

**GC 2008-248: IMPROVING ACTIVE LEARNING IN ENGINEERING EDUCATION
BY UNDERSTANDING STUDENTS**

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Improving Active Learning in Engineering Education by Understanding Students

Keywords: Active learning, Hands-on activities, Felder-Silverman Learning Styles, Myers-Briggs Type Indicator

Abstract

Through the use of active learning and hands-on activities, engineering students become more engaged in the learning process. We have developed an extensive set of Active Learning Products (ALPs) that have been found to reinforce difficult concepts and to improve overall comprehension of course materials. The ALPs were created specifically to address concepts in engineering design, mechanics of materials, and other core topics that were identified to be conceptually difficult for students to understand. The ALPs were designed to be inexpensive and easy to use by professors with minimal preparation time. A number of the APLs have been tested at multiple institutions over a three-year period. These institutions include, for example: Research institution- The University of Texas at Austin; Four year teaching institution– United States Air Force Academy; and Community College – Austin Community College. The participants of these tests are undergraduate-level students learning engineering design and mechanics of materials concepts. The activities have been evaluated through a number of assessment instruments, including surveys and pre/post short quizzes.

The goal is for these activities to enhance the learning of *all students* in the classroom. Myers-Briggs Type Indicator (MBTI) personality types and the Felder-Silverman Index of Learning Styles (ILS) are two key indicators that can identify ways that active learning activities can be improved to appeal to different types of students. Current literature does not contain statistically significant correlations between (MBTI and ILS) vs. specific aspects of active learning. This study analyzes the correlation between students' responses to (ALPs) and the student's MBTI and ILS types. The data shows that, in general, students are very positive and motivated by the activities. Students' responses show statistical improvement across personality types and learning styles, and, in some cases, statistical differences when categorized by personality type and learning styles, across survey and pre- and post-activity quiz results. By analyzing the correlation between the results and student personality/learning types, ALPs can be refined to balance effects across the categories, appealing to the broadest number of students. The analysis in this paper expands the general understanding of how the effects of active learning activities on student learning are influenced by MBTI and ILS types. Active learning activities that appeal to a broader number of students types will have greater effect on overall classroom learning and understanding. Because of the inexpensive and real-world focus of the ALPs, the transfer of these activities across global education institutions should be very tractable.

1 INTRODUCTION

Active learning approaches improve students' overall learning, a view shared, generally, by faculty teaching engineering education [2]. A recent survey of 67 instructors from 59 different universities, completed by the authors and as shown in Fig. 1, indicated that 90% of these faculty would like to include more active learning in their classes. Approximately 80% of these same

instructors indicated that the active learning approaches, as discussed in this paper, enhance or would enhance their teaching.

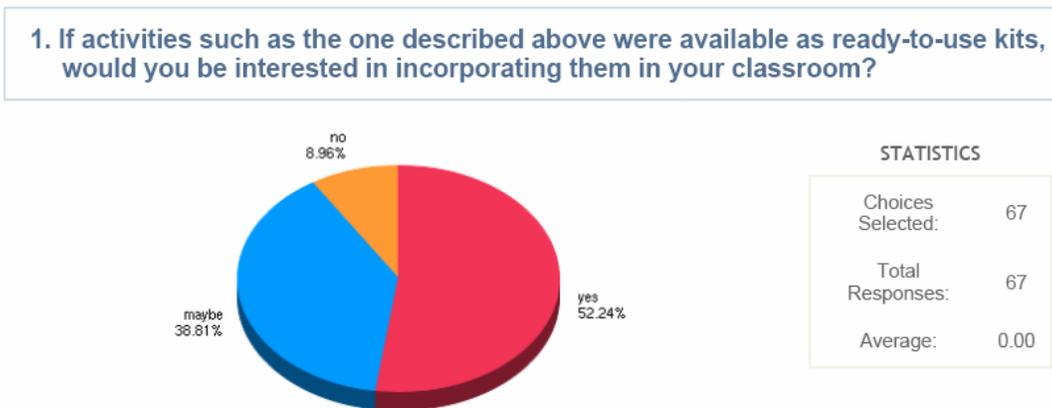


Figure 1. Survey of engineering faculty regarding interest in Active Learning Products.

There is considerable literature that addresses the advantages of using active learning in STEM curriculum [5,16,20,22,26,30,53,69,77]. This research shows, in general, that motivation and learning are simultaneously enhanced by the incorporation of active learning into the classroom. When students are properly motivated and enthusiastic about a set of concepts or topics, learning will be enhanced, especially when tapping into the students' physical senses.

While past research shows the potential of active learning, advances are needed in methods for designing active learning products (ALPs) for classroom learning objectives and topical areas. In concert with these methods, assessment instruments must be developed to determine the effectiveness of particular ALPs and to iteratively improve ALPs for the greatest possible impact. This paper presents our research findings on a general design methodology for ALPs, providing examples ALPs from the field of mechanics of materials. A complementary assessment strategy is also presented, showing our findings of ALPS assessment instruments in the context of the Myers-Briggs Type Indicator (MBTI) and the Felder-Silverman Index of Learning Styles (ILS).

2 OVERVIEW OF ACTIVE LEARNING CONTENT

Based on the general conclusion that active learning techniques have the potential to significantly enhance education, one wonders why these pedagogical techniques are not prolific in STEM education. Our research and experience have led to the conclusion that there are a number of barriers to the effective use of active learning in STEM education (Fig. 1).

- 1- Design of Active Learning Products (ALPs) is mostly an ad-hoc and time consuming process
- 2- There is a lack of ready-to-use, well designed ALPs
- 3- ALPs' use in the classroom requires prohibitive preparation time for the instructor
- 4- ALPs may not be based on sound pedagogical concepts
- 5- Assessing ALPs may be time consuming and ineffective
- 6- ALPs may benefit one gender, learning style or personality type over another
- 7- ALPs may be not effective at all types of schools (research, undergrad only, community college)

Figure 2. Barriers to the Use of Active Learning Products (ALPs) in STEM Education.

Over the last 10 years, the University of Texas at Austin (UTA) and the US Air Force Academy (USAFA) have been collaborating on work to systematically remove these barriers. Much of this work has been as part of engineering courses in engineering mechanics, design methods, product development, machine design, and the engineered world (freshman seminar), in addition to K-12 curricula on hands-on mathematics and science. Deliverables from this work include Active Learning Products (ALPs) which are active learning activities of many different types, as well as a methodology to develop these activities and an assessment approach to evaluate their effectiveness. These content components are discussed below.

2.1 PHLIPs (Producing Hands-on Learning to Inspire Students) Method

Although the importance of active learning activities is well recognized, little formal guidance in a systematic approach for development exists [41]. Many times, ready-to-use active learning activities for a given topic or concept are not available and must be constructed by the instructor. To facilitate this process and to focus our own development endeavors, a method was created for producing active learning products (ALPs) [52]. This method, called PHLIPs (Producing Hands-on Learning to Inspire Students), is based a solid understanding of pedagogical theory much the same way product design theory is tightly tied to an understanding of the physical world and the psychology of designers. Figure 3 shows a high-level summary of the methodology used to guide the development of ALPs. It begins with gathering information from the stakeholders (customers) with the intension of understanding the educational goals. At least three sets of customers need to be addressed in this step: 1) students, 2) instructors, and 3) the institution. We have found that students will express a need for the ALPs to be interesting and have a crystal clear tie to what will be assessed on exams. Instructors demand that the ALPs be tied closely to the learning objectives; especially for content they know the students will struggle with. Instructors also demand that the ALPs be easy to use, take very little additional preparation time and are based on sound pedagogical principles. The institution desires that the ALPs be either relatively low cost and/or reusable. The institution also desires that the ALPs maintain effectiveness across different types of institutions and for different types of students as measured by characteristics like gender, personality types and learning styles.

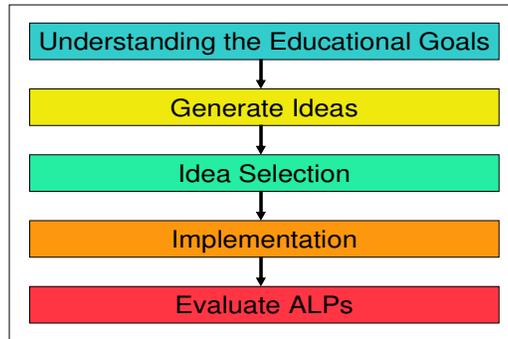


Figure 3. Design Method for Development of Effective ALPs

The next step in the ALPs design process involves generating ideas. Many of the methods used in product design for idea generation can be applied here. Techniques like 6-3-5 and mind mapping can be applied [65,66]. The third step in the process (idea selection) again can be formulated based on a similar step in the product design process. In particular, customer needs (from step 1) are used as a filter for determining what concepts should be developed into ALPs. As is commonly executed in product design, a decision matrix is formulated where each potential ALP is rated on how well it meets the different customer needs. The “winning” concept is determined based on how well it satisfies the aggregate voice of the customer. In addition to specific needs vocalized by the customer, it is beneficial to reinsert the idea that ALPs be based on sound pedagogical theory at this “concept filtering” step. In particular, we include “conformance with pedagogical Theory X” as a specific customer need in the decision matrix where “Theory X” includes Kolb’s cycle, Bloom’s taxonomy, Perry’s model and combined deductive and inductive instruction. In addition we include the predicted ability of an activity to engage students across different Myers Briggs Type Indicator (MBTI) categories and across different learning styles as identified by Felder-Silverman indicators [23,24,29,31,32,35,45-47,59-62]. The final two steps in the ALPs development process are implementation and assessment of the ALPs. Implementation involves creation of the activity itself followed by use in the classroom. Assessment normally involves comparison of an “experimental” group that uses the ALP with a “control” group that experiences that lesson in the manner it has been historically taught.

In order to facilitate the easy implementation of the PHLIpS method by instructors, we have developed a “quick access” deployment of the method in the form of a “PHLip-book”. Shown in Fig. 4 are the different tabs of the book which open to provide reminders and directions for the basic steps in the method.

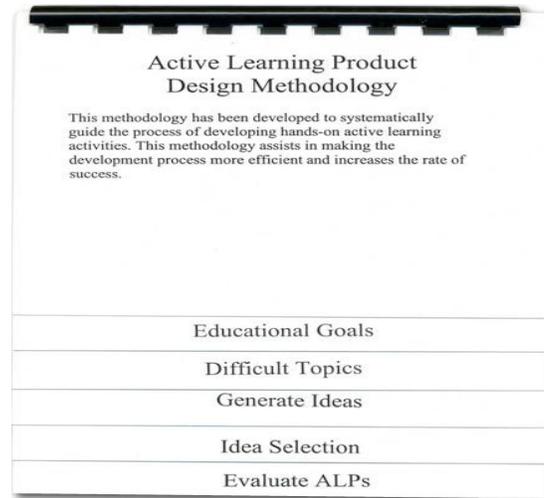


Figure 4. PHLipS-book for Easy Implementation of the ALPs Design Method

As a measure of the effectiveness of the PHLipS method, a set of graduate students, with interest in academic careers, were asked to create ALPs for the topics of axial and torsional loading in mechanics of materials. The experiment required the participants to first create ALPs based on their own intuitive approach and then in a second session to use the PHLipS method. Participants created more concepts using the PHLipS Method (normalized average of 5.5 compared to 2.2 for a fixed time frame, Fig. 5). More importantly, eight out of nine participants felt the PHLipS Method was better for producing high quality ideas than their intuitive approach for creating ALPs activities. The ninth participants felt the PHLipS and intuitive methods were equivalent.

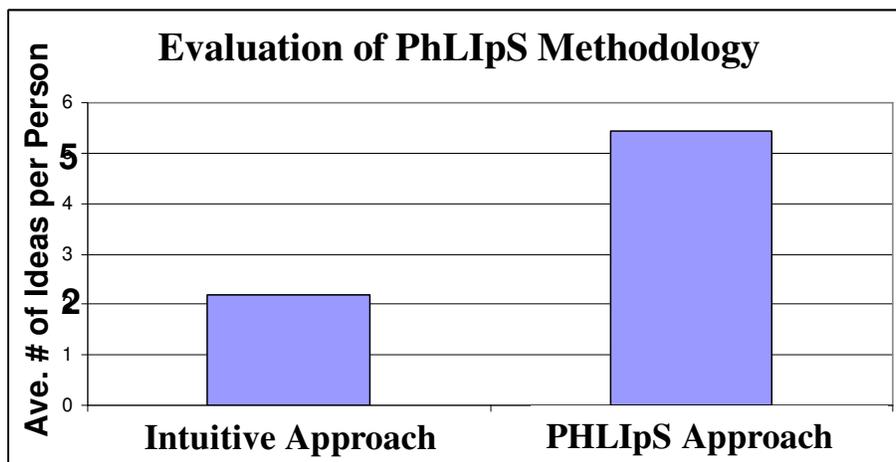


Figure 5. Evaluation of the PHLipS Method for Creating ALPs

2.2 Guiding Theories

One of the keys to effective development of ALPs is their foundation in learning theories. A number of learning theories guide the creation, assessment and improvement of ALPs. These theories range from how information is presented and processed to understanding an individual student's learning styles and personality type. Three of these theories are described below as they are central to the ALPs design, implementation and assessment. As indicated in our past

publications, other theories also contribute significantly including scaffolding, inductive/ deductive presentation and Bloom’s taxonomy [3, 24,27,49,57].

2.2.1 Kolb cycle, Learning Styles, and preferences

The Kolb model describes an entire cycle around which a learning experience progresses [48,76,8]. The goal, therefore, is to structure learning activities that will proceed completely around this cycle, providing the maximum opportunity for full comprehension. This model has been used extensively to evaluate and enhance engineering teaching [76]. The cycle is shown in Fig. 6. ALPs are designed to provide learning experiences in the Kolb cycle that are not well met with traditional lecture classes.



Figure 6 – The Kolb Cycle

We use two theories/tools to understand and evaluate student learning styles and preferences, Felder-Silverman Index of Learning Styles and Myers-Briggs Type Indicator (Tables 1 and 2). Felder- Silverman Index of Learning Styles [23,24,29,31,32,35,45-47,59-62] are composed of four dimensions (active/reflective, sensing/intuitive, visual/verbal, and sequential/global) (1). Felder and Silverman formulated the index to assess the learning style of an individual. ALPs are designed to meet the needs of students with a range of learning styles. A particular approach to teaching will often favor a certain learning preference; it is therefore important to consciously incorporate a variety of approaches to meet the various learning preferences and styles. As an example, instructors’ teaching styles often favor sensing over intuitive learning styles or vice versa. The goal of this index is to assist instructors to create ALPs that impact all student learning styles effectively. In addition, we specifically incorporate students’ learning styles into our assessment approach, Section 3.

Table 1 - Felder-Silverman's Index of Learning Styles

Felder-Soloman	
ACTIVE Doing something active with it. Discussing, applying, or explaining it to others.	REFLECTIVE Thinking about it quietly first.
SENSING Learning facts.	INTUITIVE Discovering possibilities and relationships.
VISUAL See-- pictures, diagrams, flow charts, time lines, films, and demonstrations.	VERBAL Words-- written and spoken explanations.
SEQUENTIAL Gain understanding in linear steps.	GLOBAL Learn in large jumps, suddenly "getting it."

Table 2 – Myers Briggs Type Indicator Categories

Overview of MBTI	
Manner in Which a Person Interacts With Others	
E Focuses outwardly. Gains energy from others. EXTROVERSION	Focuses inwardly. Gains energy from cognition. INTROVERSION I
Manner in Which a Person Processes Information	
S Focus is on the five senses and experience. SENSING	Focus is on possibilities, use, big picture. INTUITION N
Manner in Which a Person Evaluates Information	
T Focuses on objective facts and cause & effect. THINKING	Focuses on subjective meaning and values. FEELING F
Manner in Which a Person Comes to Conclusions	
J Focus is on timely, planned decisions. JUDGEMENT	Focus on process oriented decision-making. PERCEPTION P

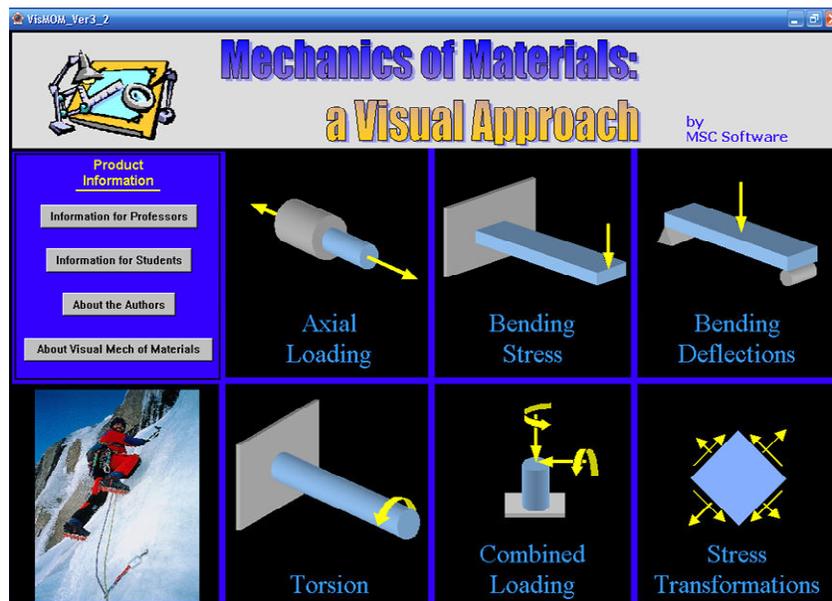
The Myers-Briggs Type Indicator (MBTI) includes four categories of preferences (introvert/extrovert, sensing / intuition, thinking/feeling, judgment/perception) [29,31,32,45,59]. Although MBTI categorization is well-established, its use as an indicator of the way people learn is far less common. The second of the four categories provides insight into how a person processes information. Those who prefer to use their five senses to process the information (sensors) are contrasted with those who view the intake of information in light of either its place in an overarching theory or its future use (intuitors). This sensor vs. intuitor category is seen by

most researchers to be the most important of the four categories in terms of implications for learning [29,31,32,35,45-47,59-62].

2.3 Exemplar ALPs

We have developed ALPs in a number of different content areas, including Engineering Mechanics, Machine Design, Engineering Design and K-12 curricula (<http://www.me.utexas.edu/~alps/alpContent/index.php>; <http://www.engr.utexas.edu/dteach>). In the Mechanics of Materials area, for example, includes over twenty active learning products and associated instructor resources. It is critical to realize though that the method for designing ALPs (PHLpS) and the Assessment Strategies below are applicable across all STEM content areas.

The activities themselves can be classified in five categories: 1) Hands-on, 2) Interactive Multimedia, 3) Thought Experiments, 4) Investigations and 5) Opportunities for Creativity. Some activities span more than one category [40,41,43,52,53,77]. “Hands-on” activities involve the direct manipulation of physical materials to explain or reinforce specific learning objectives. “Multimedia” activities use the VisMOM (for Visual Mechanics of Materials) software which elucidates concepts from Mechanics of Materials in a highly interactive and visual manner. “Thought Experiments” require the students to apply conceptual information to a given situation and make a judgment. “Investigations” ask the students to search for applications of concepts and then apply the theory by performing some engineering analysis thus connecting real world systems to engineering theory and finally to engineering analysis. Activities with “Opportunities for Creativity” provide opportunities for small-scale design, curiosity and improving innovation skills. The following sections describe and give examples for three of the five categories of activities. Complete descriptions and all ALPs materials can be found at <http://www.me.utexas.edu/~alps>.



**Figure 7 – VisMoM
A Visual Approach to Teaching Engineering Mechanics**

2.3.1 Multimedia ALPs

VisMoM (Visual Mechanics of Materials) is a suite of interactive multimedia covering many of the core concepts in a standard Mechanics of Materials course [42]. VisMoM contains hundreds of pictures, sketches, graphics, example problems and design problems all geared toward providing a visually rich, interactive environment for students to experience Mechanics of Materials in a conceptual manner (Fig. 7). The VisMoM software gives global overviews of the topics in each section and then provides students with example problems and interactive visuals including design problems. The VisMoM software is available at www.me.utexas.edu/~alps/resources/index.php.

In the Multimedia ALP depicted in Fig. 8, students are asked to design a beam to support a biplane wing strut specifically taking into account minimizing cost, safety factors, strut size, deflection and stress level. The exercise utilizes the VisMOM software to allow the students to interactively select material properties and cross section geometry. With the additional input of a free body diagram and other information, the VisMOM software provides students with the resulting model weight, safety factor, and cost.

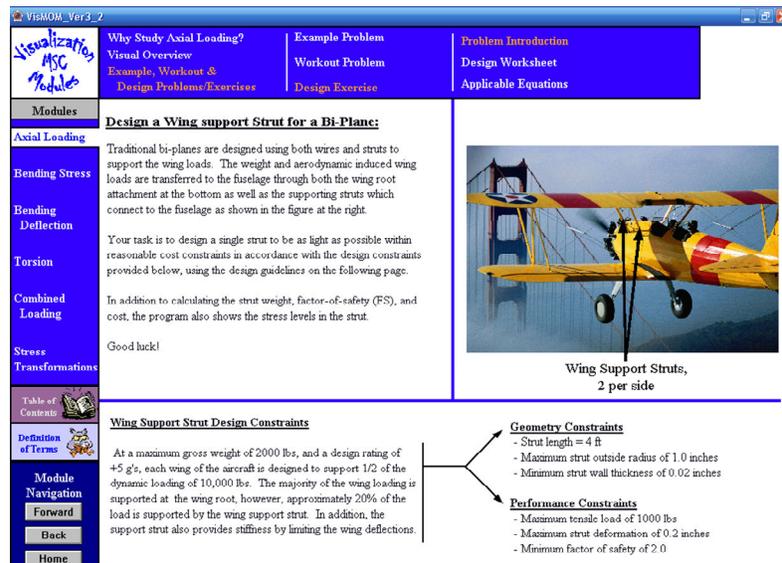


Figure 8 – VisMOM Wing Strut Design

2.3.2 Hands-on ALPs

The “Visualizing Stress Distributions in Photoelastic Beam Bending” ALP allows the student to explore, through visual and tactile feedback, different factors that affect bending stress and the internal stress states in bending members. The specific educational objective for this ALP is for students to demonstrate the ability to predict moment and normal stress distributions due to bending loads. This activity is an in-class ALP with groups of two to four students. The photoelastic box, shown in Figure 9, is made of simple wood chipboard with a metal retention bracket, polycarbonate plastic beam, and two circular polarized lenses to create a visible stress pattern in the beam. Color contours signify changes in stress (specifically changes in maximum shear stress). Therefore areas of increased color changes correspond to areas of high stress gradients. In the ALP, students attempt to predict what color contours will occur for a cantilever

photoelastic beam under light and heavy transverse loads. The students then bend the beams, observe the color contours, and compare them to their predictions. The color contours help students visualize the neutral axis as well as the moment distributions for the cantilevered bending problem.



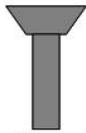
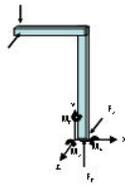
Figure 9. Loaded photoelastic beam [73,74].

2.3.3 Investigative ALPs

Investigation ALPs require the students to explore the world around them and find applications for the theories and concepts being taught. These ALPs typically require students to find examples where a given equation or theory applies in the real-world. The Investigation ALPs are normally most effective if used as an individual or group, collaborative homework. Reviewing the results in class provides reinforcement of the ties between the theory and real-world applications.

An example Investigation ALP is the activity: “Identify Items under Combined Loads ALP.” Students are asked to identify everyday devices and structures that include combined loading. The students then complete a table of information including component, type of loading, support model, and free body diagram for each device (Table 3). Examples can be found for kitchen appliances, hand tools, power tools, children’s toys, sports equipment, homes, local structures such as bridges and on the web. After the students complete the table for homework, it is brought to class for group discussion.

Table 3: Example of Combined Loads Worksheet

<i>Device/Structure</i>	<i>Component</i>	<i>Type of Loads</i>	<i>FBD</i>
 <p>Screw while it is being driven into a piece of wood</p>	 <p>Screw</p>	Axial, Torsion	
 <p>Road Sign when the wind is blowing</p>	 <p>Sign Post</p>	Bending, Axial	

3 ASSESSMENT OF ALPs

The assessment strategy depicted in Fig. 10 is intended to be used in whole or in part by others who are working to integrate active learning into STEM curriculum [39,41,77]. The assessment strategy involves obtaining assessment data from both instructors and students at three different types of institutions. For both the instructors and the students, the strategy is to acquire demographic data that can be correlated with assessment from participants. This correlation is created in order to determine if the ALPs are effective across different demographic categories. For example, correlations can be made to answer if the ALPs are effective across different MBTI types or different Learning Styles. Results from implementing this assessment strategy are shown below.

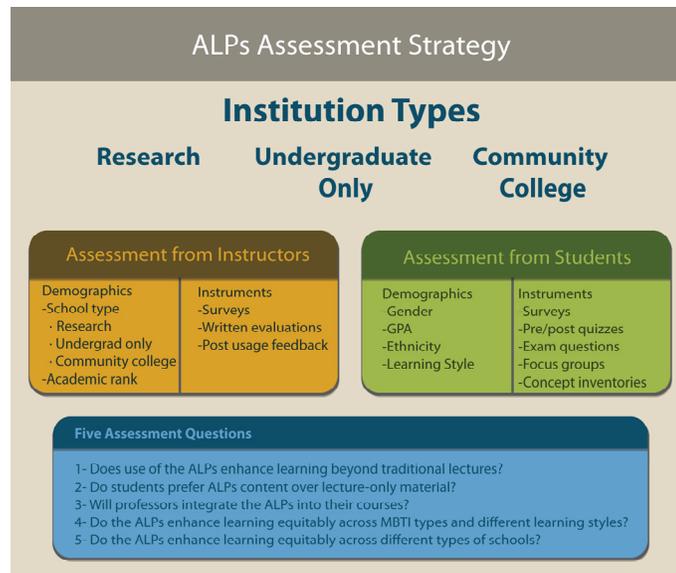


Figure 10
Overview of the Assessment Strategy for the ALPs

An assortment of assessment instruments were used to evaluate the ALPs including surveys, quick quizzes given before and after the treatment (exposure to the ALPs), exam questions, focus groups and concept inventories. This multifaceted approach, using a variety of assessment instruments, we believe, provides a much more comprehensive evaluation of the ALPs than would be possible with a single or smaller set of assessment instruments. Downloadable examples of these instruments are available on the web site at www.me.utexas.edu/~alps/alpAssessment/index.php.

Scores of assessment experiments using thousands of data points (faculty and students) have been run and are reported in detail in our refereed papers. These experiments display a clear picture of the overall effectiveness of the ALPs. The following sections include examples of the assessment results.

3.1 General Effectiveness of the ALPs

Two instruments that point specifically to the general effectiveness of the ALPs are exam questions and quick quiz data. For the exam assessment technique, question(s) on the exam which are designed to assess content which is covered in the ALP are identified. Results from control (did not see the ALP) and experimental (did see the ALP) groups are tabulated. Table 4 shows a typical set of results where the experimental group performed significantly better.

Table 4 – General Effectiveness of the ALPs Based on Exam Data		
	Number of Data Points (Students)	% of Students Correctly Answering the Exam Problem
Students Receiving the ALP (experimental group)	40	45%
Students NOT receiving the ALP (control group)	635	28%
% Difference		17%

Another technique we have used to assess the effectiveness of the ALPs is “Quick Quizzes”. These are short (< 5 minute) quizzes given to students both before and again after the content is presented. The presentation of the content is either standard lecture (control group) or ALPs (experimental group) format. Figure 11 shows results from 7 sections (3 control and 4 experimental) where the interjection of active learning is shown to increase learning.

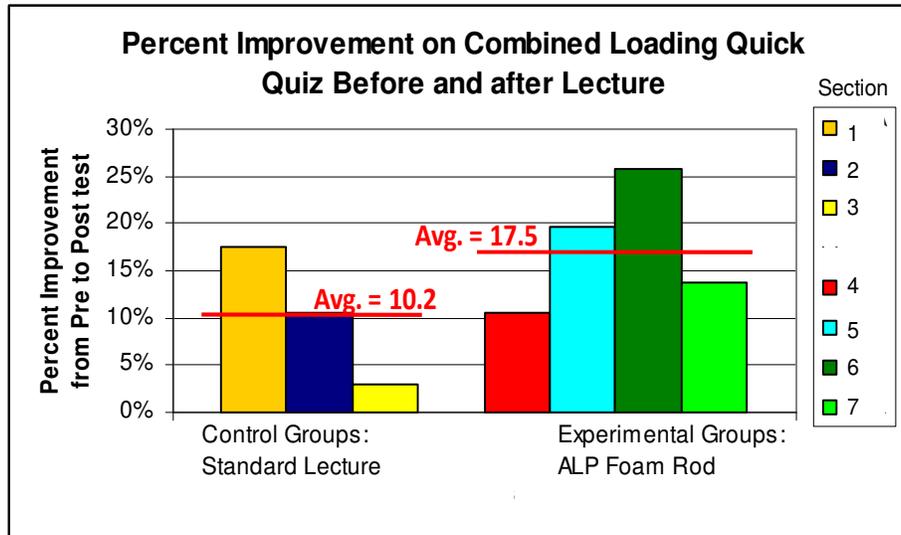


Figure 11. Quick Quiz Control & Experimental Results.

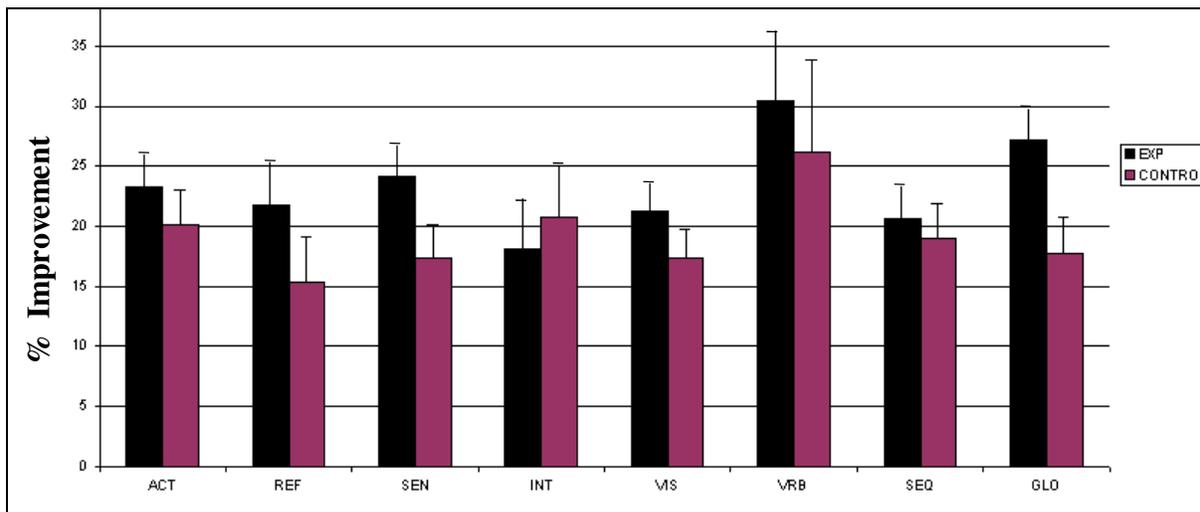
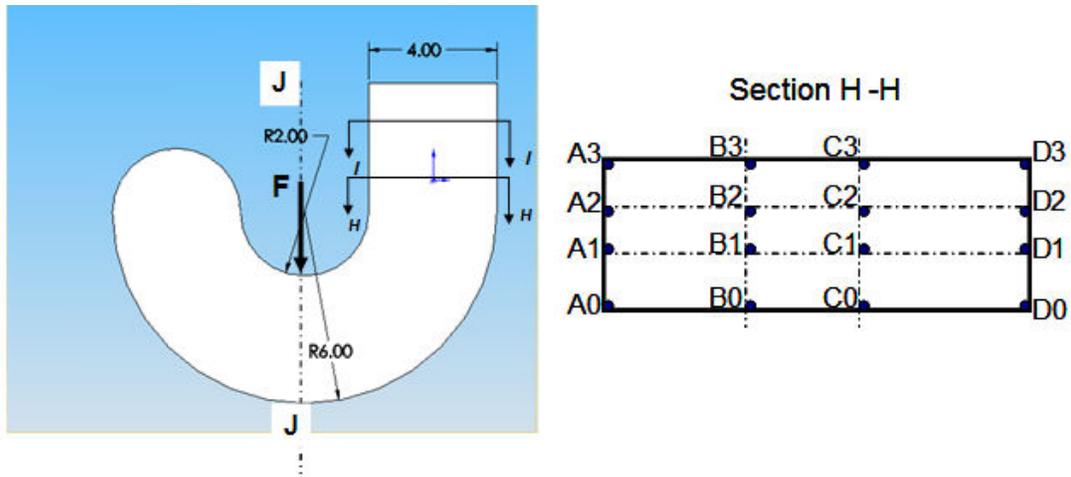


Figure 12. Quick Quiz: Control & Experimental Groups Correlated with Learning Style

3.2 Effectiveness of the ALPs for Different Learning Styles & MBTI types

Ideally, the ALPs would benefit students equally regardless of demographic factors (gender, ethnicity etc.), the type of institution they are attending (research university, undergrad only or community college), learning style or personality type. In order to determine if certain ALPs are biased toward certain student types, we have correlated the assessment results against a number of factors including gender, MBTI, Felder-Silverman Learning Styles and GPA. Figure 12 shows a typical result where the improvement in quick quiz data is broken down by learning style. Recall that the learning style indicators come in pairs (Table 1); so one is either “active” or “reflective” as indicated in the first two pairs of bars in the figure. The following three pairs of bars match the categories in Table 1. Notice first that the dark bars (experimental group) surpass the lighter bars (control) in all cases except the “verbal” category. The ALP used to produce this data was the photoelastic box (Fig. 9). This ALP allows students to experience basic relationships between force, moments and bending stresses in a tactile and visual manner.

However, the underlying physics that makes the color patterns appear in the box are not explained in detail. We hypothesize that this may be somewhat frustrating for the “Intuitors.” Note also that there are no large differences in the control group between the learning style pairs (i.e. the active and reflective scores are similar, the sensor and intuiitor scores are similar, etc.). The one exception to this is the differences between the visual and verbal learners. As the photoelastic box is a visual device, the fact that the verbal learners scored higher than the visual learners is somewhat counter-intuitive. Note however that this ALP is completed in small groups with extensive verbal interaction which may explain this result.



Circle the best answer

1. The normal stresses at points at A0, A1, A2, and A3 are the same.
 - a) True
 - b) False

2. The normal stresses at points at A0 and D0 have the relation as follows.
 - a) $\sigma_{A0} > \sigma_{D0}$
 - b) $\sigma_{A0} < \sigma_{D0}$
 - c) $\sigma_{A0} = \sigma_{D0}$

Figure 13. Quick Quiz focusing on the concept of stress as part of a concept inventory.

Similar results for correlations with MBTI, GPA and gender show that, in general, the ALPs appear to be quite unbiased and high-learning impact with respect to these different student descriptors. Figure 13 shows a pre- and post-quiz for engineering mechanics where finite-element analysis simulations are used as ALPS to provide a visual aid to ground students in the concept of stress. Tables 5 through 7 show the results of the pre- and post-quiz based on the application of the ALPs. It is clear from these tables, with a sample size of approximately 45 students, that student learning and understanding improved through the ALPs. Table 7 illustrates, however, that while all students generally improved due to the ALPs, there may exist different performance results for introverts vs. extroverts and intuitors vs. sensors. These results make sense since the finite element ALPs were performed individually by each student (if small group discussions had been used, extroverts would have been accommodated) and since physical / visual representations are aligned more directly with sensors.

Table 5. General effectiveness of finite element visualization ALPS (quick quiz, Fig. 13).

Year	Pre-quiz Average	Post-quiz Average	Improvement
2006	71.1%	82.2%	15.6%
2007	53.6%	66.4%	23.6%

Table 6. Quick Quiz (Fig. 13): Control & Experimental Groups Correlated with Learning Style

Learning Style	N	Pre-quiz	Post-quiz	Delta	Stdev	Weighted Pre-quiz	Weighted Post-quiz	Weighted Delta
Active	10	46.60	61.10	14.50	12.01	47.63	60.65	13.02
Reflective	4	69.00	78.00	9.00	9.00	86.73	89.73	3.00
Intuitive	6	62.00	73.14	11.14	13.18	53.04	64.15	11.11
Sensing	8	47.13	61.13	14.00	13.57	43.28	58.38	15.10
Global	4	51.00	64.40	13.40	11.50	31.64	44.29	12.64
Sequential	10	55.60	67.90	12.30	11.15	59.38	70.88	11.50

Table 7. Quick Quiz (Fig. 13): Control & Experimental Groups Correlated with MBTI preferences

Learning Style Differences	Unweighted Confidence Interval (%)	Weighted Confidence Interval (%)
Active vs. Reflective	61.9	86.7
Sensing vs. Intuitive	30.1	40.9
Sequential vs. Global	12.3	12.8

3.3 Effectiveness of the ALPs across institution types

The ALPs have been tested at a variety of types of institutions (school types) as shown in Fig. 10. We use, as one measure, student survey data to help determine if their effectiveness is limited by institution type. As can be seen in Table 5, data for a four question survey is tabulated for the three types of institutions.

Table 8. Assessment Across Institutions					
(Scale 5=Strongly agree, 4 = Agree, 3=Neutral, 2 = Disagree, 1 = Strongly disagree)					
Institution	Q1	Q2	Q3	Q4	Avg.
USAFA	4.1	4.2	3.5	3.8	3.9
UTA	4.3	4.4	4.1	3.6	4.1
Community College					3.7

Q1 – This activity helped me understand the topic better

Q2 – Personally manipulating the device and seeing the results was better than a similar demonstration

Q3 – I believe this activity was more effective than a normal lecture

Q4 - This activity increased my interest in engineering mechanics

The table represents data from approximately 150 students. Note that all of the responses are above the “neutral” level of 3.0 and either above or near the “agree.” Overall, the Texas students evaluated the ALPs more positively than did the Academy or Community College students. Only aggregate data was available for the community college. However, from the averages in the last column, it can be seen that the ALPs are rated quite positively across these three different types of institutions.

4 CONCLUSIONS

Active learning has many forms in the research literature. These forms range from cooperative and focus groups discussions to the use of multimedia and hands-on activities. No matter what form active learning embodies, the impact on student learning is exciting and powerful.

While the general impact and potential of active learning is well documented, methods for designing, assessing, and iteratively improving active learning activities is a frontier area of research. This paper discusses our contributions to this research area. A basic design methodology is described for active learning activities, in addition to exemplar activities in the field of engineering mechanics. An assessment strategy and assessment results are also shown for the exemplar activities. By relating student personality preferences and learning styles to assessment results, we are able to determine the cross-sectional effectiveness of the activities. We are also able to provide, at least at a basic level, an “understanding of students” and indicators for how we can maximize the use of active learning in the classroom.

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