 (19%) were female.

1. Are students' analytical skills enhanced as compared to those who did not use MechANEX?

At mid-semester, 144 (43%) of the students felt that completing the MechANEX software exercises helped to improve their analytic skills. Of the 120 students who had completed the physical lab at that point, approximately 32% (n=38) found that the physical lab increased their enthusiasm.

A similar finding was found at the end-of-semester survey, for which 178 (46%) of the students agreed or strongly agreed that the software exercises had improved these skills. Approximately 36% of the students (n=134) perceived the physical lab to have increased their analytical skills.

In the open-ended questions, students often wrote that one of the potential benefits of the MechANEX software modules is the ability to compare answers that are hand calculated to the computerized results. This ability to check answers helped students realize when they were on the right track and when they were making mistakes. For example, one student noted, "I get pretty much immediate feedback whether or not I am on the right track with solving the problem. If I'm not on the right track, I can check the software and see where I made a mistake or a wrong turn." Common themes for the benefits of the physical labs included the ability to grasp concepts more clearly and to reinforce ideas from lecture.

2. *Do students have a better understanding of the limitations of computer models as compared to reality?*

On the mid-semester survey, 44% (n=149) of the students agreed or strongly agreed that the MechANEX software assignments have helped them to understand the limitations of computer modeling. Approximately 36% (n=43) of the students who had completed the lab stated that the physical lab had helped to understand the limitations.

The perception that the software assignments contributed to their understanding increased significantly on the final survey, for which 197 (51%) of the students felt they had a better understanding of these limitations. Approximately 40% (n=149) of the students thought that the physical lab had helped this understanding.

In the open-ended questions, only one student stated that the software program had helped with his/her understanding of this concept. This student noted, "It has shown me the importance of knowing how to work problems out by hand because of the computer's limitations."

3. *Do students have a better physical sense of how things behave – e.g., the effects of forces and moments?*

On the mid-semester survey, 58% (n=197) of the students agreed or strongly agreed that the MechANEX software assignments helped them to have a better physical sense of how things behave. Of the 120 students who had completed the physical lab, a total of 52% (n=62) thought that the physical lab contributed to their sense of how things behave.

Once again, this perception for the contribution of the software increased slightly for the final survey, for which 239 (62%) of the students perceived their understanding of how things behaved had improved. Once again, students attributed their understanding slightly less to the physical lab, for which only 187 (51%) agreed or strongly agreed that the lab experiments had helped their understanding of how things behave.

In the open-ended questions, the most cited benefit of the MechANEX software program was the ability to better understand the relationships between forces. For example, one student stated, "The software modules have physically shown me how different forces react under certain conditions." As another student noted, "It shows the relationship on an actual model that can behave differently with a click of the mouse. It also gives a more accurate depiction of what device is being measured due to the different views that can be given on the object. Pictures are fine, but actual models that you can interact with are much more helpful." Similarly, the second most cited benefit of the MechANEX software modules is the ability to have a visual representation of the objects. As a third student noted, "One can see the question build up in front of his/her own eyes and hence taking observations in a set of experiments helps get a better understanding of how things behave in static equilibrium." Again, student perceptions of the physical labs tended to support this view, as the benefits noted included the ability to understand the concepts better, to visualize forces, and to reinforce concepts from lecture. Also, many students noted that it was helpful to see the theory work in real-life. One student comment is that, "In the lab, I was able to see the couple and moment actually happen. It helped me to get a better grasp on how things actually do work."

4. *Do students see that the course content is really related to engineering and do they see the relevance of statics course content to their future engineering work?*

At mid-semester, approximately 268 (80%) felt that the course had helped their understanding of how statics related to engineering. This perception had increased somewhat at the end of the semester, for which 337 of the students (87%) of the students agreed or strongly agreed that the course had helped with their understanding of how statics related to engineering.

At mid-semester, approximately 73% (n=243) felt that the course helped to see the relevance of statics to their future career. This was very similar to the perceptions in the second survey, for which 72% (n=280) agreed or strongly agreed.

At mid-semester, approximately 56% (n=189) of the students felt that the software exercises helped to understand the connection of statistics with engineering. At the end of the semester, students' perceptions had increased somewhat. A total of 239 (62%) agreed or strongly agreed that the software exercises had helped their understanding. Approximately 52% of the students found that the physical lab had also helped their understanding on the second survey. This was similar to the responses on the first survey.

A total of 8 students had written in the open-ended questions that the MechANEX software exercises provided real-life problems that they might experience as an engineer. As one student noted, "It has helped me to understand the kind of work that as an engineer I might do in the future. It has shown me a valid connection between statics and the engineering world." More students (n=19) stated that this was the greatest benefit of the physical lab. As another student noted, "The lab was very informative. We actually had to get in and measure things and solve problems like an actual engineer would."

5. *How does student perspective regarding the relevance of the subject influence motivation to study the course content?*

At mid-semester, a total of 134 (40%) students agreed or strongly agreed that the course had increased their motivation to study statics. Approximately 16% of the students felt that the software exercises had increased their enthusiasm for studying statics.

At the end of the semester, a total of 197 (51%) students had agreed or strongly agreed that the course increased their motivation for studying statics. Approximately 26% (n=101) felt that the software exercises had increased their enthusiasm for studying the subject. Approximately 24%

(n=91) of the students who had completed the physical labs agreed or strongly agreed that the labs had increased their enthusiasm for studying statics.

Several students noted in the open-ended questions that they enjoyed hands-on, interactive nature of the software. This could perhaps indicate that the software may be motivating to them. However, other students noted that there were too many assignments, that they felt like busy-work, and that they were time-consuming.

Conclusions

The above results suggest that the MechANEX exercises do offer some potential benefits to the students. Although, it is difficult to make conclusions on the effects of the software and physical labs because of the lack of a strict comparison group, the results above do suggest that the MechANEX program, particularly the software, tends to increase perceived analytic skills, understanding of limitations of computer modeling, and understanding of how things behave. The physical labs were not perceived by students to be as helpful to their understanding. Perhaps the reason for this may be that the labs only occur at one time point during the semester, whereas the students use the software program on multiple occasions.

A similar trend was found throughout the assessment question in that the ratings on various items relating to the MechANEX software exercises tended to increase from mid-semester to the end of the semester. This increase could be attributed to several factors. First, it is possible that students were better able to see potential benefits after they had become familiarized with the software. It is also a possibility that later labs tended to be more helpful to students' perceived understanding than earlier labs. This may be a question for our future evaluation.

Other future analyses will focus on more specific research questions relating to the individual labs. For example, do the ratings on various questions differ based on the physical lab that the students completed? In addition, the interview data should prove to be valuable to further identify the potential benefits that the MechANEX exercises may provide.

Students were also likely to provide suggestions on how the software and the course could be improved. This information was used at mid-semester to help improve the course. The results from both surveys will be used to improve future sections of the course.

The general trends of the effectiveness of MechANEX are promising at this point in time. The assessment of the project is vital in determining whether or not the exercises should continue to be used in the classroom, and if so, what changes and improvements should be made to maximize student learning. While each classroom innovation is unique, the assessment plan of the MechANEX projects including its challenges may prove useful to others investigating new teaching methods.

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APPENDIX A

Assessment of student achievement			
Assessment Question	**How will we measure?**	**When will we measure?**	**Analysis**
1. Are students' analytical skills enhanced compared to those who did not use MechANEX?	Pre- and post- test of statics knowledge and concepts	Start and end of EMCH 011 Also administered in previous years of EMCH 011 when MechANEX was not used	Compare scores for Fall, 2004 to scores from previous years
2. Do students have a better physical sense of how things behave – effects of forces and moments?	Pre- and post- test of statics knowledge and concepts Students perceptions of understanding of physical sense as provided from online surveys	Start and end of EMCH 011 Middle and end of semester	Compare scores for Fall, 2004 to scores from previous years Frequencies and percentages
3. Do students have a better understanding of the limitations of computer model as compared to reality?	Student perceptions on surveys Student perceptions in interviews	Middle and end of semester End of semester	Frequencies and percentages Qualitative analysis

Assessment of student attitude			
Assessment Question	**How will we measure?**	**When will we measure?**	**Analysis**
1. Do students see that the course content is really related to engineering? Do they see the relevance of course content to future work?	Student perceptions on surveys	Middle and end of semester	Frequencies and percentages Comparisons of surveys at middle and end of semester
2. How does the above perspective influence motivation to study the course content?	Student perceptions in interviews	End of semester	Qualitative analysis

References

[1] Masters, C. and R. Behr (2001). Integrated Statics Experiments in the 'MechANEX' mini-laboratory, 2001 Annual Conference Proceedings, American Society for Engineering Education, June 24-27, Albuquerque, New Mexico.

[2] Behr, R (1993). Concurrent Structural Analysis and Experimentation Using the 'AN/EX/ Mini-Laboratory, *Computer Applications in Engineering Education*, Vol. 1(3), pp. 213-222.

[3] Belarbi, A, R. Behr, M. Karson, and G. Effland (1994). Formal Assessment of the AN/EX Structural Engineering Teaching Laboratory, *Computer Applications in Engineering Education*, Vol. 2(2), pp. 109-121.

[4] Tashakkori, A. & Teddlie, C. (2003). *Handbook of Mixed Methods in Social & Behavioral Research.* Sage Publications: Thousand Oaks, CA.

[5] Frechtling, J. & Sharp, L. (1997). User-Friendly Handbook for Mixed Method Evaluations. National Science Foundation. Available at: http://www.ehr.nsf.gov/EHR/REC/pubs/NSF97-153/start.htm.

[6] Creswell, J., Plano Clark, V. L., Gutmann, M. L., & Hanson, W. E. (2003). *Advanced mixed methods research designs*. In Tashakkori, A. & Teddlie, C. (Eds.) Handbook of Mixed Methods in Social and Behavioral Research (pp. 209-240). Thousand Oaks, CA: Sage Publications.

[7] Mehta, S. and S. Danielson (2002). Math-Statics Baseline (MSB) Test: Phase I, 2002 Annual Conference Proceedings, American Society for Engineering Education, June 16-19, Montreal, Canada.

[8] Steif, P. (2004). Initial Data from a Statics Concept Inventory, 2004 Annual Conference Proceedings, American Society for Engineering Education, June 20-23, Salt Lake City, Utah.

[9] *Perseus SurveySolutions XP-User Guide* (2001). Braintree, MA: Perseus Development Corporation.

[10] Wise, J., Lee, S., & Rzasa, S. E. (In press). Learning by doing: Four years of online assessment in engineering education research. In Williams, D. (Ed.) Online Assessment, Measurement and Evaluation: Emerging Practices, Volume III.

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