(Copied from GAPS Analysis – Teaching Models Data Embedded; See pages 43-47)

GAPS Analysis Summary (Fall 2005 and **Fall 2006**)

Jule Dee Scarborough, Ph.D.

Student Learning Statements (Outcomes)

In the initial analysis of the Fall 2005 courses – where we began, professors used their existing course syllabi. Although as a college, we had improved our student learning statements during the accreditation process, they remained rather unorganized and weak in content and appropriate expression. The learning statements were expressed in mixed modes across syllabi. Some learning statements were written as course objectives; others were written as student learning objectives; yet others were written as more outcome-oriented statements. However, in generalizing, many and sometimes most of the student learning statement formats across syllabi were not active, clear, measurable, or clearly outcomes-oriented, where the professor and student could ascertain exactly what was expected and would be measured, and/or determine the culminating grade. Three professors expressed the learning statements in a way where students could see that there was a relationship between student learning outcomes and the ABET or NAIT outcomes, but if the ABET or NAIT outcomes were identified by a letter and not stated, then the relationship was not clear, nor were students about to review the accreditation outcomes for their own information. Two professors expressed the statements more clearly, with written statements for both the national standards and the learning outcomes for the course. The other five professors did not show the national statements in narrative but rather identified them by letter or number, regarding the level of coverage and depth of relationship. This had little meaning for students and did not make it easy for the professors to clearly be assured of direct links and relationships. Generally, the statements did link to the ABET or NAIT standards or outcomes, but often not clearly or strongly. It would have been difficult to determine a direct link, especially in light of the student learning assessments being used for the 2005 course. Therefore, we examined the 2005 syllabi and course content related to the standards as well as we could, with the understanding that the student learning outcomes to be redeveloped would better and more clearly and directly link to the national standards and assessments – a two-way link revealing the critical knowledge and skill connections.

Below are two charts that broadly identify the standards addressed in the Fall 2005 courses, according to the content and syllabus analysis by each professor of his/her course. The data are presented (in black) as collapsed across either all engineering professors or engineering technology professors as a broad viewpoint. The **Fall 2006** courses are presented in red, and although there are minor differences in the number of standards addressed, there is a great and very significant difference in the quality of the learning statements and their direct links to both the national standards and the learning assessments. The tables also reflect the number of learning outcomes for each standard by professor, **2005-2006** when possible. For the **2006** courses, the professors not only have improved wording and expression, but the knowledge and skill connections are much stronger; in addition, the outcome statements are improved because they are broken out into primary, second, and third level statements. The quality is improved not only because of better wording, but also because they now better understand the difference between complex statements, where there is a cluster of outcomes inherent to a single primary outcome statement. Thus the course content or the knowledge and skills to be taught became more obvious in the inherent breakouts of second and sometimes third level outcomes. This provided insight and assisted the professors in understanding what underlying or inherent knowledge and skills were required for a complex cluster of difficult primary learning outcomes – in other words, the knowledge and skills inherent to a single complex primary outcome. Therefore, readers may be amazed at the number of changes that resulted.

Usually, the primary statements would be used on syllabi or other reporting documents, but the analysis and breakout of second or third level learning statements provided a great learning experience for professors and led them to design and then engage students in more intentional, thoughtful, and higher quality learning experiences. This analysis and process can lead to more astute teaching and student learning, student assessments, instructional choices, learning process decisions, and more. Remember, each course is not required to address every national standard or outcome, but instead the standards or outcomes of focus selected should be addressed well. It is important that they understand individual course versus program requirements, that there is a cumulative effect across courses for the entire program, that the overall program is required to address all national standards or outcomes, not any single course; therefore, many standards will be addressed across multiple courses. However, particular standards may be addressed in only one or two courses across the program, depending on content, depth, program level, (e.g., introductory or capstone course). Professors sometimes mistakenly strive to address all or too many outcomes; thus the course content can become weak or superficial. Finally, when identifying the objectives or outcomes listed below, an * is used where one objective or outcome covers more than one ABET outcome or NAIT standard or where there is a greater total of “1s” than the total in the number in parentheses (4). The determining factor is the level of coverage of content.

Regarding outcomes, it is important to note that the professors analyzed the engineering or technology course content for embedded NIU General Education Goals. This analysis led them to more deeply understand why students fail to perform well in their courses if they do not come to the course with the appropriate general education knowledge and skills that are the underlying foundation for the engineering and technology content. The program leader revealed the strong relationships between NIU General Education Goals (outcomes) and the ABET and NAIT standards or outcomes by aligning and inserting them into a worksheet. That made it much easier and more efficient for the professors to see the direct relationships, then to consider the importance of acknowledging the embedded general education goals/outcomes as part of their course content, and to realize that even though they are teaching engineering or technology courses, they are actually concurrently continuing, extending, expanding, and deepening the learning of general education content in the context of engineering and technology. This was extremely important. Our professors intuitively knew this but had never “studied” the connections, mapped the connections, or included the general educational goals aligned beside their engineering or technology outcomes. They had also never thought of themselves as continuing the learning of the general education knowledge and skills in engineering and technology content. They considered the general education math, science, and communication knowledge and skills as prerequisites and only dealt with them when students did not have the knowledge or skills needed to perform on the engineering and technology content. Now the professors understand that they actually continue the learning of the mathematics, science, communication, etc. content in the engineering and technology context. The chart below reflects the 2005 course in black and the changes for the **2006** course in red. The professors improved the outcomes and connections and are committed to greater depth of change for the future. This was a very successful program component, resulting in significant learning and change.

Assumptions

Beware of assumptions when scanning the chart below and noting that one or more course outcome numbers did not seem to change. For example, one professor’s number of outcomes did not change from 2005-**2006**; however, the quality of the outcomes for **2006** was very significantly different and improved. Also, that professor’s four primary outcomes were broken out into second and third level outcomes. Again, for example, one primary outcome inherently encompassed five secondary outcomes, with each of those broken out into a third level. Thus the quality in content, linkages, and assessments was dramatically different and greatly improved for most of the courses.

Table B.11.c.1: Standards ABET-Engineering Outcomes (Fall 2005 and Fall 2006 courses) (5 engineering professors)

a. apply math, science, engineering	b. design/ conduct experiments; analyze, interpret data	c. design system, component, process-given constraints, etc.	d. function on inter-disciplinary teams	e. identify, formulate, solve engineering problems	f. understand professional, ethical responsibility	g. ability to communicate effectively	h. understand impact eng. Solutions on global, economic, environment, society	i. recognition of need for, and ability to engage in life-long learning	j. knowledge in contemporary issues	k. ability to use techniques, skills, and modern engineering tools
Fall 2005 and Fall 2006 Courses – ABET Outcomes										
5 + 5+	2+ 1partial (no DOE) 1 NR 1 c 2+	4 + 1+partial (could do lots more) 1 c 4+	1+ 1 NR 3 c 2+	4+ 1c 5+	1+ 1+ (written reports only) 1 NR 2c None	1+ 1 3c 3+	1+ 1 NR 2c 1c (minor) 1+	2+ 1+ (to small effect) 2c 2+	4+ 1c 4+	4+ 1+ (students don't use unless asked to) 5+
(6-11) 1 - 4	1 - 1	1 - 2	1 - 1	* - 8		1 - 1	1 - none	* - none	* - 2	* - 3
(3/6--5) 1-5		1 - 1		1 - 5				* - 1	* - 1	1 - 1
(4-4) 1 - 1	* -none	1 - none	* - none	1 - 1	* - none	* - 1	*		*	1 - 1
(4-5) 1 - 5		1 - 5	3	1 - 5	* - none	1 - 3	* - none	* - 1	* - 1	1 - 2
(4-5) 1 - 2		1 - 1		1 - 1	* - none				1 - 1	1 - 1

Legend: + = yes-okay; c = need to consider; other notes

Table B.11.c.2: Standards ABET/TAC/NAIT-Engineering Technology & Industrial Technology
(2 engineering technology/technology professors) (Fall 2005 and Fall 2006 courses)

a. mastery of knowledge, techniques, skills, modern tools	b. ability to apply current knowledge; adapt to emerging applications of math, science, technology	c. ability to conduct, analyze, interpret experi-ments; apply experimental results to improve processes	d. ability to apply creativity in design of systems, components, processes	e. ability to function effectively on teams	f. ability to identify, analyze, solve technical problems	g. ability to commu-nicate effectively writing	h. ability to com-municate effectively orally	i. recognize need for, ability to engage in lifelong learning	j. ability to under-stand profes-sional, ethical, social responsibilities	k. respect for diversity; know-ledge of contemporary profession-al, societal, global issues	l. commit to quality, timeliness, continuous improve-ment	m. ability to program computers and/or use computer applications effectively	n. ability to use modern labor-atory tec-niques, skills, equip-ment effect-tively	o. ability to manage projects effect-tively	p. ability to design, mani-pulate, manage industrial systems q. ability to manage or lead person-nel effect-tively
Fall 2005 and Fall 2006 Courses – ABET/TAC/NAIT Outcomes															
2+ 2+	2+ 2+	1+ 1c 2+	1+ 1c 2+	1+ 1c None	2+ 2+	1+ 1c 2+	1+ 1c None	1+ 1c 2+	1+ 1c 1+ ? not sure	1+ 1c 1+	2+ 1+	2c 1+	1+ 1c 1+	1+ 1c None	p. 1 no re-sponse 1c None q. 1no re-sponse 1c None
(5-6) 1-6 (6-19) 1-10	1 - 5 1 - 5	1- 1 * - 5	* - 1 * - 3		1 - 4 1 - 6	6 1		* - 4 4	2 1-one	1 1	2 *-none	1	1 – 1	 *-none	p. * -NR NR-NR q. *-NR NR-NR

Legend: + = yes-okay; c = need to consider; other notes

Table B.11.c.3: NIU General Education Goals (Fall 2005 and Fall 2006) (7 professors across engineering and technology)

Writing	Speaking	Listening	Quantitative Reasoning	Use of Resources-Technology	Historical Development Of Culture	Significance of Arts	Cultural Traditions Philosophical Ideas	Methods in Science Methods in Social Science	Interrelatedness Across Disciplines	Social Responsibility Citizenship
C C+ Earlier it was only lab reports. In fall 06, they had to write reports for three PA tasks.	C C+ Presentation of PA tasks	+ + Listen to guest speaker, professor, fellow students during PA task presentations	+ C+ Homework, exams, PA tasks – all involved quantitative reasoning	+ + In addition to labs that required using many resources, had to use outside resources for PA tasks.	NR NA	NR NA	NR NA	NR NA	NR C May consider more interaction with EE for signal processing	NR C+ Discussed issues such as energy conservation, noise, pollution, ethics, etc.
C+ Did consider and add, still needs improvement; will keep working on it	C	?	C+ Strong, but could be better	+ I'm quite pleased	NA	NA	C-	C+	C	C
Ok + Project, exams, homework, using MS Word	C + Oral presentations with PowerPoint	C C-	Ok + Material requires this	Ok + Software and computer to solve problems	NR NA	NR NA	NR NA	C NA	Ok, C+ Examples, exercises with topics from other disciplines	C C-
+ + PAs and homework	+ + Pas and discussion sessions	+ + Lectures, case studies, discussion sessions	+ + Problem solutions, homework, midterm and final exams	+ + PAs and homework	C NA	C NA	C NA	+ + Problem solutions, homework, midterm, final exams, and PAs	+ + Case studies and PAs	+ C-
C - + well addressed through PA reports	+ NA- possible to include for future course	C + lectures	+ + addressed in project design decisions	C + well addressed through project design decisions	NR NA	C + addressed through project design	NR - NA	C + well addressed through project design	C C+ to some extend when making design decisions	C C- possible to include for future courses
+ + Performance Tasks	+ + Group learning and interactions	+ + Group interactions	+ + Performance tasks, lab demonstrations	C NA	+ C+	C + Lectures	+ C+	+ NA?	C C+	+ C+
C +	C C-	C C-	+ N+	+ +	+ NR	C NA	C NA	+ NA	C NA	C N\A

Legend: + addressed well; NA-does not really apply in professor's opinion; C- do not do it, but still need to consider adding it in as professor continues to make changes; C+ did consider and add in; still needs improvement and professor will keep working to improve or add;

Research Semester Results on Teaching Styles (Fall 2005 and Fall 2006)

During the initial course analysis, professors analyzed their 2005 courses for use of teaching styles. They referenced Mosston and Ashworth (1990) only. At the end of the research semester, professors were provided the same Teaching Styles list by Mosston and Ashworth and also Grasha's (1996). They were asked to consider which styles were used during the research semester. The responses ranged from check-offs to comments. Mosston and Ashworth's styles are compared for the 2005 and 2006 courses on (Table 5) below the one for Grasha (Table 4). The results from considering Grasha's are presented in the chart immediately below in narrative. Some professors estimated how many times they used each style; others made comments about the ones they choose; and others did both. All professors made comparisons using Mosston and Ashworth's teaching styles, but some professors also considered Grasha's Mosston and Ashworth were provided during the initial analysis early in the program. Later in the program we were trying to present them with varying options and perspectives. Therefore, they were also exposed to Grasha's styles. The most important aspect of this reporting activity was to reinforce consideration of teaching styles and to stimulate a broader repertoire of teaching styles or the use of a greater variety of teaching styles in their courses. Grasha is presented first. **Note: Outcomes vary across professors, so the two tables, Grasha and Mosston and Ashworth, reflect which teaching styles are used across the total of individual primary course outcomes by professor. Outcomes are presented by number only in left column. This program component was very successful in that professors varied their teaching styles beyond those used in their 2005 courses.**

Table B.11.c.4: Student Learning Outcomes & Teaching Styles (Fall 2006) (7 professors across engineering and technology)

# of Outcomes	Expert	Formal Authority	Personal Model	Facilitator	Delegator
6	Yes -4	Yes – 5	NR	Yes – 6	Yes - 3
3-6	Used Felder formally	NR	NR	NR	NR
	Responded to Kolb				
4	Yes	Yes	NR	NR	NR
	Used Kolb formally				
4	Yes, but used less this time	Used for fundamentals	NR	Used with PA tasks, especially 1 & 2	Used for final PA task #3
	Used Kolb formally				
5	No Response to Grasha	NR	NR	NR	NR
	Responded to Kolb				
6	No Response to Grasha	NR	NR	NR	NR
	Responded to Kolb				
4	Yes	Yes	No	Yes	Yes
	Responded to Kolb				

Table B.11.c.5: Student Learning Outcomes & Teaching Styles (Fall 2005 and Fall 2006)
(7 professors across engineering and technology)

# of Outcomes	Command	Practice	Reciprocal	Self-Check	Inclusion	Guided Discovery	Convergent Discovery	Divergent Production	Learner Designed	Learner Initiated	Self Teaching
6	6+ yes -10	6+ yes-4	2c, 4+ yes -5	6c-1min.	6c	5+, 1c yes -20	6c	3c (min) 3c yes -6	6c	6c yes -1	6c
3-6	6+ Less than before	6c Much more	5c, (1 little) a few times; did not guide ob.	6c more than normal	6c	3+, 3c more than before	1can do more 1+, 4c more than before	5c, 1little	6c	6c more than before	6c more than before
4	2ok yes	2ok,c yes	2c yes	2c	2c	NR	2c yes	NR	NR	NR	NR
4	4+ used less this time	4+	2c, 2+ used much more during oral discussions	4c	4c new, somewhat accomplished through implementation of the rubrics	4c	4c used much more – a lot through PA tasks, discussions	4c	4c	4c	4c
5	5+	5some used appx. 6 times mainly/PAs	NR	4+(1some)	4c, 1NR	3c, 2NR	3c, 2NR	NR used appx. 12 times / problem solving	NR	4NR,1c	NR
6	5+, 1c yes - 20	5+, 1c yes - 6	6c yes - 6	6c	6c	3+, 2c	5c, 1+ yes - 3	5+, 1c	5c, 1+	6c yes - 3	5+, 1c
4	4+ no; but, yes with other styles below	4+ yes, when solving problems in class	4+, c within the group; but without professor supervision	4c yes; feedback within group	NR yes	4c+	4c+ yes	4c yes, sometimes; when the was design problems	4c yes	4c yes, but with some guidelines; instruction is given	4c yes, with projects; but not with deep consultation

*Research Semester Teaching Models (Fall **2006**)*
In the table below, the professors' analysis of their Fall 2005 course is compared to what they indicated actually occurred in the same, but significantly revised, course during the research semester of Fall **2006**. The Fall 2005 course is presented first in black, and beneath that information, the teaching models used during the Fall **2006** course during the research semester are presented in red. There are 24 teaching models; therefore, the complete list is presented in two charts; models are identified across the first row. The numbers in black represent what they would consider using, acknowledging that in the 2005 course those were not in use. The number or comments in red represent what they felt they tried in the 2006 experimental course.

Although it may appear that professors selected only a few new models to use during their experimental course in 2006, remember there are 24 different models to consider. They were encouraged to select just a few models to try out in the 2006 courses, and then to add other models gradually in consecutive semesters. Thus, each professor chose a few models to try that were different than the most-often used "lecture" model.

This aspect of the program was successful: professors were exposed to 24 teaching models. They used this initial approach to analyze what models they felt were used in the 2005 course. Most of them had no previous knowledge of these models nor had they considered "teaching models" at all, even those who had attended teaching workshops. Several had been exposed to "cooperative learning," one of the teaching models below, but had not used the model formally at all and only weakly structured informally.

During the teaching model program component, the professors studied the 24 models more in depth; this was after the initial analysis with a list and brief descriptions. The worksheet used as a study guide along with the Joyce, Weil, and Calhoun's (2004) *Models of Teaching* book reveal how they felt about each model and whether they felt each model had potential for use in teaching their course. That worksheet is presented later, as it is a formal segment of the program for the redevelopment of the course. However, when reviewing the worksheet, each professor's comments, and then the comments after the experimental course, one can see the growth, comments, or questions.

After the research semester, Fall 2006, we returned their initial analysis and the study worksheet and asked them to note which teaching models they felt they had actually used during the experimental semester. Did they use the ones that they expected to try out? Did they use others not expected? The red numbers below labeled 2006 are those responses. The data reveal significant change, considering the context was one course and their first effort to expand their teaching model repertoires.

(See Teaching Models In Portfolio Section B.11)

Table B.11.c.6: Student Learning Outcomes & Teaching Models (Fall 2005 & Fall 2006) (7 professors across engineering and technology)

# Out-comes	Memory	Progressive Part	Advanced Organizers	Lecture	Reciprocal Teaching	Mastery Learning	Cooperative Learning	Graphic Organizers	Concept Attainment	Concept Formation	Concept Presen-tation	Conceptual
6	6c	6c	5c,2+ yes 20+	6+ yes 10	6c (1min.)	5c, 1+	3+, 3c yes 3	3+, 3c (1min) yes 4	6c (1min)	6c (1min)	6c	3+,3c yes 6
3-6	6c	6c couple times liked it	6c have always used it	6+ do much less	6c several times	6c used, not completely rigorous	6c used much more & more formal	6c (1 min) used about as much as before	5c,1+ used…probably slightly more	6c	6c used a little	6c used
4	NR	2c yes 14	2c yes	2+ yes 14	2c yes 7	2c yes 10	2ok,c yes 7	2c	NR	NR	2c yes	2c
4	NR	NR	NR yes, good response	4+ yes, several times	2c, 2+	NR	2c, 2+ yes, good response, more assessments taken the time	4c	4c	4c	4c *Used with *C, more often than before; now I know what this is called.	4+ **** used with * CP
5	2+	4+	4+	4+ 20-used frequently to deliver course materials	4c 3-used while executing PAs; demon-strated good outcomes.	NR	4c 3- used to enhance implementation of PAs	4+	NR	NR	3c,1NR	4c
6	5c	4+,2c 15 lectures	4+, 2c 3 theory linked with lab demonstration	5+, 1c 20 lectures	6c	6c	6c 6-group learning & PA#3	5+,1c 10-during lectures-visual aids	6c	6c	2c, 4+ 6-lectures on funda-ment	4+,2c
4	4c used, but not much	4+ yes	4+ yes	4+ some parts lecture, but not majority	4c did this with projects	4c	4+ yes, done with PA projects	4c yes, every group did that	4c	4c	4+	4+

# Out-Comes	Inductive	Deductive	Inquiry	Simulation	Jurisprudential	Direct Instruction	Training	Synectics	Psychomotor	Metaphore	Non-Direct	Role
6	6c yes 4	6c (1min)	6c(2min) yes 5	6c(2min) yes 2	6c	4+,2c(1min) yes 8	4+, 2c yes 5	6c	5NR,1c yes 2	NR yes 1	NR yes 2	NR yes 2
3-6	6c used a lot	6c used less than before	2+, 4c used a lot	6c extensive use	6c	6c	1+, 5c about as before	6c	6c some	6c	6c	6c
4 NR→	NR	2ok	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
4	4+ used much more; students responded well! Used past also.	4+ used much more; students responded well! Used past as well.	NR	4c	NR	NR	NR done some before; use-ful for pro-blem solving procedures; excellent / conceptuali-zation; able to discuss different approaches after one as presented.	NR	NR	NR	NR	NR
5	NR	NR	4+ 7	4c	NR	4c 10 suitable for certain topics	1c, 4NR	NR	NR	NR 3	4c	1c, 3NR
6 .	6c 9 – Pas & assignments	6c	6c	4+, 2c 2 lab demos	6c	2+, 4c 15 lectures on basics	5c, 1+ 2 lab demos	6c	5c, 1+	6c	6+	5c, 1+
4	4c yes, hidden in lecture	4+ yes, but professor dos that when needed	4c	4c yes, students simulate perfor-mance of rubrics	4c	4c	4c	4c	4c	4c	4c	4c

(Scarborough, 2006 based on Joyce, Weil, & Calhoun, 2004)

Student Learning Outcomes & Kolb (1984) Learning Styles

The Chart below identifies what learning styles, according to Kolb's (1984) styles, the professors felt they were providing opportunity for students to use in both the 2005 and **2006** courses. It appears that more attention was paid to learning styles across professors in the 2006 experimental course. Two professors used the Kolb Learning Styles inventory formally with the entire class, and a third professor used the Felder Learning Styles Inventory formally with his/her class. This segment of the program was also considered very successful, as it greatly enhanced the professors' understanding of the overall focus of teaching and the relationship between teaching styles, teaching models, and student learning styles. Their awareness was greatly increased; their understanding increased; and, their commitment to working on increasing the diversity of teaching models and styles to better engage a broader range of student learning styles and to also culminate in expanding individual student learning styles was significant. Below are reflections from the three professors who formally used LS Inventories. (See Felder notes)

Table B.11.c.7: Student Learning Outcomes & Kolb Learning Styles 2005 & 2006 (7 professors across engineering & technology)

# Outcomes	**Concrete Experience**	**Abstract Conceptualization**	**Active Experimentation**	**Reflective Observation**
6 **Also used Felder's SL, IL, VL, VL, AL, RL, GL.**	**2c-minimal, 2c, 2+** **yes**	**5+, 1c** **yes**	**3c, 3+** **yes**	**6c** **yes**
3-6 **Used Felder's only.** **The notes are ture for the concept tests, but less so on the problem solving tests. See write up below.**	**6+** **Global learners did better than sequential learners.**	**3+, 2c** **Intuitive learners did Better than sensing learners.**	**4+, 2c** **Visual and verbal learners did equally well.**	**3+, 1 not so much, 2c, 1 a little** **Reflective learners did better than active learners.**
4 **Formally used Kolb with students as a way to show students their learning styles. Will use it next time to also create activities tailored to students' distribution of L. styles.**	**NR** **yes**	**2ok,c** **yes**	**2ok, c** **yes**	**2c** **yes**
4 **Formally used Kolb's Inventory.**	**2c, 2+** **Yes** **Concentrated effort was**	**4+** **Yes** **made to have activities**	**4+** **yes** **to engage all four (4)**	**4+** **yes** **learning styles.**
5	**5+**	**1NR, 1+, 3c**	**1NR, 1c, 3+** **yes**	**4+, 1c**
6 **No response**	**6c**	**5+, 1c**	**5c, 1+**	**4+, 2c**
4 Also used Felder's SL, VL, VL, AL, RL, SL, GL	**4+**	**4+** **yes**	**2c, 2+** **yes**	**2c, 2+**

Legend: **Black-Kolb 2005 course analysis;** **Red-2006 course analysis;** **Blue-2006 course using Felder**

Reflections on using Felder & Soloman Learning Styles

B.D. Collar

In the fall of 2006, we conducted a research project experimentally investigating student learning in an introductory engineering mechanics course. As part of the project, we administered Felder and Soloman's Index of Learning Styles. The survey is designed for engineering undergraduates. It consists of 44 questions aimed at illuminating students' preferred modes of learning. Felder and Soloman characterize student learning styles with four dimensions:

1. *active vs. reflective,*
2. *sensing vs. intuitive,*
3. *visual vs. verbal,*
4. *sequential vs. global.*

In the research project, we randomly split the class into two groups. With one group, we used hands-on manipulatives to present many of the concepts. The second group is a control group in which we used more traditional graphical techniques to introduce and solidify concepts.

As it turned out, there was no statistically significant difference in the two groups' performances on objective performance tests. However, when we examined the data more closely, we did find an interesting distinction. Electrical engineering students in the experimental group did significantly better than their counterparts in the control group. It was an effect not present in the mechanical engineering students, who make up the bulk of the class. In fact mechanical engineering students in the control group tended to do slightly better than their counterparts in the experimental group, but not by a statistically significant margin.

It is apparent from our data that electrical engineering students think and learn differently than mechanical engineering students. An obvious question is what makes the electrical engineering students more receptive to the hands-on teaching strategy? When we correlated students' learning styles to exam performance, we found that

1. *Reflective learners tended to perform better than active learners.*
2. *Intuitive learners tended to perform better than sensing learners.*
3. *There was no correlation between the visual/verbal dimension of learning and exam performance.*
4. *Global learners tended to perform better than sequential learners.*

In results 1, 2, and 4 above, the p-values were all less than 0.002. However, all correlation coefficients had magnitudes on the order of 0.4. Therefore, while certain learning styles showed a tendency for better performance, it is clear that there was no definite one-to-one correspondence. So are the more advantageous learning styles more prevalent in electrical engineering students? The answer is no.

We found no statistical difference between the learning styles of electrical and mechanical engineering students. In the study, we tested for several other differences between mechanical and electrical engineering students that also correlated with exam scores. We were not able to find any. For now, the difference is a mystery.

Application of Kolb's Learning Styles to ISYE370

By Reinaldo Moraga

I started my Operations Research class –ISYE370– by giving the Kolb's learning inventory test to my students in such a way that they and I became aware of the type of learning style they used to learn and which other styles they were able to pursue. In addition, Kolb's learning styles helped me to improve the delivery of the teaching.

The test was given to each student in the first class after the presentation of the syllabus. Then I explained to them the importance of recognizing their preferred learning style and how this information could be used for them and me to enrich the learning environment in the classroom. In addition, I tried to connect the importance of this tool with their professional career in terms of communicating in the workforce and collaborating in groups. Step by step, I went through the booklet to let them know how to fill the questionnaire and interpret the results. The students were inclined to think that there was a correct outcome for this test. Therefore, I had to make clear that this was only a way to diagnose a preferred style *of learning. Finally, I asked to take the test home, answer the questionnaire, and next class give me a brief essay reporting (a) their preferred learning style, (b) actions they could take to expand their learning into other styles, and (c) which type of activities in this class could produce connection with their preferred and other learning styles.*

Most of the students were able to identify their preferred learning style. To expand their learning styles, most of them reported activities such as "exploring the world around," "reading more books," "doing more [hand work]," "being more sensitive to people's feelings," "trying to make the subject fun while learning," etc. Some interesting comments on how to connect their learning styles with my class were "by becoming personally involved and influencing the others to work together," "to have a review session or a guide study," and "to gather into groups to think out problems."

I found this activity relevant because we may use Kolb's test to help us identify our strengths and weaknesses as instructors, recognize our students' preferred styles, use teaching techniques to require all learning styles, and encourage our students to extend into other styles. Of particularly interest to me as instructor was to learn the use of the learning cycle to design some of my "lectures." The learning cycle consisted of four questions: why?, what?, how? and what if? (Harb, Durrant, & Terry, 1993.) I tried to emphasize in my lectures the answers to these questions because in that way I could reach most of the different learning styles of my students. This framework opened my eyes to the importance of Kolb's learning styles, and because of its practical applications in teaching, I would like to keep using Kolb learning cycles as part of my other classes I teach for the College of Engineering.

Reference:
Harb, Durrant, & Terry, (1993). Use of the Kolb learning cycle and the 4MAT system in engineering. *Education, Journal of Engineering Education,* 70-77.

Use of Kolb's Inventory of Learning Styles
CITL – IENG 475 Fall 2006
Regina Rahn

The Kolb Learning Style Inventory was administered to students in the Fall 2006 IENG 475 Decision Analysis class. They completed the questionnaire and interpreted their learning styles. We discussed, as a class, the strengths of each learning style and talked about the types of activities that were useful for facilitating learning of each type. The idea was to set a premise for the assessment and instructional activities that would be implemented during the semester.

In addition, we discussed ways that individuals could use the knowledge of their learning styles to expand the ways in which they learn to incorporate other styles. The discussion included the use of group work (cooperative learning) and peer review as ways to aid in accomplishing this goal.

A graduate student used this as one of the bases for her graduate project. The project was completed at the end of the semester. The IENG 475 students were surveyed about their thoughts in regard to the use of the learning style inventory. The responses were extremely positive, and they definitely saw the value in the exercise.

The Decision Analysis class also posed a unique opportunity for discussions surrounding learning styles. We investigated relationships between learning styles and peoples' attitude toward risk, which is a key element in the course subject matter. I intend to continue utilizing learning style inventories in my courses.

Student Learning Outcomes & Bloom & Dale (Fall 2005 and Fall 2006)

The professors analyzed their student learning outcomes against Bloom's Learning Dimensions and Dale's Cone of learning. The analysis of the 2005 course is presented in black below and also as a composite, number of outcomes achieving what level on Bloom's and Dale's models. The 2006 course analysis, however, is presented in red. Dale's levels are presented by number of outcomes and level of the Cone. For Bloom, each outcome is listed at the level achieved. This program component was also successful. The professors really seemed to grasp Bloom's intentions, whether traditional or revised. They not only benefited from using it as an analysis tool, but in the later re-development of their courses. They also grasped Dale's intentions about passive versus active learning. These models seemed to build good initial awareness, which deepened as they used them as tools more and more, beginning with the initial 2005 analysis and then as a metric for the re-development of the 2006 courses. There was significant change in the quality of their student learning outcomes. The professors' student learning outcomes were developed and written to achieve higher cognitive processing levels on Bloom's Cognitive Dimension. T he outcomes also reflective higher quality in that they reflected more active learning. The outcomes reflected a potentially higher level of critical thinking as well. This program component resulted in significant change and left them with simple tools to use as metrics for ongoing change and quality checks.

Table B.11.c.8: Student Learning Outcomes & Bloom & Dale (Fall 2005 and Fall 2006)
(7 professors across engineering and technology)

# Outcomes: **05 reported as composite** **06 reported- specific outcome**	**Dale's Cone Levels : P AA+**	**Knowledge Remember**	**Comprehension Understand**	**Application Apply**	**Analysis Analyze**	**Synthesis Evaluate**	**Evaluate Create**	**Critical Thinking Level: L M H**
(1) 6 outcomes composite **1-11 numbers 1-11**	**NR** **1-11** **(8-10) A+**	**1+, 5NR**	**2+, 4NR**	**2+, 4NR**	**1c, 5NR** **1, 3, 7. 8. 9**	**1+, 5NR** **2, 5, 6, 7. 10, 11**	**6NR** **1, 4**	**2Lm 3M, 1H**
(2) 3/6 **5**	**3P, 1A** **2A-** **1-5** **(10) A+**	**6+**	**6+**	**3+, 3c**	**5c, 1NR**	**6c**	**6c** **1-3/6**	**2L, 2L+, 1L/M, 1M; 2Mc**
(3) 2 **2**	**2 PA-C** **1-2** **(8-10) A+**	**2 +c**	**2 +c**	**2+c**	**2 +c**	**2 +c**	**2c** **1, 2**	**2Mc**
(4) 4 **5**	**2A, 2A+** **NR**	**4+** **NR**	**4+** **NR**	**4+** **NR**	**4+** **NR**	**1c, 1+-, 2+** **NR**	**4c** **NR**	**2M, 2H**
(5) 5 **19**	**2P, 2A, 1A+** **1 (6);** **2-3 (9)** **4 (6)** **5-19** **(9-10)A+**	**2+, 3NR** **NR**	**2NR, 3+** **NR**	**2NR, 3+** **NR**	**NR** **NR**	**NR** **NR**	**NR** **NR**	**3M**
(6) 6 **6**	**4P, 2A** **3 (2)** **4 (1,3,5)** **8-9 (1)** **8 (1)**	**2+, 4c**	**3+, 3c** **1, 2, 3, 5**	**5+, 1c**	**4+, 2c**	**5+, 1c** **4**	**4c, 2+** **6**	**3L, 2M, 1H**
(7) 4 **4**	**1P, 1P-A, 2A-P** **1-4 (1-10)**	**4+**	**4+**	**1+c, 3+**	**1c, 1c+, 2+** **1**	**2c, 2+** **2**	**2c, 2+**	**2c, 2c+** **3, 4**

Bloom (1956); Anderson & Krathwohl (2001); Legend for Blooms levels: NR = no response; number + = number of outcomes at that level; +c = okay, but still need to consider; c = need to consider achieving; c+ = some positive accomplishment, but still needs work (**e.g., outcome number reported by each Boom level)**
Dale (1969): Legend for Dale's levels: 9-10 = active learning-doing level; 8 = active learning-participating; 3-7 = visual receiving/passive; 2-1 = verbal receiving-passive,
(e.g., outcome number - level)