AC 2008-1680: PHLIPS FOR ACTIVE LEARNING

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PHLIpS for Active Learning

Abstract

The PHLIpS (Producing Hands-on Learning to InsPire Students) Method provides a systematic approach for professors desiring to develop active learning activities for their classrooms. Many professors appreciate the benefits of active learning and wish to include more activities in their classroom. Unfortunately, activities for a given topic or course are commonly not available as an off-the-self, ready-to-use product. The PHLIpS's purpose is to be a quick and effective method for professors to streamline the development process for creating active learning activities for their classrooms. This paper briefly presents the method and then details a controlled experimental evaluation of the PHLIpS Method and supporting tools such as the flip book which contains short guidelines of each step. A between-participants experiment was used to measure the method's effects. Participants were students in a graduate engineering class. Many planned to teach after graduation and most had experience as teaching assistants. Outcome measures included a post-session opinion survey and measures related to the concepts generated. The PHLIpS Method was found to be effective and was well received by the participants.

1. Introduction

Active learning approaches improve students' overall understanding[1]. There is considerable literature that addresses the advantages of using hands-on experiences in engineering and STEM curricula[2-17]. Although the importance of active learning activities is well recognized, few ready-to-use activities are currently available for a given subject or topic. In addition, little formal guidance as a systematic approach for their development exists[18]. The paper first presents the PHLIpS Method (Producing Hands-on Learning to InsPire Students)[19] for the creation of active learning products (ALPs). The paper next focuses on validating and evaluating the PHLIpS Method with a controlled experiment. Results from the experiment are shown and discussed. Finally conclusions are made and future work is discussed.

2. Overview of the PHLIpS Method

The PHLIpS Method[19] is a tool to guide professors in the efficient creation of ALPs. Figure 1 shows a summary of the method used to guide the development of ALPs. A set of cards which serve as a quick reference for each ALP is shown in Figure 2. ALPs are based on enhancing learning through the use of hands-on and student-driven active learning experiences. The method begins with understanding the educational goals, generating ideas, systematic selection of ideas, and finally implementation and evaluation of the newly-created ALPs (Figure 1). This methodology also seeks to relate all types of student personality types and learning styles to active learning. This is done as part of the "evaluation" step. ALPs are categorized into themes, such as hands-on exercises, thought experiments, forensic investigations, physical measurements, multimedia exercises and design applications. Currently, over twenty-five ALPs for mechanics of materials have been created across these themes. The PHLIpS Method can also be used for design of ALPs for other technical topics. See Linsey, *et al.*,[19] for a more detailed explanation of the method.

A complete set of ALP materials including student worksheets, detailed professor notes and supporting material, are available at the Active Learning for Mechanics of Materials website (http://www.me.utexas.edu/~alps/).

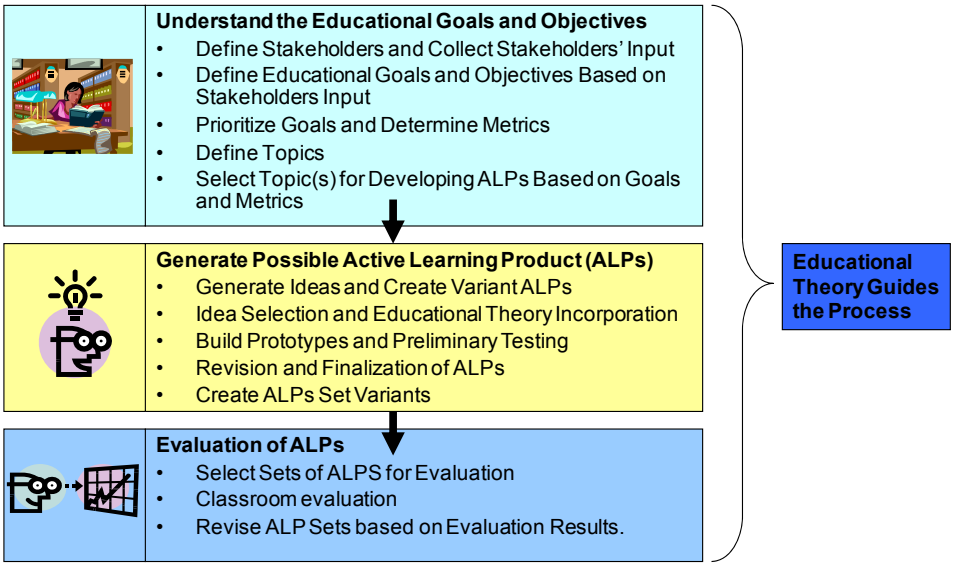

Figure 1: Overview of the PHLIpS Method for Developing Active Learning Activities

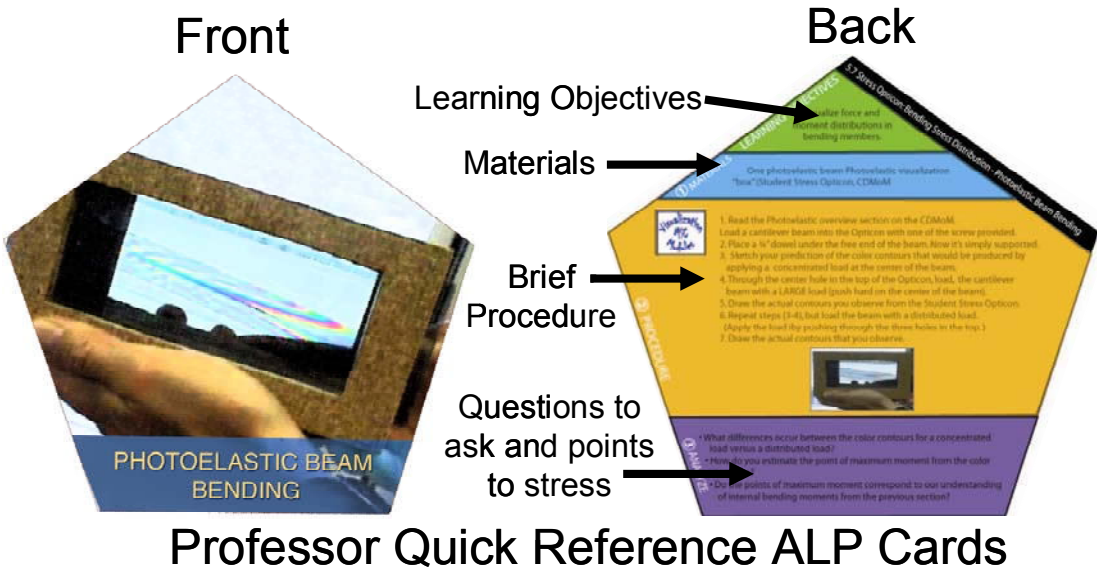

Figure 2: As a tool for implementation, a set of cards to accompany the more detailed description of the ALPs are available (see table for text on cards). Each card provides a quick reference to assist a professor in implementing the activities in their classrooms.

Table 1: Text on ALPs Cards

Learning Objectives	Visualize force and moment distributions in bending members.
Materials	One photoelastic beam Photoelastic visualization "box" (Student Stress Opticon, VisMoM)
Brief Produce	1. Read the Photoelastic overview section on the VisMoM. Load a cantilever beam into the Opticon with one of the screw provided. 2. Place a ¾" dowel under the free end of the beam. Now it's simply supported. 3. Sketch your prediction of the color contours that would be produced by applying a concentrated load at the center of the beam. 4. Through the center hole in the top of the Opticon, load, the cantilever beam with a LARGE load (push hard on the center of the beam). 5. Draw the actual contours you observe from the Student Stress Opticon. 6. Repeat steps (3-4), but load the beam with a distributed load. (Apply the load by pushing through the three holes in the top.) 7. Draw the actual contours that you observe
Questions to ask and points to stress	• What differences occur between the color contours for a concentrated load versus a distributed load? • How do you estimate the point of maximum moment from the color contours? • Do the points of maximum moment correspond to our understanding of internal bending moments from the previous section?

3. Controlled Experimental Approach

To explore the effect of the PHLIpS Method on the creation of new ALPs, a controlled experiment was run in the fall of 2006. This experiment is intended to be a preliminary evaluation of the method. The experiment consists of a group of ten participants that were tested twice, a between-participants set-up. This set-up allows for individual differences in ability to be eliminated from the experiment. The two test setups were identical except in the second test the participants were also given the PHLIpS Method in addition to the other materials provided. The two evaluations occurred five days apart. They were not aware that the following weeks' tasks would be to generate more ideas, but the set-up does allow the possibility for participants to contemplate solutions during the break. The concepts generated from both sessions were analyzed for quantity of unique concepts created, to determine the effect of the method on creating ALPs.

3.1. Participants

The experiment consisted of the creation of active learning products by eleven graduate students. The participants were enrolled in a graduate design class. Greater than ninety percent of the students indicated they expect they may teach in some format in the future. The participants were ten males and one female, 23-31 years old. Nine were mechanical engineering majors and the

other two were education and architecture majors. The ethnicity of the participants was varied and only two had taken any education courses previously. One participant's data was removed since he was involved in the development and evaluation the experiment.

3.2. Materials

At the beginning of each session, the participants were given a folder of background material relevant to creating ALPs on axial and torsional loading. Also included in the folder was a list of difficult topics and learning objectives for torsional and axial loading generated based on informal professor surveys and literature. In addition, the folder contained an example ALP, and a basic review of torsional and axial stresses equations, nomenclature and definitions. Education pedagogy was also included in the form of a brief paragraph discussion of the Kolb Cycle, Bloom's Taxonomy, Felder's Index of Learning Styles and Myers-Briggs Type Indicator. The last section of the folder contained eight papers on hands-on activities to give a survey of background literature.

At the beginning of the second experiment, the participants were also given the PHLIpS Method Flipbook. The flipbook contains an overview of the five key steps in the creation of ALPs with flip up sections containing detailed guidelines and examples for each key step, shown in Figure 3.

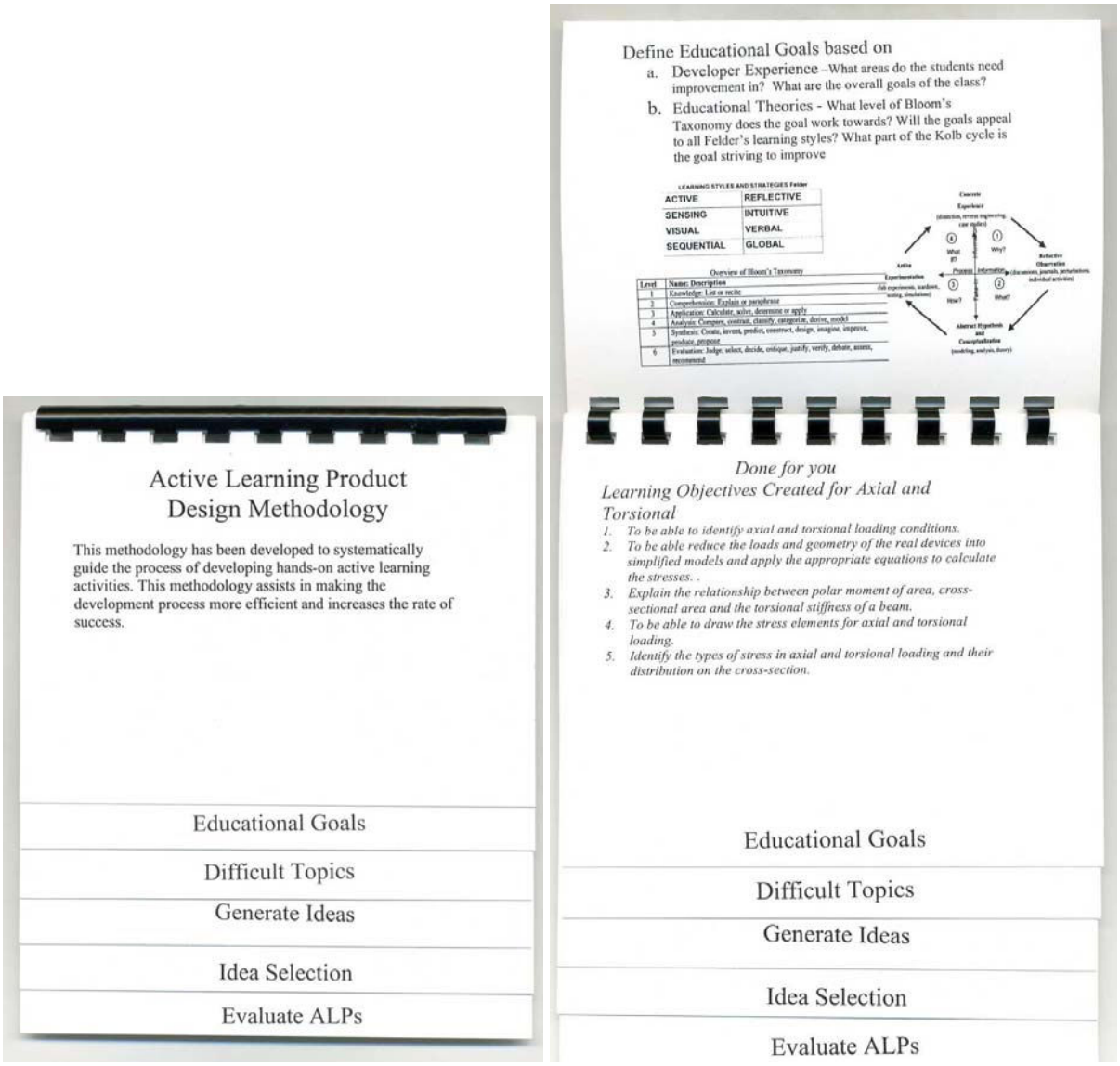

Figure 3: PHLIpS Method Flipbook

3.3. Method

The experiment consisted of two, one hour sessions on a Monday and a following Friday. At the beginning of the first session, the participants were given a folder of background material relevant to creating ALPs on axial and torsional loading. Most of the participants had little background in the education theories, so a ten-minute overview lecture of the Kolb Cycle[20], Bloom's Taxonomy[21], Felder's Index of Learning Styles[22] and Myers-Briggs Type Indicator[23] learning theories was given. After the lecture, the participants were asked to create as many high quality, unique concepts as possible in forty-five minutes. They were also told to write down everything they could think of. At the end of the session, participants were filled out a survey on the experience.

The Friday session was set up the same as the Monday session. The same participants, background folder and instructions were used. The only changes were the participants were now also given the PHLIpS Method Flipbook and the lecture on educational theories was not repeated. The participants were again asked to try and create of as many new high quality unique concepts as possible in forty-five minutes, while writing down everything they could think of. At the end of the session, the participants' concepts were collected and they were asked to fill out a second survey on the experience of creating ALP concepts with the methodology flipbook. Main measures for this experiment were the number of concepts created and the survey results.

4. Controlled Experiment Results and Discussion

Figure 4 shows the average number of ideas produced by each participant after the first session and then the total after two sessions. Figure 5 summarizes participant responses to a survey taken immediately after the first session asking participants if they felt they had run out of ideas or not. More than half of the participants felt they had run out of ideas after the first session. The participants were not aware that the following weeks' activity would be to create additional ideas, therefore it is unlikely they dedicated any time to thinking of more ideas during the week. The results from Figures 4 and 5 show that the PHLIpS Method assists participants in creating more ideas for ALPs than their intuitive approach.

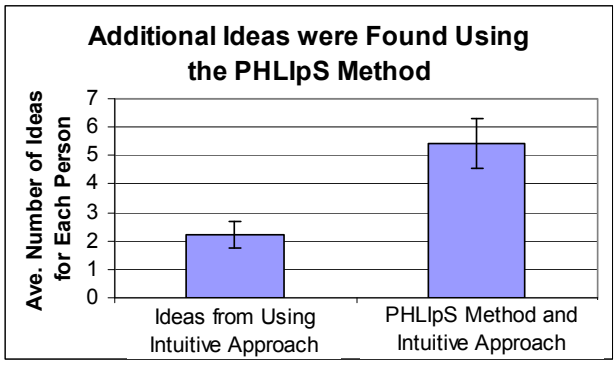

Figure 4: PHLIpS Method helps participants find new ideas for ALPs. Error bars are +/- one standard error.

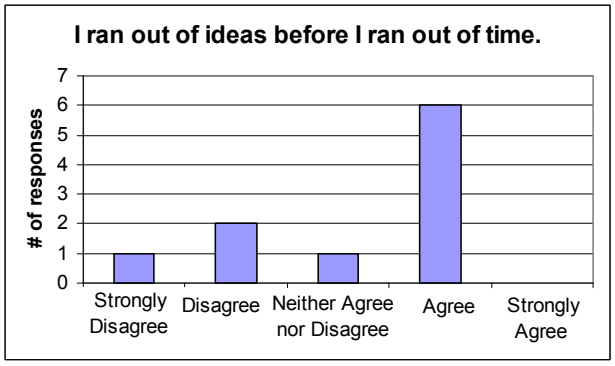

Figure 5: After the first session using their intuitive approach, most participants felt they had run out of ideas.

To further explore and understand the effects of the PHLIpS method participants' responses to the two surveys were summarized. One set of survey questions required participants to compare the PHLIpS Method to their intuitive approach on a number of dimensions (Table 2). Partial results are shown below for these survey questions (Figures 6-8). For all of these criteria, participants consistently believe the PHLIpS method is equal to or better than their intuitive approach. These results illustrate the effectiveness and usefulness of the PHLIpS Method.

Table 2: Survey questions comparing the PHLIpS Method to the Individual's Intuitive Approach.

Which approach was the most effective for each of the following items:
1. Finding ideas for difficult topics
2. Finding ideas for the learning objectives
3. Generating ideas
4. Approach that felt most comfortable
5. Most willing to use in the future
6. Generating high quality ideas
7. Quickly generating ideas
8. Efficiency

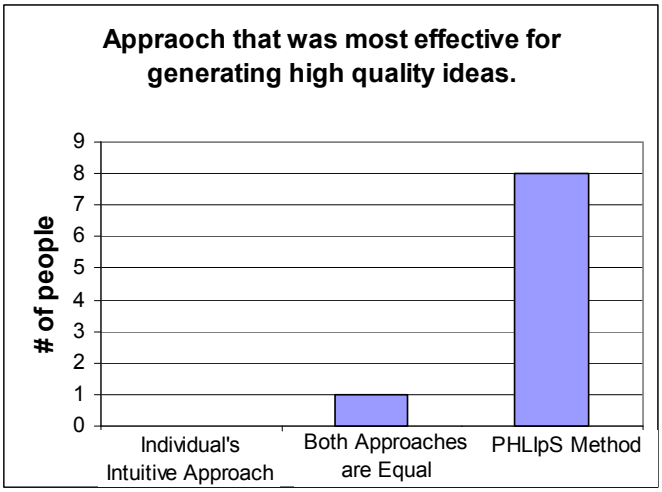

Figure 6: Participants felt the PHLIpS Method is more effective for generating high quality ideas.

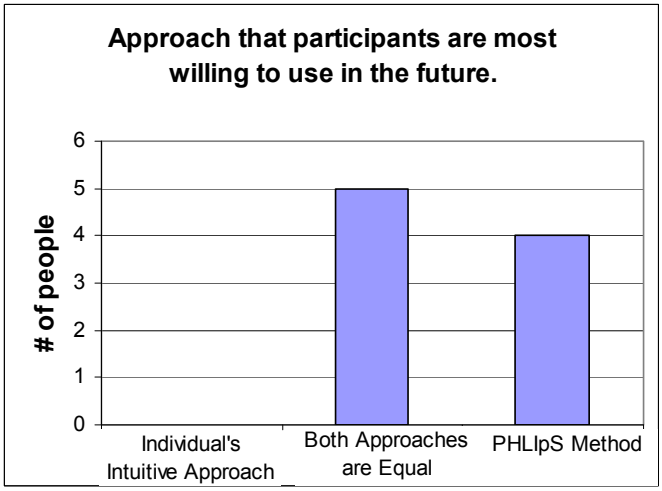

Figure 7: Overwhelming participants are willing to use the PHLIpS Method in the future.

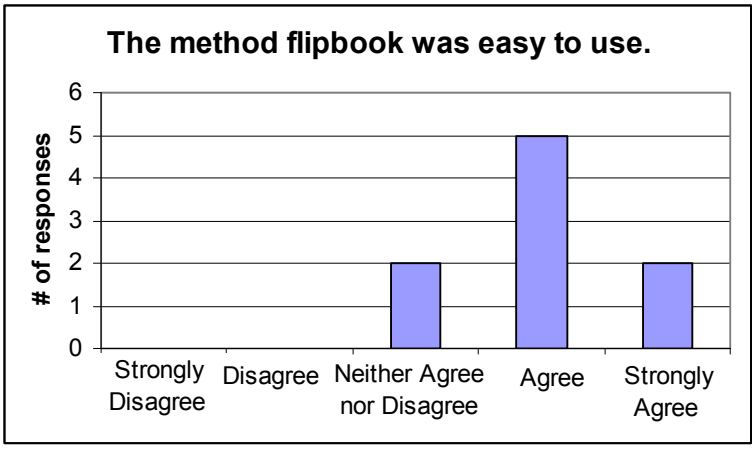

Figure 8: The flipbook presentation of the PHLIpS Method is effective.

5. Conclusion and Future Work

Active learning is a highly effective approach for enhancing engineering education which many professors desire to incorporate into their classrooms. Unfortunately, few developed activities are typically available for a given topic and the time required to create new activities tends to be prohibitive. The PHLIpS Method (Producing Hands-on Learning to InsPire Students) seeks to overcome this by providing a fast, effective approach to guide professor in developing active learning activities that are solidly founded on educational theory and meet learning objectives. This paper's evaluation of the method highlights the method's advantages. A controlled experiment showed that participants generated more ideas with the method. The participants also evaluated the PHLIpS method to be as least as good as or better than their intuitive approach to the design of these activities on a range of criteria including quality of the ideas produced and efficiency. The PHLIpS method enhances engineering education by supporting professors' endeavors to incorporate active learning into their classrooms.

More evaluation needs to be completed with currently practicing professors. Evaluations need to take place over longer and more realistic development time periods to determine if the method creates higher quality activities and is more efficient. Further refinements will be made to more seamlessly incorporate pedagogical theory, student learning styles and educational objectives.

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Bibliography

[1] Prince, M., "Does Active Learning Work? A Review of the Research," Journal of Engineering Education, Vol. 93, No. 3, 2004, pp. 223-231.

[2] Carlson, L.E., "First Year Engineering Projects: An Interdisciplinary, Hands-on Introduction to Engineering," Proceedings of the ASEE Annual Conference and Exposition, pp. 2039-2043, 1995.

[3] Aglan, H.A. and Ali, S.F., "Hands-on Experiences: An Integral Part of Engineering Curriculum Reform," Journal of Engineering Education, Vol. 85, no. 4, pp. 327-330, Oct., 1996.

[4] Regan, M. and Sheppard, S., "Interactive Multimedia Courseware and the Hands-on Learning Experience: An Assessment," Journal of Engineering Education, pp. 123-131, April, 1996.

[5] Catalano, G.D. and Tonso, K.L., "The Sunrayce '95 Idea: Adding Hands-on Design to an Engineering Curriculum," Journal of Engineering Education, pp. 193-199, July, 1996.

[6] Bonwell, C.C., "Active Learning and Learning Styles," Active Learning Workshops Conference, Content available at http://www.active-learning-site.com/vark.htm, 1998.

[7] Kresta, S.M., "Hands-on Demonstrations: An Alternative to Full Scale Lab Experiments," Journal of Engineering Education, Vol 87, no. 1, pp. 7-9, Jan., 1998.

[8] Otto, K., Wood, K.L., Murphy, M.D., and Jensen, D.D., "Building Better Mousetrap Builders: Courses to Incrementally and Systematically Teach Design," Proceedings of the ASEE Annual Conference and Exposition, Seattle, WA, June, 1998.

[9] Jensen, D.D. and Bowe, M., "Hands-On Experiences to Enhance Learning of Design: Effectiveness in a Reverse Engineering / Redesign Context When Correlated with MBTI and VARK Types," Proceedings of the ASEE Annual Conference and Exposition, Charlotte, NC, June, 1999.

[10] Wood, J.J. and Wood, K.L., "The Tinkerer's Pendulum for Machine System's Education: Creating a Basic Hands-On Environment with Mechanical Breadboards," Proceedings of the ASEE Annual Conference and Exposition, St. Louis, MO, June, 2000.

[11] Bridge, J., "Incorporating Active Learning in an Engineering Materials Science Course," Proceedings, ASEE Annual Conference and Exposition, 2001.

[12] Dennis, S., Bowe, M., Ball, J., and Jensen, D.D., "A Student-Developed Teaching Demo of an Automatic Transmission," Proceedings of the ASEE Annual Conference and Exposition, Albuquerque, NM, June, 2001.

[13] Ditcher, A., "Effective Teaching and Learning in Higher Education, with Particular Reference to the undergraduate Education of Profession Engineers," International Journal of Engineering Education, Vol. 17 No. 1, 2001, pp. 24-29.

[14] Shakerin, S. and Jensen, D.D., "Enhancement of Mechanics Education by Means of Photoelasticity and the Finite Element Method," International Journal of Mechanical Engineering Education, Oct., 2001.

[15] Wood, K.L., Jensen, D.D., Bezdek, J., and Otto, K., "Reverse Engineering and Redesign: Courses to Incrementally and Systematically Teach Design," Journal of Engineering Education, Vol. 90, no. 3, pp. 363-374, July, 2001.

[16] Feland, J.M. and Fisher, C.A., "Cramming Twenty pounds into a Five-Pound Bag: Increasing Curricular Loads on Design Students and Enjoying it!," Proceedings of the ASEE Annual Conference and Exposition, Montreal, Quebec, Canada, June, 2002.

[17] Roselli, R., and Brophy, S., "Effectiveness of Challenge-Based Instruction in Biomechanics," Journal of Engineering Education, Vol. 95, No. 4, pp. 311-324, 2006.

[18] Jensen, D., Wood, J. and Wood, K., "A Design Methodology for Hands-on Classroom Experiences," *Proceedings of the ASEE Annual Conference and Exposition,* June, 2004.

[19] Linsey, J., Cobb, B., Jensen, D., Wood, K.L., and Eways, S., "Methodology and Tools for Developing Hands-on Active Learning Activities". in Proceeding of 2006 ASEE Annual Conference. 2006. Chicago, IL.

[20] Kolb, D.A., *Experiential Learning: Experience as the Source of Learning and Development*, Prentice Hall, Englewood Cliffs, NJ, 1984.

[21] Bloom, B.S., *Taxonomy of Educational Objectives*, David McKay, New York, NY, 1956.

[22] Felder, R.M., and Spurlin, J., "Applications, Reliability and Validity of the Index of Learning Styles," *International Journal of Engineering Education*, Vol. 21, No. 1, pp. 103-112, 2005,

[23] Myers, I.B., and McCaulley, M.H., *Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator*, Consulting Psychologists Press, Palo Alto, CA, 1985.