Robotics-Centered Curriculum (2007-2008)

Annual Report

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MEMORANDUM

DATE: December 21, 2009
TO: David Hall, Ph.D.
Associate Professor of Mechanical Engineering
Program Chair and James F. Naylor Endowed Professor
Louisiana Tech University

FROM: Patsy Brackin & Shannon Sexton, Rose-Hulman Institute of Technology

SUBJECT: Robotics-Centered Curriculum Annual Assessment Report

The Office of Assessment has continued the assessment implemented during spring quarter, 2007. The items received during the 2007-08 academic year have been added to the initial baseline data. This report comments on the following information:

Spring 2007

- ENGR 120 - end of quarter surveys - old curriculum (1 section)
- ENGR 121 - end of quarter surveys - old curriculum (2 sections)
- ENGR 122 - end of quarter surveys - old curriculum (2 sections)
- ENGR 122H - end of quarter surveys - Living with the Lab (2 sections)

2007-08 Academic Year

- ENGR 120 – end of quarter surveys - Living with the Lab (10 sections)
- ENGR 120H –end of quarter surveys- Living with the Lab (3 sections)
- ENGR 121 – end of quarter surveys – Living with the Lab (6 sections)
- ENGR 121H – end of quarter surveys – Living with the Lab (1 section)
- ENGR 122 – end of quarter surveys – Living with the Lab (2 sections)
- ENGR 122H – end of quarter surveys – Living with the Lab (2 sections)

In addition, a site visit was made in May 2008. Although an interim report was completed on the site visit, for completeness, information from that report will also be included here. The visit included faculty interviews, focus groups, and attendance at the design symposium.

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Background

LIVING WITH THE LAB

The major aim of the LIVING WITH THE LAB curriculum is to create innovative students with a can-do spirit through a project based curriculum where students repeatedly apply technology and fundamentals to solve problems. The new curriculum boosts experiential learning by putting the ownership and maintenance of the "lab" into the hands of the students. Each student purchases a robotics kit (~$150) with a programmable controller, sensors, servos, and software to provide the basis for a mobile laboratory and design platform. A basic tenet of the curriculum is that student-owned labs motivate student learning and broaden the spectrum of projects and design topics that can be addressed, thus facilitating innovation.

Assessment Activities

LIVING WITH THE LAB is a college-wide freshman course sequence focusing on several of the attributes listed in "The Engineer of 2020." The curriculum objectives are grouped into seven threads that span the freshman year. These seven themes include Systems, Electromechanical, Fabrication and Acquisition, Software, Fundamentals, Communication and Broadening Activities. Specific outcomes were developed within each of the three courses to support the curriculum objectives.

A variety of assessment activities were undertaken to examine the effectiveness of the curriculum and the extent to which the objectives were obtained. Student surveys, focus groups, student work products, and faculty and staff interviews were examined to assess the effectiveness of the curriculum innovation. As a primary focus of the curriculum change is to develop an innovative spirit, students were surveyed to determine their confidence in their abilities and the frequency with which they used those abilities.

Table 1 lists the target group, method of assessment, timeline and focus of assessment for each instrument administered since Spring Quarter, 2007. Part of this assessment effort is to continue to evaluate the effectiveness of the assessment methods employed and to make suggestions to enhance the assessment effort throughout the grant period. In addition, comparisons to the baseline data obtained during the Spring of 2007 will be investigated.

Table 1: Summary of Grant Assessment Activities

Assessment Schedule	Target Group	Method	Focus of Assessment
Spring 2007	ENGR 120	Survey	• Skills practiced • Course outcomes
Spring 2007	ENGR 121	Survey	• Skills practiced • Course outcomes
Spring 2007	ENGR 122	Survey	• Skills practiced • Course outcomes
Spring 2007	ENGR 122 (old and new curriculum)	Focus Group	• Student perceptions • Student aspirations
Spring 2007	ENGR 120, 121, 122	Syllabus Analysis	• Opportunities for practice
Spring 2007	ENGR 122	Student Work	• Evidence of student ideas
Fall 2007	ENGR 120	Survey	• Skills practiced • Course outcomes
Winter 2008	ENGR 120	Survey	• Skills practiced • Course outcomes
Winter 2008	ENGR 121	Survey	• Skills practiced • Course outcomes
Spring 2008	ENGR 120	Survey	• Skills practiced • Course outcomes
Spring 2008	ENGR 121	Survey	• Skills practice d • Course outcomes
Spring 2008	ENGR 122	Survey	• Skills practiced • Course outcomes
Spring 2008	ENGR 121, 122	Focus Group	• Student perceptions • Student aspirations
Spring 2008	ENGR 120, 121, 122	Faculty interviews	• Faculty engagement • Opportunities for improvement
Spring 2008	ENGR 122	Design	• Evidence of student ideas • Student engagement

Participants

The survey was administered during the fall, winter, and spring quarters in the 2007-08 academic year in 3 courses; ENGR 120, ENGR 121, and ENGR 122. A total of 549 student responses to the survey were analyzed from the 2007-08 academic year. The number of surveys analyzed for each course is tabulated by quarter.

Table 2: Description of Student Participants from Spring 2007-Spring 2008

Quarter	Course	Honors	Regular
Spring 2007	ENGR 120	0	34
	ENGR 121	0	56
	ENGR 122	24	66
Fall 2007	ENGR 120	36	147
	ENGR 121	0	0
	ENGR 122	0	0
Winter 2008	ENGR 120	0	65
	ENGR 121	16	104
	ENGR 122	0	0
Spring 2008	ENGR 120	0	43
	ENGR 121	0	51
	ENGR 122	28	58

Statistical Analysis

The student responses from the surveys were analyzed and are presented in several ways. First, frequency of student responses was calculated overall. Second, an ANOVA was conducted to compare each course participating in the assessment. An Independent T-test was run to compare course objectives for cases where only 2 of the courses had a common objective. Finally, an ANOVA or Paired Samples T-Test was run to compare each course over time.

Data Collection Process

The course instructors administered the course survey to students throughout the academic year. (See Appendices for copies.) The data was then collected, entered in an Excel spreadsheet in various formats and sent for common formatting and analysis. The rating scales used for each survey consisted of a 6 point confidence scale and a 7 point frequency scale. The confidence anchors and the frequency anchors are defined in Table 3.

Table 3: Anchors Used in Surveys

Rating	Confidence Anchor	Frequency Anchor
1	Completely Unconfident	Never
2	Mostly Unconfident	Very Infrequently
3	Slightly Unconfident	Rarely
4	Slightly Confident	Occasionally
5	Mostly Confident	Frequently
6	Completely Confident	Very Frequently
7		Always

Robotics-Centered Curriculum (Spring 2007 – Spring 2008)

Findings

Common Item Comparisons

The common item comparisons shown in Table 4 include all data collected to date. This means that ENGR 120 contains responses from students in the old curriculum from the spring of 2007; ENGR 121 data contains responses from students in the old curriculum from the spring of 2007; and ENGR 122 data contains responses from students in the old curriculum from the spring of 2007. All data reported from the honors sections contains only student responses from "Living with the Lab."

When comparing student survey responses across courses, 10 statistically significant differences appeared on ratings of confidence in common course outcomes. These means can be seen in Table 4 on the following page.

- Students in ENGR 120 and 121 rated their confidence lower in their ability to "utilize the prescribed solution format when solving problems" than students in ENGR 122.
- Students in ENGR 120 and ENGR 121 rated their confidence lower in their ability to present the results of assignments and projects using oral communication lower than those students in ENGR 122 and ENGR 122H.
- Students in ENGR 120 rated their confidence lower in their ability to "generate 3D models of engineering components and assemblies using Solid Edge" than students in ENGR 120H, ENGR 121, ENGR 122 and ENGR 122H.
- Students in ENGR 120H rated their confidence higher in their ability to "present technical data in table and on graphs in a professional manner" than students in ENGR 120, ENGR 121, and ENGR 122. Students in ENGR 120 also rated their confidence less than those in ENGR 121.
- Students in ENGR 122 rated their confidence higher in "locate specifications and prices…" than students in ENGR 120 and ENGR 121. Students in ENGR 121 rated their confidence lower than students in ENGR 120, ENGR 120H, and ENGR 122.
- Students in ENGR 120H rated their confidence in their ability to "use linear regression analysis as appropriate in class projects" higher than students in ENGR 120, ENGR 121, ENGR 122 and ENGR 122H.
- Students in ENGR 120 rated their confidence in their ability to "utilize MathCAD to assist in solving engineering problems" less than students in ENGR 122. Students in ENGR 120H also rated their confidence on this item higher than students in ENGR 120 and ENGR 121. Students in ENGR 122 rated their confidence less than students in ENGR 120 and ENGR 122H.

- Students in ENGR 120 H rated their confidence in their ability to “utilize Excel to assist in solving engineering problems” higher than students in ENGR 122 and ENGR 121. Students in ENGR 120 also rated their confidence on this item higher than students in ENGR 121.
- Students in ENGR 121 and Honors ENGR 121 rated their confidence lower in their ability to “enjoy developing technical tools that improve the quality of life for people” than students in both sections of ENGR 120 and both sections of ENGR 122.
- Students in ENGR 122H rated their confidence in “using creative techniques to overcome at least one project difficulty” higher than students in ENGR 120 and ENGR 121. Students in ENGR 120H rated their confidence higher than students in ENGR 121.

It was initially hypothesized that students would become more confident in the common course outcomes as they were reinforced throughout the curriculum. This cannot currently be substantiated. There are a few instances when the confidence is statistically higher in the later course. This should be reexamined next year when we have more data. In addition, when there is more data for the “Living with the Lab” curriculum the data from the old curriculum should be removed from the common course comparisons. The encouraging news is that the confidence is relatively high throughout the curriculum.

Table 4: Common Course Outcome Confidence Means by Course

Item	ENGR 120	ENGR 120H	ENGR 121	ENGR 121H	ENGR 122	ENGR 122H	*Sig.
	A	B	C	D	E	F	
Utilize the prescribed solution format when solving problems.	5.12	5.49	5.02	5.25	5.46	5.44	E>AC
Work collaboratively with one or more other students.	5.31	5.34	5.19	4.94	5.43	5.50	
Present the results of assignments and projects using written communication.	4.98	5.31	4.89	5.00	5.02	5.13	
Present the results of assignments and projects using oral communication.	4.57	4.86	4.55	4.94	4.94	5.08	AC<EF
Generate 3D models of engineering components and assemblies using Solid Edge.	4.16	4.89	4.72	4.81	4.70	4.71	A<BCEF
Present technical data in tables and on graphs in a professional manner.	5.15	5.69	4.90	5.38	5.14	5.23	A>C B>ACE
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	4.80	5.26	4.44	4.88	5.18	4.94	C<ABE E>AC
Use linear regression analysis as appropriate in class projects.	4.70	5.46	4.62	5.25	4.65	4.51	B>ACEF
Utilize MathCAD to assist in solving engineering problems.	4.55	5.60	4.39	4.88	5.00	5.02	B>AC C<AF A<E
Utilize Excel to assist in solving engineering problems.	5.31	5.71	5.02	5.63	5.23	5.21	C<AB B>E
Use creative techniques to overcome at least one project difficulty.	4.79	5.20	4.63	4.81	4.92	5.21	C<BF F>A
When I set a goal, I keep going after it no matter what the obstacles.	5.10	5.29	5.09	5.06	5.17	5.31	
I enjoy developing technical tools that improve the quality of life for people.	5.14	5.35	5.07	5.44	5.02	5.25	
I intend to develop new products/processes during my career as an engineer.	5.04	5.23	4.88	5.19	5.21	5.02	

I prefer improving products/processes that already exist instead of developing something new.	4.55	4.46	4.38	4.00	4.40	4.56	
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	4.31	4.89	4.40	4.44	4.51	4.41	
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	4.42	5.54	3.86	5.06			

Notes: * indicates statistically significant difference between means.

There were 9 statistically significant differences on ratings of performance in common course outcomes. These means can be seen in Table 5 and are summarized below.

- Students in ENGR 120 rated the frequency of their performance in "work collaboratively with one or more other students" lower than students in ENGR 121, ENGR 122 and ENGR 122H. Students in ENGR 121H rated the frequency less than ENGR 122.
- Students in ENGR 120 reported the frequency of presenting the results of assignments and projects using oral communication less than students in ENGR 122 and ENGR 122 H.
- Students in Honors ENGR 120 rated the frequency of their performance in "generate 3D models of engineering components and assemblies using Solid Edge" higher than students in all other courses except ENGR 121H. Students in ENGR 121were greater than ENGR 122.
- Students in ENGR 121 and ENGR 121 H rated the frequency of their performance in "present technical data in tables and on graphs in a professional manner lower than students in ENGR 121, ENGR 122, and ENGR 122H.
- Students in ENGR 122 rated the frequency of their performance in "locate specifications and prices for the supplies, parts and systems used in course projects from manufactures and on-line retailers" higher than students in ENGR 120 and ENGR 121.
- Students in ENGR 122 and ENGR 122H rated the frequency of their performance in "Use linear regression analysis as appropriate in class projects" less than students in all other sections. Students in Honors ENGR 121 rated the frequency of their performance on this item less than students in ENGR 120H and ENGR 121H.
- Students in ENGR 120H rated the frequency of their performance in "utilize MathCAD to assist in solving engineering problems" higher than students in ENGR 120, ENGR 121, and ENGR 122.
- Students in ENGR 120 and ENGR 120H rated the frequency of their performance in "utilize Excel to assist in solving engineering problems" higher than students in ENGR 121, ENGR 122 and ENGR 122H.
- Students in ENGR 120 H reported their frequency of "enjoying the development of technical tools that improve the quality of life for people" greater than students in ENGR 121 and ENGR 122.

As with the confidence means, there is no clear trend in the frequency of performance means when analyzed by course. The frequency of performance should be analyzed when more data are available.

Table 5: Common Course Outcome Frequency of Performance Means by Course

Item	ENGR 120 A	ENGR 120H B	ENGR 121 C	ENGR 121H D	ENGR 122 E	ENGR 122H F	*Sig.
Utilize the prescribed solution format when solving problems.	5.66	5.83	5.50	5.81	5.70	5.56	
Work collaboratively with one or more other students.	5.03	5.31	5.55	5.00	5.83	5.87	A<CEF D<E

Present the results of assignments and projects using written communication.	5.15	5.57	5.25	5.69	5.02	5.08	
Present the results of assignments and projects using oral communication.	4.06	4.41	4.17	4.25	4.50	4.65	A<EF
Generate 3D models of engineering components and assemblies using Solid Edge.	4.49	5.34	4.54	4.38	4.11	4.27	B>ACEF C>E
Present technical data in tables and on graphs in a professional manner.	5.22	5.80	4.77	5.38	4.58	4.69	A>CEF B>CEF
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	3.91	4.54	3.96	4.69	4.54	4.40	E>AC
Use linear regression analysis as appropriate in class projects.	4.73	5.23	4.44	5.44	3.83	3.57	EF<ABCD C<BD
Utilize MathCAD to assist in solving engineering problems.	4.77	5.86	4.58	5.00	4.96	4.98	B>ACE
Utilize Excel to assist in solving engineering problems.	5.61	5.97	4.83	5.31	4.97	4.83	A>CEF B>CEF
Use creative techniques to overcome at least one project difficulty.	4.72	5.29	4.77	5.06	4.79	5.19	
When I set a goal, I keep going after it no matter what the obstacles.	5.50	5.71	5.50	5.75	5.44	5.79	
I enjoy developing technical tools that improve the quality of life for people.	4.96	5.48	4.60	4.94	4.58	4.81	B>CE
I intend to develop new products/processes during my career as an engineer.	4.98	5.30	4.82	5.19	5.00	5.06	
I prefer improving products/processes that already exist instead of developing something new.	4.56	4.64	4.57	4.94	4.72	4.83	
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	4.07	4.66	4.35	4.81	4.06	4.22	
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	4.57	5.86	3.67	4.44			

Notes: * indicates statistically significant difference between means.

Table 6 compares the baseline “Hands-0n” data obtained during the spring of 2006-07 with the values from the new “Living with the Lab” curriculum. The data do NOT contain values from honors courses. The ENGR 120 data comes from the fall, winter, and spring of 2007-08. The ENGR 121 data comes from the winter and spring of 2007-08. The ENGR 122 data comes from the spring of 2007-08. In order to emphasize the increases, cells where the value is more than 3 times greater in the “Living with the Lab” curriculum than in the old curriculum have been highlighted yellow. For ENGR 120, 8 out of

15 cells have been highlighted. For ENGR 121 15 out of 15 cells have been highlighted. For ENGR 122, 11 out of 15 cells have been highlighted. The results indicate that the "Living with the Lab" curriculum increases the "Hands-On" application significantly.

Table 6: "Hands-On" Application Means by Course and Quarter

Item	ENGR 120 Old	ENGR 120 New	ENGR 121 Old	ENGR 121 New	ENGR 122 Old	ENGR 122 New
Assembly	2.15	2.69	.55	7.84	3.10	11.11
Bending	1.04	0.70	.18	1.88	4.77	7.05
Cutting internal or external threads	.23	1.21	.02	6.01	.55	3.89
Drilling	1.81	2.33	.55	8.54	4.29	10.95
Implementing circuits on a breadboard	.04	11.49	.49	14.36	.62	15.84
Layout	1.35	1.77	.63	7.55	2.24	13.00
Milling	.34	1.87	.00	4.14	.09	3.73
Rapid Prototyping	.21	0.68	.00	0.91	.71	2.25
Sawing	1.52	0.31	.15	0.91	2.05	6.82
Soldering	.14	1.28	.05	4.14	2.17	5.71
Using a dial indicator	.07	3.83	.02	5.85	.17	6.22
Using a lathe	.24	0.45	.02	1.68	.06	1.42
Using a multimeter	.26	6.63	.33	6.72	2.28	6.38
Using a scale	4.12	2.37	1.06	8.53	3.59	15.71
Writing PBASIC programs	.00	15.64	.05	12.41	.02	11.89

ENGR 120 Survey Results

In addition to the 17 common course outcomes discussed above, students in ENGR 120 also rated their confidence and frequency of performance in 19 other course outcomes specific to ENGR 120. The means for all 36 outcomes for confidence are listed in Table 7. (Note that one question was deleted from the survey during the 2007-08 cycle.)

When examining the results listed in Table 7, it is important to remember that the data reported in the spring of 06-07 represents the old curriculum while the data reported in the 2007-08 academic year represents the new "Living with the Lab" curriculum. The confidence level of students in the old curriculum is statistically less than students in the new curriculum (B, C, D, and E) ***in 23 items:***

1. Generate 3D models of engineering components and assemblies using Solid Edge.
2. Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.
3. Use linear regression analysis as appropriate in class projects.
4. Utilize MathCAD to assist in solving engineering problems.
5. Utilize MathCAD to build functions, to solve sets of linear equations and to create plots.
6. Utilize Excel to assist in solving engineering problems.
7. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
8. Explain the origin of electric charge and define electric current, voltage, resistance, and power.
9. Compute current, resistance, voltage and power for circuits composed of resistors and DC power sources using Ohm's law and Kirchhoff's laws.

10. Identify and describe the purpose of each component on the BASIC Stamp II microcontroller.
11. Identify and describe the purpose of each component on the Board of Education.
12. Identify and describe the purpose of each component on Boe-Bot.
13. Convert between decimal numbers and binary numbers.
14. Explain how programs and variables are stored in EEPROM and RAM on the BASIC Stamp II microcontroller.
15. Implement whisker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
16. Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
17. Implement LED and piezospeaker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
18. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
19. Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.
20. Program a BASIC Stamp II microcontroller using the PBASIC language to control the frequency and duration of sound output from piezospeakers.
21. Fabricate a centrifugal pump driven by a DC motor with an impeller drawn in Solid Edge and printed on a rapid prototyping machine.
22. Utilize a multimeter to troubleshoot circuits and to measure the current, voltage and power usage of an electric pump.
23. Compute the efficiency and evaluate the performance of a centrifugal pump using DC circuit analysis, conservation of energy, and linear regression analysis.

In addition, students in section C, the Honors section during the Fall of 2007-08 were more confident than any of the other Living with the Lab sections in 7 categories:

1. Identify and describe the purpose of each component on Boe-Bot.
2. Convert between decimal numbers and binary numbers.
3. Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
4. Implement LED and piezospeaker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
5. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
6. Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.
7. Program a BASIC Stamp II microcontroller using the PBASIC language to control the frequency and duration of sound output from piezospeakers.

The 7 areas identified by the Honors section appear to be related to programming. Reasons for the increased confidence may be due to being designated as “Honors,” having greater academic potential, smaller class sections, or greater emphasis on programming. If desired, this difference can be explored in further years.

Finally, there were isolated cases where one section was significantly different than another. (Section C > Section E for Utilize the prescribed solution format when solving problems.) As there was no clear pattern to these cases, they are not discussed here.

The survey indicates that the Living with the Lab Curriculum has made a significant increase in the confidence of students to perform given tasks. In addition, there appears to be a link between frequency of performing a task and reporting confidence in one's ability to perform a task. All items that are statistically significant in the frequency of performance table are also statistically significant in the confidence table.

Table 7
ENGR 120 Specific Course Outcome Means - Confidence

Item	Spring 06-07	Fall 07-08	Fall 07-08H	Winter 07-08	Spring 07-08	*Sig
	A	B	C	D	E	
Utilize the prescribed solution format when solving problems.	5.00	5.16	5.49	5.23	4.88	C>E
Work collaboratively with one or more other students.	5.41	5.28	5.34	5.42	5.17	
Present the results of assignments and projects using written communication.	4.85	4.94	5.31	5.15	4.95	
Present the results of assignments and projects using oral communication.	4.39	4.48	4.86	4.72	4.79	
Generate 3D models of engineering components and assemblies using Solid Edge.	2.55	4.47	4.89	4.34	4.07	A<BCDE C>E
Present technical data in tables and on graphs in a professional manner.	4.76	5.18	5.69	5.32	5.07	C>ABE D>A
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	3.85	4.92	5.26	5.03	4.76	A<BCDE
Use linear regression analysis as appropriate in class projects.	3.58	4.84	5.46	4.78	5.00	A<BCDE C>BD
Utilize MathCAD to assist in solving engineering problems.	1.67	4.86	5.60	5.15	4.79	A<BCDE C>BE
Utilize MathCAD to build functions, to solve sets of linear equations and to create plots.	1.61	4.55	5.29	4.85	4.69	A<BCDE C>B
Utilize Excel to assist in solving engineering problems.	4.85	5.29	5.71	5.52	5.43	A<BCDE C>B
Create Excel spreadsheets using formulas and built-in functions and generate plots of the spreadsheet data.	5.00	5.37	5.77	5.52	5.24	A<CD C>E
Use creative techniques to overcome at least one project difficulty.	4.61	4.82	5.20	4.89	4.67	
When I set a goal, I keep going after it no matter what the obstacles.	4.97	5.13	5.29	5.20	4.93	
I enjoy developing technical tools that improve the quality of life for people.	4.88	5.10	5.35	5.30	5.21	
I intend to develop new products/processes during my career as an engineer.	4.82	4.95	5.23	5.23	5.24	
I prefer improving products/processes that already exist instead of developing something new.	4.28	4.56	4.46	4.85	4.26	
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	3.25	4.31	4.89	4.64	4.57	A<BCDE
Explain the origin of electric charge and define electric current, voltage, resistance, and power.	2.76	4.93	5.40	5.19	4.93	A<BCDE

Compute current, resistance, voltage and power for circuits composed of resistors and DC power sources using Ohm’s law and Kirchhoff’s laws.	2.58	5.28	5.69	5.38	5.12	A<BCDE
Compute the mean, median, standard deviation, and variance of a data set.	4.91					
Determine the best fit equation for a set of (x,y) data points, considering linear, power, polynomial and exponential functions.	4.88	5.24	5.66	5.05	5.05	C>ADE
Identify and describe the purpose of each component on the BASIC Stamp II microcontroller.	1.30	4.27	4.83	4.25	4.45	A<BCDE
Identify and describe the purpose of each component on the Board of Education.	1.56	4.27	4.91	4.05	4.17	A<BCDE C>BD
Identify and describe the purpose of each component on Boe-Bot.	1.21	4.34	5.06	4.22	4.29	A<BCDE C>BDE
Convert between decimal numbers and binary numbers.	2.79	4.74	5.66	4.91	4.71	A<BCDE C>BDE
Explain how programs and variables are stored in EEPROM and RAM on the BASIC Stamp II microcontroller.	1.55	4.19	4.51	4.41	4.36	A<BCDE
Implement whisker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.33	4.76	5.49	4.95	4.76	A<BCDE C>BE
Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.42	4.49	5.23	4.46	4.39	A<BCDE C>BDE
Implement LED and piezospeaker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.38	4.91	5.57	4.92	4.88	A<BCDE C>BDE
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	1.28	4.81	5.54	4.86	4.76	A<BCDE C>BDE
Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.	1.23	4.89	5.66	4.94	4.64	A<BCDE C>BDE
Program a BASIC Stamp II microcontroller using the PBASIC language to control the frequency and duration of sound output from piezospeakers.	1.26	4.91	5.51	4.83	4.67	A<BCDE C>BDE
Fabricate a centrifugal pump driven by a DC motor with an impeller drawn in Solid Edge and printed on a rapid prototyping machine.	1.42	5.12	5.23	5.08	4.98	A<BCDE
Utilize a mulitmeter to troubleshoot circuits and to measure the current, voltage and power usage of an electric pump.	1.58	4.77	5.26	4.85	4.74	A<BCDE
Compute the efficiency and evaluate the performance of a centrifugal pump using DC circuit analysis, conservation of energy, and linear regression analysis.	1.32	4.75	5.09	4.83	4.64	A<BCDE

In addition to rating their confidence, students in ENGR 120 also rated their frequency of performance in 19 other course outcomes specific to ENGR 120. (This gives a total of 36 items.) The means for these outcomes for performance are listed in Table 8. Comparison of the results from ENGR 120 A (old curriculum) to ENGR 120 B, C, D and E (Living with the Lab) reveals ***21 statistically significant*** items:

1. Generate 3D models of engineering components and assemblies using Solid Edge.
2. Use linear regression analysis as appropriate in class projects.
3. Utilize MathCAD to assist in solving engineering problems.
4. Utilize MathCAD to build functions, to solve sets of linear equations and to create plots.
5. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
6. Explain the origin of electric charge and define electric current, voltage, resistance, and power.
7. Compute current, resistance, voltage and power for circuits composed of resistors and DC power sources using Ohm's law and Kirchhoff's laws.
8. Identify and describe the purpose of each component on the BASIC Stamp II microcontroller.
9. Identify and describe the purpose of each component on the Board of Education.
10. Identify and describe the purpose of each component on Boe-Bot.
11. Convert between decimal numbers and binary numbers.
12. Explain how programs and variables are stored in EEPROM and RAM on the BASIC Stamp II microcontroller.
13. Implement whisker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
14. Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
15. Implement LED and piezospeaker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
16. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
17. Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.
18. Program a BASIC Stamp II microcontroller using the PBASIC language to control the frequency and duration of sound output from piezospeakers.
19. Fabricate a centrifugal pump driven by a DC motor with an impeller drawn in Solid Edge and printed on a rapid prototyping machine.
20. Utilize a multimeter to troubleshoot circuits and to measure the current, voltage and power usage of an electric pump.
21. Compute the efficiency and evaluate the performance of a centrifugal pump using DC circuit analysis, conservation of energy, and linear regression analysis.

In addition, there was one instance in which the Honors section, C, rated their frequency of performance greater than all of the other "Living with the Lab" sections (C, D, E). This was in the category of "Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos."

As noted above, there is a link between confidence and frequency of performance. All 21 of the items that were statistically significant in frequency of performance were also statistically significant in confidence. The only items that were statistically significant in confidence, but not in frequency of performance, were "Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers, and utilize Excel to assist in solving engineering problems." It is not unreasonable to assume that students might have performed these two tasks in other courses. It is interesting that the "Living with the Lab" sections have more confidence.

Table 8
ENGR 120 Specific Course Outcome Means - Performance

Item	Spring 06-07 A	Fall 07-08 B	Fall 07-08H C	Winter 07-08 D	Spring 07-08 E	*Sig
Utilize the prescribed solution format when solving problems.	5.66	5.70	5.83	5.85	5.19	E<BCD
Work collaboratively with one or more other students.	5.36	5.05	5.31	4.91	4.90	
Present the results of assignments and projects using written communication.	4.79	5.21	5.57	5.29	5.00	
Present the results of assignments and projects using oral communication.	3.91	4.05	4.41	3.97	4.36	
Generate 3D models of engineering components and assemblies using Solid Edge.	2.41	4.89	5.34	4.77	4.38	A<BCDE C>E
Present technical data in tables and on graphs in a professional manner.	4.53	5.42	5.80	5.40	4.79	A<BCD E<BC
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	3.15	4.04	4.54	3.91	4.10	A<BC
Use linear regression analysis as appropriate in class projects.	3.58	4.91	5.23	4.75	4.98	A<BCDE
Utilize MathCAD to assist in solving engineering problems.	1.32	5.21	5.86	5.42	5.05	A<BCDE C>BE
Utilize MathCAD to build functions, to solve sets of linear equations and to create plots.	1.44	4.80	5.40	4.94	4.98	A<BCDE
Utilize Excel to assist in solving engineering problems.	5.26	5.64	5.97	5.85	5.45	A<CD
Create Excel spreadsheets using formulas and built-in functions and generate plots of the spreadsheet data.	5.24	5.68	5.94	5.86	5.48	A<CD
Use creative techniques to overcome at least one project difficulty.	4.47	4.79	5.29	4.65	4.81	C>A
When I set a goal, I keep going after it no matter what the obstacles.	5.59	5.44	5.71	5.69	5.34	
I enjoy developing technical tools that improve the quality of life for people.	4.76	4.97	5.48	5.20	4.69	
I intend to develop new products/processes during my career as an engineer.	4.35	4.99	5.30	5.40	4.86	D>A
I prefer improving products/processes that already exist instead of developing something new.	4.12	4.58	4.64	4.87	4.38	
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	2.88	4.16	4.66	4.42	4.21	A<BCDE
Explain the origin of electric charge and define electric current, voltage, resistance, and power.	2.29	5.05	5.60	5.39	4.90	A<BCDE
Compute current, resistance, voltage and power for circuits composed of resistors and DC power sources using Ohm's law and Kirchhoff's laws.	2.38	5.42	5.94	5.63	5.55	A<BCDE
Compute the mean, median, standard deviation, and variance of a data set.	4.65					
Determine the best fit equation for a set of	4.82	5.27	5.71	5.20	5.26	C<A

(x,y) data points, considering linear, power, polynomial and exponential functions.						
Identify and describe the purpose of each component on the BASIC Stamp II microcontroller.	1.18	4.34	4.71	4.37	4.57	A<BCDE
Identify and describe the purpose of each component on the Board of Education.	1.15	4.37	4.77	4.11	4.26	A<BCDE
Identify and describe the purpose of each component on Boe-Bot.	1.18	4.43	4.89	4.08	4.45	A<BCDE C>D
Convert between decimal numbers and binary numbers.	2.47	4.52	5.11	4.57	4.50	A<BCDE
Explain how programs and variables are stored in EEPROM and RAM on the BASIC Stamp II microcontroller.	1.53	4.24	4.37	4.18	4.26	A<BCDE
Implement whisker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.18	4.67	5.31	4.77	4.76	A<BCDE
Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.24	4.54	5.11	4.58	4.74	A<BCDE
Implement LED and piezospeaker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.24	4.93	5.54	4.77	5.00	A<BCDE C>D
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	1.18	5.03	5.86	5.00	5.00	A<BCDE C>BDE
Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.	1.18	5.07	5.57	4.69	5.10	A<BCDE
Program a BASIC Stamp II microcontroller using the PBASIC language to control the frequency and duration of sound output from piezospeakers.	1.15	4.99	5.51	4.69	4.90	A<BCDE C>D
Fabricate a centrifugal pump driven by a DC motor with an impeller drawn in Solid Edge and printed on a rapid prototyping machine.	1.15	4.82	4.71	4.53	4.60	A<BCDE
Utilize a mulitmeter to troubleshoot circuits and to measure the current, voltage and power usage of an electric pump.	1.39	4.66	5.03	4.63	4.83	A<BCDE
Compute the efficiency and evaluate the performance of a centrifugal pump using DC circuit analysis, conservation of energy, and linear regression analysis.	1.21	4.57	4.89	4.58	4.81	A<BCDE

Table 9 contains the tabulations of the “Hands-On” application means by quarter. Examination of the table indicates that the students in the old curriculum reported more sawing than those in the “Living with the Lab” sections. The “Living with the Lab” sections reported a statistically greater frequency in cutting threads, implementing circuits on a breadboard, soldering, using a dial indicator, using a multimeter, and writing PBASIC programs. It should be noted that the method for reporting the value for “hands-on” application changed after Spring 06-07. In the spring 06-07, students were asked to report a number. Beginning in the fall of 07-08, students were asked to report a range. Even with the change in the method of reporting data, the “Living with the Lab” curriculum reported a statistically greater “hands-on” application in 7 of the 15 items.

Table 9
"Hands-On" Application Means by Quarter for ENGR 120

Item	Spring 06-07 A	Fall 07-08 B	Fall 07-08H C	Winter 07-08 D	Spring 07-08 E	* Sig.
Assembly	2.15	2.20	2.11	3.62	2.98	D>B
Bending	1.04	.44	.69	.82	1.38	
Cutting internal or external threads	.23	1.07	.66	1.35	1.48	A<BCDE C<DE
Drilling	1.81	2.01	2.31	2.92	2.55	
Implementing circuits on a breadboard	.04	11.67	15.69	9.77	13.48	A<BCDE C>D
Layout	1.35	1.57	1.63	1.63	2.69	
Milling	.34	1.57	1.51	2.26	2.29	A<BDE
Rapid Prototyping	.21	.56	.66	.89	.76	
Sawing	1.52	.13	.06	.42	.76	A>BCDE
Soldering	.14	1.24	1.29	1.35	1.31	A<BCDE
Using a dial indicator	.07	4.37	5.37	2.95	3.31	A<BCDE C>D
Using a lathe	.24	.23	.11	.38	1.33	E>ABCD
Using a multimeter	.26	6.39	8.66	6.25	8.02	A<BCDE C>B
Using a scale	4.12	1.73	1.83	2.31	4.67	E>BCD
Writing PBASIC programs	.00	15.71	20.29	14.98	16.40	A<BCDE

Notes: * indicates statistically significant difference between means.

ENGR 121 Survey Results

In addition to the 17 common course outcomes discussed earlier, students in ENGR 121 also rated their confidence and frequency of performance in 12 other course outcomes specific to ENGR 121. The means for all 29 outcomes when considering confidence are listed below in Table 10. In Table 10, the Spring 06-07 data represents the old curriculum and the other sections (B & C) represent the "Living with the Lab" sections. The "Living with the Lab" sections reported statistically higher confidence in ***16 items:***

1. Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.
2. Use linear regression analysis as appropriate in class projects.
3. Utilize Excel to assist in solving engineering problems.
4. I enjoy developing technical tools that improve the quality of life for people.
5. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
6. Compute quantities such as iron concentration, mass of reactants and products, and electrical current for a salt water mixture undergoing oxidation/reduction reactions due to the presence of a conductivity probe.
7. Apply conservation of energy to a small volume of water that is heated using an electrical resistance heater, computing quantities such as heater wattage, temperature change, and heating time.
8. Design an electrical resistance heater to heat a small volume of water in a specified period of time, where the design involves choosing the gage and length of a segment wire.

9. Evaluate the compatibility of electrical components and devices (transistors, solenoid valves, heaters, pumps, sensors) with the BASIC Stamp II microcontroller, the Board of Education and with external power supplies.
10. Implement cascaded switching circuits consisting of transistors and relays to allow the BASIC Stamp II microcontroller to turn external components on and off.
11. Implement RC circuits and PBASIC programs to interface the BASIC Stamp II microcontroller with sensors.
12. Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.
13. Design a nickel-based RTD by computing the width and length of the resistor and by drawing the chosen resistor layout using Solid Edge.
14. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
15. Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.
16. Troubleshoot, test, and validate a system where the temperature and salinity of a small fluid volume are measured and controlled.

Table 10
ENGR 121 Specific Course Outcome Means - Confidence

Item	Spring 06-07	Winter 07-08	Spring 07-08	*Sig
	A	B	C	
Utilize the prescribed solution format when solving problems.	5.14	5.04	4.86	
Work collaboratively with one or more other students.	5.20	5.24	5.08	
Present the results of assignments and projects using written communication.	4.88	4.89	4.90	
Present the results of assignments and projects using oral communication.	4.50	4.46	4.80	
Generate 3D models of engineering components and assemblies using Solid Edge.	4.54	4.82	4.70	
Present technical data in tables and on graphs in a professional manner.	4.66	4.98	5.00	
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	3.17	4.90	4.82	A < B & C
Use linear regression analysis as appropriate in class projects.	3.98	4.82	4.90	A < B & C
Utilize MathCAD to assist in solving engineering problems.	4.11	4.37	4.74	A < C
Utilize Excel to assist in solving engineering problems.	4.64	5.14	5.16	A < B & C
Use creative techniques to overcome at least one project difficulty.	4.45	4.77	4.56	
When I set a goal, I keep going after it no matter what the obstacles.	5.05	5.10	5.10	
I enjoy developing technical tools that improve the quality of life for people.	4.77	5.18	5.20	A < B & C
I intend to develop new products/processes during my career as an engineer.	4.57	4.99	5.00	
I prefer improving products/processes that already exist instead of developing something new.	4.63	4.31	4.24	
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	3.51	4.73	4.59	A < B & C

Compute the molarity, concentration, and mass of the constituents in a salt water mixture.	4.33	4.64	4.92	A < C
Compute quantities such as iron concentration, mass of reactants and products, and electrical current for a salt water mixture undergoing oxidation/reduction reactions due to the presence of a conductivity probe.	3.06	4.29	4.41	A < B & C
Apply conservation of mass to batch and rate problems to compute the inputs, outputs and changes of system constituents.	3.94	4.37	4.86	C > A & B
Apply conservation of energy to a small volume of water that is heated using an electrical resistance heater, computing quantities such as heater wattage, temperature change, and heating time.	2.92	4.49	4.68	A < B & C
Design an electrical resistance heater to heat a small volume of water in a specified period of time, where the design involves choosing the gage and length of a segment wire.	2.24	4.18	4.44	A < B & C
Evaluate the compatibility of electrical components and devices (transistors, solenoid valves, heaters, pumps, sensors) with the BASIC Stamp II microcontroller, the Board of Education and with external power supplies.	2.04	4.34	4.54	A < B & C
Implement cascaded switching circuits consisting of transistors and relays to allow the BASIC Stamp II microcontroller to turn external components on and off.	1.92	4.46	4.64	A < B & C
Implement RC circuits and PBASIC programs to interface the BASIC Stamp II microcontroller with sensors.	1.60	4.30	4.46	A < B & C
Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.	1.48	4.64	4.70	A < B & C
Design a nickel-based RTD by computing the width and length of the resistor and by drawing the chosen resistor layout using Solid Edge.	1.62	4.59	5.02	A < B & C
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	1.52	4.65	4.58	A < B & C
Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.	1.54	4.63	4.60	A < B & C
Troubleshoot, test, and validate a system where the temperature and salinity of a small fluid volume are measured and controlled.	1.70	4.42	4.55	A < B & C

The reported frequency of performance for all 29 outcomes is listed below in Table 11. The frequency for the “Living with the Lab” sections is statistically higher for the following 21 items:

1. Present technical data in tables and on graphs in a professional manner.
2. Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.
3. Use linear regression analysis as appropriate in class projects.
4. Use creative techniques to overcome at least one project difficulty.
5. When I set a goal, I keep going after it no matter what the obstacles.
6. I intend to develop new products/processes during my career as an engineer.
7. I prefer improving products/processes that already exist instead of developing something new.
8. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
9. Compute the molarity, concentration, and mass of the constituents in a salt water mixture.

10. Compute quantities such as iron concentration, mass of reactants and products, and electrical current for a salt water mixture undergoing oxidation/reduction reactions due to the presence of a conductivity probe.
11. Apply conservation of mass to batch and rate problems to compute the inputs, outputs and changes of system constituents.
12. Apply conservation of energy to a small volume of water that is heated using an electrical resistance heater, computing quantities such as heater wattage, temperature change, and heating time.
13. Design an electrical resistance heater to heat a small volume of water in a specified period of time, where the design involves choosing the gage and length of a segment wire.
14. Evaluate the compatibility of electrical components and devices (transistors, solenoid valves, heaters, pumps, sensors) with the BASIC Stamp II microcontroller, the Board of Education and with external power supplies.
15. Implement cascaded switching circuits consisting of transistors and relays to allow the BASIC Stamp II microcontroller to turn external components on and off.
16. Implement RC circuits and PBASIC programs to interface the BASIC Stamp II microcontroller with sensors.
17. Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.
18. Design a nickel-based RTD by computing the width and length of the resistor and by drawing the chosen resistor layout using Solid Edge.
19. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
20. Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.
21. Troubleshoot, test, and validate a system where the temperature and salinity of a small fluid volume are measured and controlled.

There is a link between confidence and frequency of performance. There were 16 items where students reported statistically greater confidence in their ability in the "Living with the Labs" sections. 14 of those items were statistically greater in the frequency of performance table as well.

Table 11
ENGR 121 Specific Course Outcome Means - Performance

Item	Spring 06-07	Winter 07-08	Spring 07-08	*Sig.
	A	B	C	
Utilize the prescribed solution format when solving problems.	5.71	5.47	5.30	
Work collaboratively with one or more other students.	5.46	5.64	5.48	
Present the results of assignments and projects using written communication.	5.04	5.40	5.16	
Present the results of assignments and projects using oral communication.	3.91	4.26	4.28	
Generate 3D models of engineering components and assemblies using Solid Edge.	4.27	4.65	4.64	
Present technical data in tables and on graphs in a professional manner.	4.29	4.84	5.16	A < B & C
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	2.11	4.58	4.64	A < B & C
Use linear regression analysis as appropriate in class	3.65	4.66	4.84	A < B & C

projects.				
Utilize MathCAD to assist in solving engineering problems.	4.71	4.36	4.88	B < C
Utilize Excel to assist in solving engineering problems.	4.11	5.06	5.16	
Use creative techniques to overcome at least one project difficulty.	3.95	5.04	5.14	A < B & C
When I set a goal, I keep going after it no matter what the obstacles.	4.89	5.79	5.56	A < B & C
I enjoy developing technical tools that improve the quality of life for people.	4.21	4.76	4.68	
I intend to develop new products/processes during my career as an engineer.	4.17	5.12	4.90	A < B & C
I prefer improving products/processes that already exist instead of developing something new.	4.10	4.72	4.76	A < B & C
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	3.04	4.82	4.63	A < B & C
Compute the molarity, concentration, and mass of the constituents in a salt water mixture.	3.85	5.06	5.35	A < B & C
Compute quantities such as iron concentration, mass of reactants and products, and electrical current for a salt water mixture undergoing oxidation/reduction reactions due to the presence of a conductivity probe.	2.83	4.69	4.86	A < B & C
Apply conservation of mass to batch and rate problems to compute the inputs, outputs and changes of system constituents.	3.76	4.87	5.16	A < B & C
Apply conservation of energy to a small volume of water that is heated using an electrical resistance heater, computing quantities such as heater wattage, temperature change, and heating time.	2.46	4.48	4.90	A < B & C
Design an electrical resistance heater to heat a small volume of water in a specified period of time, where the design involves choosing the gage and length of a segment wire.	1.90	3.56	4.16	A < B & C
Evaluate the compatibility of electrical components and devices (transistors, solenoid valves, heaters, pumps, sensors) with the BASIC Stamp II microcontroller, the Board of Education and with external power supplies.	1.86	4.86	5.06	A < B & C
Implement cascaded switching circuits consisting of transistors and relays to allow the BASIC Stamp II microcontroller to turn external components on and off.	1.67	4.79	4.92	A < B & C
Implement RC circuits and PBASIC programs to interface the BASIC Stamp II microcontroller with sensors.	1.40	4.76	4.84	A < B & C
Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.	1.34	4.53	4.44	A < B & C
Design a nickel-based RTD by computing the width and length of the resistor and by drawing the chosen resistor layout using Solid Edge.	1.30	4.01	4.38	A < B & C
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	1.32	4.41	4.52	A < B & C
Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.	1.28	4.30	4.64	A < B & C
Troubleshoot, test, and validate a system where the temperature and salinity of a small fluid volume are measured and controlled.	1.34	4.53	4.88	A < B & C

Table 12 contains the reported results for number of times that students performed various operations in ENGR 121. Section A (old curriculum) is significantly less than sections B & C (Living with the Lab) for ***every item***. It should be noted that the method for reporting the value for "hands-on" application changed after Spring 06-07. In the spring 06-07, students were asked to report a number. Beginning in the fall of 07-08, students were asked to report a range. Table 12 indicates that the Living with the Lab significantly increased the "hands-on" application.

Table 12
"Hands-On" Application Means by Quarter ENGR121

Item	Spring 06-07	Winter 07-08	Winter 07-08H	Spring 07-08
	A	B		C
Assembly	0.50	7.84	5.75	9.06
Bending	0.18	1.88	1.69	3.24
Cutting internal or external threads	0.02	6.01	5.69	5.76
Drilling	0.55	8.54	6.63	8.48
Implementing circuits on a breadboard	0.49	14.36	16.69	13.94
Layout	0.63	7.55	6.88	8.14
Milling	0.00	4.14	5.00	4.74
Rapid Prototyping	0.00	0.91	0.13	2.66
Sawing	0.15	0.91	0.13	3.18
Soldering	0.05	3.68	1.94	4.96
Using a dial indicator	0.02	5.85	2.81	4.84
Using a lathe	0.02	1.68	2.06	3.20
Using a multimeter	0.33	6.72	4.63	7.68
Using a scale	1.06	8.53	6.19	9.96
Writing PBASIC programs	0.05	12.41	15.81	14.30

ENGR 122 Survey Results

In addition to the 16 common course outcomes discussed earlier, students in ENGR 122 also rated their confidence and frequency of performance in 16 other course outcomes specific to ENGR 122. The means for these outcomes are listed on the following pages in Table 14 and 15 respectively.

Students in ENGR 122 were also asked to list the 5 steps in the IDEO design methodology and to list the "Seven Secrets for Better Brainstorming." Results from the spring of 2007 and 2008 are shown in Table 13. In 2007, the Honors section was the "Living with the Lab" group. In 2008, both the Honors Section and the Traditional Section were "Living with the Lab" groups. Several comparisons can be made:

1. In 2007, the honors sections performed significantly better than the traditional section. This was expected because the traditional section did not cover the material.
2. The 2008 honors section performed better than the 2007 honors section. This was not expected.
3. The 2008 traditional sections performed significantly better than the 2007 traditional sections. This was expected because the 2007 group did not cover the material.
4. The results for the honors and traditional sections in 2008 are much closer than the results between honors and traditional sections in 2007.
5. All students in all sections perform better on the 5 steps than the "Seven Secrets"

Table 13
ENGR 122 Number of Steps Correct Spring 2007

Number Correct	IDEO		Seven Secrets	
	Honors	Traditional – Old Curriculum	Honors	Traditional – Old Curriculum
0	42%	99%	83%	100%
1	0%	1%	0%	0%
2	4%	0%	4%	0%
3	4%	0%	4%	0%
4	8%	0%	0%	0%
5	42%	0%	0%	0%
6			0%	0%
7			8%	0%

ENGR 122 Number of Steps Correct Spring 2008

Number Correct	IDEO		Seven Secrets	
	Honors	Traditional	Honors	Traditional
0	11%	21%	57%	55%
1	0%	0%	7%	3%
2	0%	5%	4%	5%
3	0%	3%	0%	9%
4	21%	7%	21%	14%
5	68%	64%	7%	12%
6			0%	0%
7			4%	2%

Table 14 shows the comparison between the old curriculum for ENGR 122 (A: Spring 06-07) and the "Living with the Lab" (B, C, D) curriculum on all course outcomes. Students in the new curriculum have confidence means that are statistically higher for the following ***13 items*:**

1. Apply the principles of electrical circuits, statics and conservation of energy to evaluate the efficiency of a motor/gearbox system, computing quantities such as electrical power usage, mechanical power output, torque and angular velocity.
2. Implement an infrared LED/receiver circuit (IR pair) to detect objects.
3. Implement a Hall-effect sensor circuit as a proximity sensor.
4. List the specifications and PBASIC commands to interface selected sensors to the BASIC Stamp II microcontroller.
5. Explain the physics behind how sensors function.
6. Explain the roles of the ten "Faces of Innovation" as discussed in "The Ten Faces of Innovation" by Tom Kelley.
7. Create a Mind Map to organize ideas around a central topic.
8. Apply the Pugh method to evaluate concept ideas.
9. Conceive a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.
10. Design a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.
11. Fabricate a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.

12. Test a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.
13. Develop a work plan to manage your time and resources to successfully produce a prototype of an innovative product.

Table 14
ENGR 122 Specific Course Outcome Means - Confidence

Item	Spring 06-07 A	Spring 06-07H B	Spring 07-08 C	Spring 07-08H D	*Sig.
Utilize the prescribed solution format when solving problems.	5.33	5.63	5.38	5.75	
Work collaboratively with one or more other students.	5.51	5.63	5.36	5.36	
Present the results of assignments and projects using written communication.	4.91	5.00	5.11	5.32	
Present the results of assignments and projects using oral communication.	4.88	5.13	4.93	5.21	
Generate 3D models of engineering components and assemblies using Solid Edge.	4.52	4.38	4.88	5.07	D>B
Generate 3D models of an innovative product using Solid Edge.	4.47	3.54	4.68	4.71	B<ACD
Present technical data in tables and on graphs in a professional manner.	4.89	5.58	5.14	5.50	B >A
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	4.92	5.50	5.13	5.18	
Purchase supplies and parts for an innovative product.	5.23	4.92	4.98	5.18	
Use linear regression analysis as appropriate in class projects.	4.05	5.13	4.80	5.11	BD>A
Utilize MathCAD to assist in solving engineering problems.	4.92	5.08	4.96	5.21	
Utilize Excel to assist in solving engineering problems.	5.06	5.63	5.15	5.43	B>A
Use creative techniques to overcome at least one project difficulty.	4.97	5.00	4.91	5.29	
When I set a goal, I keep going after it no matter what the obstacles.	5.28	5.04	5.18	5.25	
I enjoy developing technical tools that improve the quality of life for people.	4.77	5.00	5.40	5.29	C>A
I intend to develop new products/processes during my career as an engineer.	5.11	4.00	5.29	5.11	
I prefer improving products/processes that already exist instead of developing something new.	4.65	4.83	4.00	4.54	AB>C
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	3.97	4.96	4.76	4.71	B>A
Apply statics to determine resultants of force systems.	4.92	5.43	4.89	5.14	B>A
Apply statics to determine unknown forces and moments for concurrent and non-concurrent force systems.	4.79	5.22	4.69	5.11	
Apply the principles of electrical circuits, statics and conservation of energy to evaluate the efficiency of a motor/gearbox system, computing quantitites such as electrical power usage, mechanical power output, torque and angular velocity.	3.85	5.13	4.71	4.85	A<BCD
Compute present worth, future worth, and annuity schedules to perform engineering economic analyses.	5.36	4.00	4.93	4.71	A>B
Implement an infrared LED/receiver circuit (IR pair) to detect objects.	1.95	5.39	4.78	5.18	A<BCD
Implement a Hall-effect sensor circuit as a proximity sensor.	1.68	4.83	3.07	2.71	A<BCD
List the specifications and PBASIC commands to interface	1.30	5.17	4.85	5.00	A<BCD

selected sensors to the BASIC Stamp II microcontroller.					
Explain the physics behind how sensors function.	1.86	4.74	4.51	4.46	A<BCD
Explain the roles of the ten “Faces of Innovation” as discussed in “The Ten Faces of Innovation” by Tom Kelley.	1.62	4.13	4.51	4.39	A<BCD
Create a Mind Map to organize ideas around a central topic.	2.67	3.96	5.07	4.82	A<BCD
Apply the Pugh method to evaluate concept ideas.	1.48	4.87	4.38	4.39	A<BCD
Conceive a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.	1.62	5.09	5.00	5.00	A<BCD
Design a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.	1.61	5.17	4.88	4.82	A<BCD
Fabricate a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.	1.62	5.04	4.95	5.00	A<BCD
Test a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.	1.68	5.09	4.98	5.11	A<BCD
Develop a work plan to manage your time and resources to successfully produce a prototype of an innovative product.	4.02	4.74	4.80	4.79	

Table 15 shows all course outcome means for frequency of performance in ENGR 122. The “Living with the Lab” curriculum (B, C, D) is significantly higher than the old curriculum (A) for the following ***13 items:***

1. Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.
2. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
3. Apply the principles of electrical circuits, statics and conservation of energy to evaluate the efficiency of a motor/gearbox system, computing quantities such as electrical power usage, mechanical power output, torque and angular velocity
4. Implement an infrared LED/receiver circuit (IR pair) to detect objects.
5. List the specifications and PBASIC commands to interface selected sensors to the BASIC Stamp II microcontroller.
6. Explain the physics behind how sensors function.
7. Explain the roles of the ten “Faces of Innovation” as discussed in “The Ten Faces of Innovation” by Tom Kelley.
8. Create a Mind Map to organize ideas around a central topic.
9. Apply the Pugh method to evaluate concept ideas.
10. Conceive a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.
11. Design a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.
12. Fabricate a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.
13. Test a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.

There is a link between confidence and frequency of performance as reported by the students in ENGR 122. 10 of the 13 items that are statistically significant in Table 15 are also statistically significant in Table 14.

Table 15
ENGR 122 Specific Course Outcome Means - Performance

Item	Spring 06-07 A	Spring 06-07H B	Spring 07-08 C	Spring 07-08H D	*Sig.
Utilize the prescribed solution format when solving problems.	5.23	6.25	5.75	5.96	B>A
Work collaboratively with one or more other students.	5.98	6.08	5.70	5.57	
Present the results of assignments and projects using written communication.	4.50	5.25	5.32	5.54	A<CD
Present the results of assignments and projects using oral communication.	4.11	5.00	4.73	4.82	B>A
Generate 3D models of engineering components and assemblies using Solid Edge.	4.14	3.54	4.38	4.32	
Generate 3D models of an innovative product using Solid Edge.	3.59	3.42	4.07	3.64	
Present technical data in tables and on graphs in a professional manner.	4.00	5.38	4.78	5.07	BD>A
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	3.70	5.00	4.96	5.04	A<BCD
Purchase supplies and parts for an innovative product.	4.23	4.25	4.35	4.46	
Use linear regression analysis as appropriate in class projects.	3.25	4.43	4.00	3.86	B>A
Utilize MathCAD to assist in solving engineering problems.	4.97	4.96	4.82	5.25	
Utilize Excel to assist in solving engineering problems.	4.44	5.46	5.13	5.21	B>A
Use creative techniques to overcome at least one project difficulty.	4.56	5.00	5.04	5.39	D>A
When I set a goal, I keep going after it no matter what the obstacles.	5.53	5.33	5.55	5.75	
I enjoy developing technical tools that improve the quality of life for people.	4.11	4.92	5.00	5.00	
I intend to develop new products/processes during my career as an engineer.	4.60	4.91	5.42	5.29	C>A
I prefer improving products/processes that already exist instead of developing something new.	4.46	4.35	5.05	5.18	
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	3.28	4.87	4.58	4.46	A<BCD
Apply statics to determine resultants of force systems.	4.91	5.35	5.25	5.29	
Apply statics to determine unknown forces and moments for concurrent and non-concurrent force systems.	4.73	5.00	5.18	5.25	
Apply the principles of electrical circuits, statics and conservation of energy to evaluate the efficiency of a motor/gearbox system, computing quantitites such as electrical power usage, mechanical power output, torque and angular velocity.	3.71	5.30	4.75	4.93	A<BCD
Compute present worth, future worth, and annuity schedules to perform engineering economic analyses.	5.14	4.65	5.09	5.00	
Implement an infrared LED/receiver circuit (IR pair) to detect objects.	1.71	5.35	4.36	4.39	A<BCD
Implement a Hall-effect sensor circuit as a proximity sensor.	1.52	4.30	2.31	2.14	A<B
List the specifications and PBASIC commands to interface selected sensors to the BASIC Stamp II microcontroller.	1.27	5.04	5.27	5.46	A<BCD
Explain the physics behind how sensors function.	1.56	5.04	4.55	4.32	A<BCD
Explain the roles of the ten “Faces of Innovation” as discussed in “The Ten Faces of Innovation” by Tom Kelley.	1.48	4.17	4.02	3.54	A<BCD
Create a Mind Map to organize ideas around a central topic.	2.09	2.96	4.11	3.71	A<BCD
Apply the Pugh method to evaluate concept ideas.	1.35	3.65	3.69	3.25	A<BCD

Conceive a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.	1.33	5.17	4.89	4.82	A<BCD
Design a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.	1.32	5.09	4.76	4.54	A<BCD
Fabricate a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.	1.27	5.09	4.73	4.64	A<BCD
Test a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.	1.32	5.04	4.98	5.11	A<BCD
Develop a work plan to manage your time and resources to successfully produce a prototype of an innovative product.	3.61	4.39	4.82	4.68	

Table 16 is a comparison between the reported "Hands-On" activities between 06-07 and 07-08. Spring 06-07 is the old curriculum. Spring 06-07H, Spring 07-08, and Spring 07-08H are all the "Living with the Lab" curriculum. The data has not been adjusted to take into account the difference between the surveys during the spring of 06-07 and 07-08. Because this adjustment has not been made, it is not possible to determine statistical significance; however, the increase in "Hands-On" application is striking when comparing the old curriculum to the new curriculum. Of the 15 items, ***10 of the items are more than 3 times greater than the old curriculum for all sections.***

Table 16
"Hands-On" Application Means by Quarter for ENGR 122

Item	Spring 06-07	Spring 06-07H	Spring 07-08	Spring 07-08H
	A	B	C	D
Assembly	3.10	11.19	11.11	11.64
Bending	4.77	3.32	7.05	4.25
Cutting internal or external threads	0.55	1.62	3.89	1.29
Drilling	4.29	13.14	10.95	7.14
Implementing circuits on a breadboard	0.62	21.73	15.84	1.86
Layout	2.24	10.05	13.00	8.68
Milling	.09	.36	3.73	2.93
Rapid Prototyping	.71	.30	2.25	1.21
Sawing	2.05	7.77	6.82	4.21
Soldering	2.17	13.83	5.71	3.50
Using a dial indicator	.17	2.71	6.22	1.89
Using a lathe	.06	1.17	1.42	.93
Using a multimeter	2.28	3.55	6.38	3.11
Using a scale	3.59	2.27	15.71	10.79
Writing PBASIC programs	0.02	20.23	11.89	11.71

Table 17 shows the ratings for confidence and performance for the ENGR 122 sections. The confidence anchor is rated on a scale of 1-6 and the frequency anchor is rated on a scale of 1-7. Students are most confident in their ability to use the prescribed solution format when solving problems and this is also the highest rated performance item. In addition, the prescribed solution format is introduced in ENGR 120 and continued in ENGR 121 and ENGR 122. At this time, the amount of reinforcement necessary to keep student confidence high is not apparent. This is a possibility for study in future work.

Table 17
Comparison between Confidence and Performance for ENGR 122, Academic Year 07-08

Item	Confidence	Performance
	ENGR 122	ENGR 122
Utilize the prescribed solution format when solving problems.	5.59	5.65
Work collaboratively with one or more other students.	5.38	5.62
Present the results of assignments and projects using written communication.	5.09	5.15
Present the results of assignments and projects using oral communication.	5.03	4.68
Generate 3D models of engineering components and assemblies using Solid Edge.	4.88	4.24
Generate 3D models of an innovative product using Solid Edge.	4.74	3.94
Present technical data in tables and on graphs in a professional manner.	5.15	4.76
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	5.32	4.88
Purchase supplies and parts for an innovative product.	4.97	4.41
Use linear regression analysis as appropriate in class projects.	4.76	3.74
Utilize MathCAD to assist in solving engineering problems.	4.94	4.62
Utilize Excel to assist in solving engineering problems.	5.12	5.03
Use creative techniques to overcome at least one project difficulty.	4.94	4.94
When I set a goal, I keep going after it no matter what the obstacles.	5.21	5.56
I enjoy developing technical tools that improve the quality of life for people.	5.38	4.79
I intend to develop new products/processes during my career as an engineer.	5.24	5.35
I prefer improving products/processes that already exist instead of developing something new.	3.79	5.03
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	4.74	4.44
Apply statics to determine resultants of force systems.	4.79	5.18
Apply statics to determine unknown forces and moments for concurrent and non-concurrent force systems.	4.68	5.00
Apply the principles of electrical circuits, statics and conservation of energy to evaluate the efficiency of a motor/gearbox system, computing quantitites such as electrical power usage, mechanical power output, torque and angular velocity.	4.65	4.59
Compute present worth, future worth, and annuity schedules to perform engineering economic analyses.	4.82	5.06
Implement an infrared LED/receiver circuit (IR pair) to detect objects.	4.82	4.38
Implement a Hall-effect sensor circuit as a proximity sensor.	3.18	2.29
List the specifications and PBASIC commands to interface selected sensors to the BASIC Stamp II microcontroller.	5.00	5.26
Explain the physics behind how sensors function.	4.50	4.44
Explain the roles of the ten “Faces of Innovation” as discussed in “The Ten Faces of Innovation” by Tom Kelley.	4.41	3.85
Create a Mind Map to organize ideas around a central topic.	5.15	3.97
Apply the Pugh method to evaluate concept ideas.	4.44	3.74
Conceive a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.	5.15	4.85
Design a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices, and the BASIC Stamp II microcontroller.	4.94	4.74
Fabricate a functional prototype of an innovative product that utilizes	5.12	4.74

one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.		
Test a functional prototype of an innovative product that utilizes one or more sensors, actuators, or other output devices, and the BASIC Stamp II microcontroller.	5.12	4.97
Develop a work plan to manage your time and resources to successfully produce a prototype of an innovative product.	4.88	4.74

Professional Society Meetings and Student-Led Functions

All students in ENGR 120, 121, and 122 were asked to indicate the number professional society meetings and student-led functions they attended each quarter. The average of those responses is listed in Table 18 below. The meetings and functions are listed alphabetically and the number of students listing each function is broken down by course and quarter.

This data does not appear to be valid. In the fall and winter quarters, a significant number of students left the question blank. Either they did not notice the questions or they were tired of completing the survey. Individual instructors do keep count of the number of events that students attend. The data would be more accurate if it could be linked to what the students actually report during the quarter. Ways of automating this data collection should be considered to reduce the load on individual instructors.

Table 18
Professional Society Meetings and Student-Led Functions

Count			Meeting/Function
Fall 08	**Winter 08**	**Spring 08**	
120 – 7	120 – 8	120 – 13	American Chemical Society (ACS)
	121 – 3	121 – 3	
		122 – 8	
120 - 15	120 – 1	120 – 16	American Institute of Chemical Engineers (AIChE)
	121 – 1	121 – 6	
		122 – 5	
120 – 30	120 – 0	120 – 6	American Society of Civil Engineers (ASCE)
	121 – 0	121 – 5	
		122 – 2	
120 - 38	120 – 1	120 – 3	American Society of Mechanical Engineers (ASME)
	121 – 1	121 – 5	
		122 – 0	
120 – 20	120 – 1	120 – 0	COES project meetings/workdays (Steel Bridge, Concrete Canoe, etc)
	121 – 2	121 – 6	
		122 – 3	
120 – 8	120 – 0	120 – 1	Biomedical Engineering Society (BMES)
	121 – 0	121 – 13	
		122 – 0	
120 – 61	120 – 0	120 – 0	COES Events (Christmas Party, Gumbofest, etc.)
	121 – 5	121 – 5	
		122 – 0	
120 – 7	120 – 0	120 – 1	COES Speaker
	121 – 0	121 – 9	
		122 – 3	
120 – 7	120 – 1	120 – 0	Engineering and Science Association (ESA)
	121 – 0	121 – 24	
		122 – 0	
120 – 9	120 – 0	120 – 3	Institute of Electrical and Electronics Engineers (IEEE)

	121 – 0	121 – 0	
		122 – 4	
120 – 10	120 – 0	120 – 0	Institute of Industrial Engineers (IIE)
	121 – 0	121 – 0	
		122 – 1	
120 – 14	120 – 0	120 – 0	National Society of Black Engineers (NSBE)
	121 – 1	121 – 0	
		122 – 2	
120 – 7	120 – 1	120 – 0	Society of Automotive Engineers (SAE)
	121 – 3	121 – 0	
		122 – 2	
120 – 6	120 – 3	120 – 3	Society of Nanosystems Engineers (SNES)
	121 – 5	121 – 0	
		122 – 1	
120 – 10	120 – 2	120 – 1	Society of Women Engineers (SWE)
	121 – 2	121 – 0	
		122 – 2	
120 – 1	120 – 4	120 – 1	University Meetings (SGA, Union Board, etc)
	121 – 7	121 – 0	
		122 – 12	
120 – 1	120 – 0	120 – 2	University Service Projects (ES Day, The Big Event, etc)
	121 – 0	121 – 0	
		122 – 1	
120 – 0	120 – 0	120 – 3	Meeting Outside of University (Kiwanis, Church, etc)
	121 – 4	121 – 0	
		122 – 4	
120 – 12	120 – 11	120 – 1	Other Meetings
	121 – 12	121 – 0	
		122 – 21	

Robotics-Centered Curriculum (Spring 2008)

Focus Group Results

During the interim visit, 11 students participated in a focus group. Transcription of the focus group results is given in Attachment D. The primary goal of the focus group was to interact with students in the curriculum. Although no definitive conclusions can be drawn from such a small number of students, the students who chose to participate were highly motivated, enthusiastic and articulate. They indicated that they understood that the "Living with the Lab" was a curriculum that was different from the traditional freshmen engineering sequence. Several of the focus group members had talked to friends at other universities and to upper classmen at Louisiana Tech. These discussions had given them an appreciation that their curriculum had much more hands-on application. The students interviewed enjoyed the hands-on approach.

Robotics-Centered Curriculum (Spring 2008)

Student Work Analysis-Design Symposium

The design expo for ENGR 122 was held Wednesday, May 7, 2008 from 4:00 -8:00 PM in the student center. There were 32 projects on display. A list of the projects is contained in Attachment E. Each project was assigned a table. Students from the project team displayed posters and gave explanations of their projects. The variety of projects was impressive. Among the 32 projects there were 26 distinct ideas. Students interviewed at the Expo demonstrated the ability to explain their projects clearly. Students also demonstrated pride in their prototypes and what they had learned. Students reported that the design project was difficult and rewarding.

Robotics-Centered Curriculum (Spring 2008)

Faculty/Staff Interviews

Faculty, administration, and staff interviews were conducted on Wednesday, May 7, 2008. A transcription of comments is included in Attachment F. Several observations were made as a result of these interviews:

1. The Living with the Lab Curriculum is recognized by the administration as being a significant improvement in the freshmen curriculum. The administration supports the goals of the curriculum.
2. The faculty has formed a cohesive team that works together effectively and strives to deliver an excellent curriculum.
3. The faculty is motivated, well-qualified, and dedicated.
4. There is a sense of excitement about the curriculum.

Summary

The goals for the assessment efforts during the 2007-2008 academic year were to update the assessment method, determine if there were differences between the old curriculum and new curriculum that could be quantified, and make suggestions. Each goal will be discussed separately:

Development of Assessment Method

The use of student surveys provided a wealth of information about student confidence and the frequency with which they performed desired activities. The use of student surveys should be continued. Implementation of on-line surveys has been an advantage although not all data is exported in the same manner. A common approach to exporting the data will reduce the amount of time required to reformat the data prior to analysis.

The Design Expo contains a wealth of information about student abilities. The list of all completed student projects demonstrates the breadth of student projects. The invitation of outside evaluators to review the projects is an excellent resource that can be further utilized. For example, the evaluators see what the students are able to do. A rubric for the design projects should be developed that addresses the curriculum goals so that outside evaluators can comment on the effectiveness of the curriculum. This could be used as a direct measure for accreditation purposes, if desired.

In addition, if possible, it would be interesting to see if employers of students for internships and/or co-ops detected any difference in the students that have taken the “Living with the Lab” curriculum. Finally, it would also be interesting to question faculty in later courses to see if they detect any difference in the students who have been in the “Living with the Lab” curriculum.

There appears to be concern about the number professional society meetings and student-led functions that students report that they attend each quarter. In addition to answering the survey questions, students also give a list to their instructor. The students appear to pay more attention to the creation of the list. It is recommended that this list be used to judge the values and that those questions about professional society meeting and student-led functions be deleted. Mechanisms for automating the collection of this data should be investigated as the number of students participating is high.

Because the number of students involved has increased significantly since the spring of 2007-08, it is recommended that the survey results be analyzed and a report prepared each quarter. A summary report would then be prepared each year and at the end of the grant period.

Quantification of Differences between Old Curriculum and New Curriculum

One of the major assumptions of the “Living with the Lab” is that students’ ownership and maintenance will result in students obtaining more hands-on practice. This assumption is dramatically demonstrated by examining Tables 6, 9, 12 and 16. The data from those tables, which indicates the “hands-on” application by class, is used to produce a visual demonstration of significance. The yellow shading indicates that the “Living with the Lab” is ***more than 3 times greater than the “Old” curriculum for all sections***. The black shading indicates that the old curriculum is greater than all sections of the “Living with the Lab” curriculum. This only occurred with the sawing operation in ENGR 120. The blue shading indicates that the “Living with the Lab” sections are greater than the “Old” curriculum but not 3 times greater for all sections. The red shading indicates that the results are inconsistent. In some cases the new curriculum is greater and in some cases the new curriculum is smaller than the old curriculum. In Table 19, the “Living with the Lab” curriculum is more than 3 times greater than the “Old” curriculum 29 out of 45 opportunities. The “Living with the Lab” curriculum is greater than the “Old” curriculum 37 out of 45 opportunities. In only one instance, is the “Old” curriculum consistently less than the “Living with the Lab” curriculum. The results in Table 19 demonstrate that students’ ownership and maintenance does result in students obtaining more hands-on practice.

In addition to evidence provided by student surveys, students in focus groups and in the Design Expo indicated that they spent a significant portion of their time in “hands-on” practice.

Table 19: Shaded Representation of More Hands-On Practice in 120 and 121

Item	120 “Old”	120 “LWL”	121 “Old”	121 “LWL”	122 “Old”	122 “LWL”
	A	B	C	D		
Assembly						
Bending						
Cutting internal or external threads						
Drilling						
Implementing circuits on a breadboard						
Layout						
Milling						
Rapid Prototyping						
Sawing						
Soldering						
Using a dial indicator						
Using a lathe						
Using a multimeter						
Using a scale						
Writing PBASIC programs						

The surveys from ENGR 120, ENGR121, and ENGR 122 also demonstrated dramatic difference between the confidence and frequency of performance between students in the old curriculum and the new curriculum. For ENGR 120, there were 23 items where the “Living with the Lab” students reported a statistically greater confidence than the students in the old curriculum and 21 items where they reported a statistically greater frequency of performance than students in the old curriculum. For ENGR 121, there were 16 items where the “Living with the Lab” students reported a statistically greater confidence and 21 items where they reported a statistically greater frequency of performance than students in the old curriculum. Finally, in ENGR 122 there were 13 items where the students in “Living with the Lab” reported a statistically greater confidence than students in the old curriculum and 13 items where they reported frequency of performance was statistically higher.

The preponderance of evidence indicates that the “Living with the Lab” curriculum is successful in increasing confidence and frequency of performance when compared with the old curriculum.

The relationship between confidence and frequency of performance is not clear. There is definitely a link, but it is possible to perform an activity frequently and still not feel confident and it is also possible to feel confident without having to perform an activity. This relationship should be explored further as more data becomes available.

Items of Interest outside the Scope of the Project

The "Living with the Lab" curriculum has demonstrated the ability to increase student confidence and frequency of performance in several key items. Sharing the expertise that has been developed at Louisiana Tech should be investigated. There are several options that could be explored: developing a book or workshops, seeking partner schools for implementation, and/or seeking additional grant funding to increase implementation such as a CCLI Phase 3 grant.

ENGR 120 Survey

ENGR 120 Survey Hardcopy.pdf

ENGR 121 Survey

ENGR 121 Survey
Hardcopy.pdf

Attachment C

ENGR 122 Survey

ENGR 122 Survey
Hardcopy.pdf

Attachment D

Focus Groups

The transcription of the focus groups is listed below:

ENGR 120/121

(5 ME's, 1 IE, 2 ChemE's)

Things that you liked about Living with the Lab:

I liked how we used math and engineering formulas together.
I enjoyed the Boe-bot.
Boe-bot –cool, fun, programming – first time I'd ever done that.
I like that they didn't always tell us what to do – we had to figure it out on our own.
Not just lecture – learn while doing.
It was cool that we got to program the Boe-bot. I liked the parts where you programmed and figured it out. I liked the hands-on. I liked the way they threw it at us, and we got to do what we wanted. We had to figure out how to fix it. We learned a lot more because we had things that went wrong. They don't spoon feed, we have to figure it out. I liked the Bobot. I learned while we did stuff, it was not just lecture. We knew why we were doing what we were doing. I liked that we used the pump. We knew how to do it, you could fix it.
No spoon feeding
We got classmates to help.
Definitely like working on a team – can help each other and it good to have different views.
Not much group conflict. Some people have problems with their group members all contributing.
There's a reason for everything that you learn.
Using the same pump from last quarter
Always someone there to help, faculty, classmates
There was always someone who could help if you had trouble with your project.
I'm glad that we learned MathCad.
I liked Excel.
The ENGR 120 is very stressful, but it gets you prepared. I'm glad I didn't take 120 in the first quarter and pushed it back.
You start learning right off the bat.
Good faculty.
Overall good curriculum, stressful but worth it
People know what they want to do (major) or if engineering is not for them
I'm glad that I started the program one quarter behind – that way we're not guinea pigs.
Same formulas in math and engineering

Things that could be improved with Living with the Lab:

I wish that we could have more choice (for scheduling.) I don't like blocks. I would like to mix and match blocks. Sometimes you want to avoid a certain teacher.
Give us more of a choice in teachers.
I was in an all girls group and I didn't like it – we didn't know all that stuff. I was frustrated by troubleshooting.

We don't know how to compare this experience to other colleges. People tell us it is different, but we don't have anything to compare it to.
I had to restore my computer. I had to buy Solid Edge 3 times. A lot of people had software problems with Solid Edge.
You have to spend a lot of money on software and parts.
There is no instruction in Solid Edge.
I would like more instruction in Solid Edge.
I think it would be better if we were given more instruction in Solid Edge in class.
There were some problems with pacing of the course. Some classes seemed fast paced – too much so. Other classes were slower and we could keep up.
The midterm had some random questions – what is a certain drill bit called.
I can't grasp programming and circuitry.
Chem Lab could be more difficult – I learned that in high school.

What skills and concepts have you learned outside your major?
Students weren't sure what was in their major, so we asked for them to describe what they were learning.
I liked learning about the pump. I learned how to scale up a pump. It was good that we used low quality stuff so that we know how to fix it.
I want to learn more about ergonomics after graduation. I now appreciate how comfortable a chair is. The student center chairs are too short.
I am thinking about taking more programming classes after working with the Bobot.
I like team projects better – they help you to understand. We have 4 different ideas and we have to compromise. Some groups have problems getting along.
ENGR 120 and Math 240 shows a lot of people they should be engineers.
Good to get a taste of different engineering areas before I go into a major.
Chemistry lab was very easy.
I had a lot of the chemistry in high school.
Too soon to tell -I want to learn more about ergonomics after graduation.
It helps to see a lot of thing, electrical circuits and logic and mass balance.
Our projects are small scale of real life – water pump, pool heater

ENGR 122
(2 CE's, 1 Nano Systems)

Things that you liked about Living with the Lab:
I liked the projects. I liked working with electronics and programming.
I got a good grasp of how to take the project from start to finish.
I liked the hands on work, I liked working in teams, I liked using machines, I liked getting help on programs.
I liked fabrication. I liked the fact that we got to build it ourselves. The group thing worked out pretty good.
I got to meet new people and get used to working with other people. We had to figure out what they were good at.
I liked the help desk. They were helpful and had spare parts. They fixed my MathCad (software).
I liked the video clip the Deep Dive by IDEO.

I thought it was strange because of the 10 roles they had people segregated into. Caregiver, storyteller, experimenter, anthropologist, director, producer, cross pollinator.

Things that could be improved with Living with the Lab:
The pump project wasn't smooth. We didn't do enough research before we did the pump.
Homework could be put up more quickly. Once it was posted at 8:00 at night and was due the next morning. He did let us turn it in late.
I would have liked more examples of global problems, energy crisis, population problem – I felt like they were just tacked on and not part of the class – like just so we could say that we did it
I would like more emphasis on Boe-bot programming. Not just commands, but how to write a good program.
We had a lot of problems with programming.
The Boe-bot has problem with interfacing to the computer.
I would have liked more in-depth with MathCad – because the program can do a lot of cool things.
I thought the IDEO video was stupid at first, a little too much. But maybe it is me just going against something different. But it works!

What skills and concepts have you learned outside your major?
Patience, programming, building, measuring, drilling, milling, everything to do with machines, Solid Edge, MathCad, mass balance, circuits, linear regression, statics, engineering economics, and physically building a circuit.
Prototype, prototype, prototype
Talk it through and then prototype
IDEO roles

What ideas do you have for new products?
Using a distance indicator on a front bumper, need enough clearance to make the curb.
Automatic guitar tuner - measure tension, tweak until get the tension right,
Keep sound level on a TV constant – don't have it go up with commercials.
I would love to have my project, but I don't want to bring it to market myself. I would be happy to help someone else.
My project is already being done by other car companies.

What would you like to do after graduation?
Maybe research in nanosystems
Build bridges or dams
Work in the construction industry

Freshman Design Expo – Spring, 2008

Project titles are listed below with like projects grouped together:
Radio Frequency Parking Identification
Blind Spot Detector
Mail Arrived Detector
Automated Book End System
Self-Leveling System for Trailers
Electronically Assisted Trailer Hitching
Beta Cruise Control
Coin Bundle Vending Machine
Master Key Detector
Keyless Door Entry
Remote Controlled Door Lock
Remote Locator
Remote Car Jack
Industrial Safety Crosswalk
Automated In-Home Inventory System
Robotic Lawn Mower
Automated Bubble Air Freshening System (SmellGoods)
Portable Themed Pinball Machines
Alert Bracelet
Escalator
Wallet protection
High Beam/Low beam Headlight Switching
Rescue Ranger
Talkman
Paranoid Space Detector
Modernized Home Security System
Parking Sensor
Smart Backpack
Air Cannon Deer Feeder
Eco Friendly Lighting System
SPOTBOT
Radio Doggie Door

Summary of Faculty Comments

I'm very much looking forward to the summer and a time to rest and reflect on the past year. Your suggestions to offload responsibility for various courses to others yesterday as well as increasing the role and responsibilities of student assistants are on target for sustainability. I also hope to get Heath and Mikey to take charge of supervising the student labor aspects of the help desk / prototyping lab next year; they have definite ideas of how the lab and help desk should be run and will do a good job.

While I did do much of the development work this past year, I'm afraid that you may have the impression that I did it with little help from others. Mark Barker and I have been developing the freshman sequence since back in 2002. Kelly taught a section a couple of years ago, and Mikey became involved last year. Many of the handwritten notes posted on the web are Mikey's. This past year, everyone teaching the courses has contributed on one way or the other:

Stan Cronk
- Finds the errors in the notes and alerts me.
- Teaches most of the review sessions before exams.
- Developed engineering economics problems in 122 as well as regression notes in 120
- Primary author of one of the ASEE papers

Hisham Hegab
- Handled almost everything related to the RTD project (with student help)

Mark Barker
- Helps keep us going in the right direction - lots of conversations
- Helped hammer out the schedule and content for the entire year last summer
- Writes homework problems
- Some of the handwritten notes are Mark's
- Made up 1st drafts of class plans
- Carried half the load of the summer workshop last year

Anthony Reed (a student)
- Worked with Mark and me to hammer out the schedule last summer
- Primary author of one of the ASEE papers (with help from other students)

Mikey Swanbom
- 555 and transistor notes in 121, some statics notes, some ENGR econ notes
- Writes homework problems
- Selected and purchased lathes and mills in freshman room
- Primary author of one of the ASEE papers

Kelly Crittenden
- Most of the IDEO / Pugh method / 10 faces of innovation / bug list / etc. 122

Davis Harbour
- Set up and maintains the computer in the freshman room
- Screen capture notes

Entire Team

- Make out problems for exams
- Provide input at meetings
- After-hours monitoring of labs
- Develop and modify projects

I'm sure there are a lot of contributions that I'm forgetting. I'm lucky to have these guys working with me and continuing to graciously put up with me as the year has gone on.

My job this year was . . .

* Developing the web site(s)
* Learning several software packages related to the web site (Dreamweaver, Illustrator, Photoshop)
* Posting previously generated content to the web
* Developing new notes or modifying old notes
* Developing homework problems
* Purchasing course supplies and equipment
* Preparing the supplies for distribution to students
* Organizing events / writing annual reports / papers
* Supervising student workers

Fall quarter was the most difficult since we were just starting to scale things up. My late nights have decreased as the year has progressed, but I'm still working more than I'd like to (for various reasons). I've been determined to complete what we started with the ENGR 12X courses this year and try to make it as high-quality as possible. What happens with the ENGR 22X courses will be mostly up to Kelly, Davis and Mark, but I feel some level of responsibility as the NSF project director for our grant.

Faculty comments

- Curriculum has made great strides
- Likes projects
- Thinks that freshmen are still forming impressions of what engineering is like
- Made exams more difficult to condition students to a hard world, want to emphasize fundamentals more
- Most graduates go to work in industry, many in the oil industry
- Can't give students too much – students must learn how to learn
- Students aren't aware of how good they have it with so much project work
- The lag sections need to be the same quality as the first sections
- The faculty meet regularly to make sure everyone is on the same page. We only meet one hour, we need more time.