Robotics-Centered Curriculum (2007-2010)

Summary Report

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MEMORANDUM

DATE: July 25, 2010
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 2008-09 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)

2008-09 Academic Year

- ENGR 120 – end of quarter surveys – Living with the Lab (8 section)
- ENGR 120H – end of quarter surveys – Living with the Lab (4 sections)
- ENGR 121 – end of quarter surveys – Living with the Lab (8 sections)
- ENGR 121H – end of quarter surveys – Living with the Lab (2 sections)
- ENGR 122 – end of quarter surveys – Living with the Lab (6 sections)
- ENGR 122H - end of quarter surveys – Living with the Lab (3 sections)

In addition, a site visit was made in May 2008 and June 2010. Although an interim report was completed for each site visit, for completeness, information from both of those reports will also be included here.

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LIVING WITH THE LAB

The major aim of the LIVING WITH THE LAB (LWTL) 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

LWTL 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, 120H	Survey	• Skills practiced • Course outcomes
Winter 2008	ENGR 120, 121, 121H	Survey	• Skills practiced • Course outcomes
Spring 2008	ENGR 120, 121, 122H	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
Fall 2008	ENGR 120, 120H, 121, 122	Survey	• Skills practiced • Course outcomes
Winter 2009	ENGR 120, 121, 121H, 122	Survey	• Skills practiced • Course outcomes
Spring 2009	ENGR 120, 121, 122, 122H	Survey	• Skills practiced • Course outcomes
Summer 2010	ENGR 120-122	Faculty and Staff Interviews	• Faculty Engagement • Faculty Perceptions • Program Sustainability

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 2009

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
Fall 2008	ENGR 120	73	107
	ENGR 121	0	37
	ENGR 122	0	42
Winter 2009	ENGR 120	0	41
	ENGR 121	36	116
	ENGR 122	0	26
Spring 2009	ENGR 120	0	31
	ENGR 121	0	61
	ENGR 122	44	86

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 2010)

Findings

Common Item Comparisons

The common item comparisons shown in Table 4 include all data collected to date. It was expected that student confidence would increase throughout the curriculum. This was not the case. Student confidence started relatively high and stayed there. The data was next examined to determine if there were significant differences between the honors' sections and the regular LWTL sections. The items where a significant difference was observed are highlighted in yellow. There are 5 significant differences between ENGR 120 and 120H: Generate 3D models of engineering components and assemblies using solid edge, Use linear regression analysis as appropriate in class projects, Utilize MathCAD to assist in solving engineering problems, Utilize Excel to assist in solving engineering problems, and Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos. There are 4 significant differences between ENGR 121 and 121H: Use linear regression analysis as appropriate in class projects, I enjoy developing technical tools that improve the quality of life for people, Utilize Excel to assist in solving engineering problems, and Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos. There is only one significant difference between ENGR 122 and 122H: Present technical data in tables and on graphs in a professional manner. This indicates that LWTL is effective in developing the "can do" attitude with both honors and regular sections.

Table 4: Common Course Outcome Confidence Means by Course

Item	ENGR 120	ENGR 120H	ENGR 121	ENGR 121H	ENGR 122	ENGR 122H	*Sig.
	N=467	N=108	N=423	N=68	N=305	N=67	
	A	B	C	D	E	F	
Utilize the prescribed solution format when solving problems.	5.05	5.24	5.04	5.35	5.43	5.51	A<EF C<EF
Work collaboratively with one or more other students.	5.17	5.15	5.12	5.19	5.33	5.49	C<EF
Present the results of assignments and projects using written	4.90	5.06	4.86	5.07	5.04	5.19	C<F

communication.							
Present the results of assignments and projects using oral communication.	4.51	4.66	4.60	4.91	4.87	5.10	A<DEF F>ABC E>C
Generate 3D models of engineering components and assemblies using Solid Edge.	4.29	4.83	4.74	4.97	4.78	4.87	A<ALL
Present technical data in tables and on graphs in a professional manner.	5.05	5.31	4.90	5.41	4.80	5.19	E<ABDF B>C D>ACE
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	4.71	4.88	4.59	4.87	5.10	5.03	E>AC F>C
Use linear regression analysis as appropriate in class projects.	4.80	5.23	4.64	5.25	4.90	4.64	A<BD B<F C<DE
Utilize MathCAD to assist in solving engineering problems.	4.61	5.30	4.44	4.85	4.96	5.06	A>C B>ACDE
Utilize Excel to assist in solving engineering problems.	5.19	5.53	4.97	5.47	4.83	5.15	DC>A<B B>CE D>CE
Use creative techniques to overcome at least one project difficulty.	4.68	4.87	4.63	5.00	4.87	5.24	A<EF
When I set a goal, I keep going after it no matter what the obstacles.	5.02	5.16	4.96	5.15	5.15	5.35	
I enjoy developing technical tools that improve the quality of life for people.	5.08	5.21	5.05	5.41	4.95	5.28	D>CE
I intend to develop new products/processes during my career as an engineer.	5.00	5.06	4.97	5.16	5.13	5.06	
I prefer improving products/processes that already exist instead of developing something new.	4.42	4.15	4.28	4.16	4.85	4.78	E>ABCD F>BCD
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	4.37	4.61	4.49	4.63	4.84	4.64	E>AC
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	4.42	5.54	4.17	4.82	4.84	5.07	B>ACDE C<DEF

The common course outcome frequency of performance was examined for trends in the statistically significance. There appears to be three statistically significant occurrences throughout the progression from ENGR 120 – ENGR 121- ENGR 122. These occurrences have been highlighted in green. Students in ENGR 122 and 122H report a higher frequency of working collaboratively with one or more other students. Students in ENGR 122 and 122H also report a higher frequency of presenting the results of assignments and projects using written communication. Finally, students in ENGR 120 and 120H report a lower frequency of locating specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers. Although there is a statistical difference in the frequency of performance for the items, there was not a statistical difference in the confidence associated with the item.

When examining the differences between the honors and regular sections in ENGR 120 and 120H, there are two statistical differences in reported frequency of performance: Utilize MathCAD to assist in solving engineering problems, and Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos. It is interesting to note that in the two areas where the reported frequency of performance is statistically lower, the reported confidence is also lower. In ENGR 121 and 121H, there are four statistically difference frequency of performance items: Use linear regression analysis as appropriate in class projects, Utilize MathCAD to assist in solving engineering problems, Use creative techniques to overcome at least one project difficulty, and Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos. The ENGR 121 and ENGR121H students also had a statistical significant difference in confidence for linear regression and programming a BASIC Stamp microcontroller. Finally, there is only one statistically reported significant frequency of performance between ENGR 122 and ENGR 122H: Use creative techniques to overcome at least one project difficulty.

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

Item	ENGR 120 N=467 A	ENGR 120H N=108 B	ENGR 121 N=423 C	ENGR 121H N=68 D	ENGR 122 N=305 E	ENGR 122H N=67 F	*Sig.
Utilize the prescribed solution format when solving problems.	5.60	5.64	5.56	5.96	5.90	5.82	E>AC
Work collaboratively with one or more other students.	5.03	5.22	5.53	5.34	5.83	5.94	A<C EF>ABCD
Present the results of assignments and projects using written communication.	5.23	5.53	5.30	5.51	5.32	5.28	
Present the results of assignments and projects using oral communication.	4.05	4.10	4.28	4.35	4.79	4.84	EF>ABC
Generate 3D models of engineering components and assemblies using Solid Edge.	4.59	5.04	4.63	4.59	4.34	4.43	B>ACEF E<C
Present technical data in tables and on graphs in a professional manner.	5.25	5.41	4.88	5.29	4.37	4.64	F<ABD E<ABCD C<AB
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	3.96	3.83	4.34	4.72	4.92	4.66	AB<CDEF C<E
Use linear regression analysis as appropriate in class projects.	4.91	5.15	4.67	5.24	4.50	4.03	C<BD E<ABD F<ABCD
Utilize MathCAD to assist in solving engineering problems.	4.92	5.58	4.56	4.91	4.82	5.07	E<A<BF C<BDEF
Utilize Excel to assist in solving engineering problems.	5.58	5.83	4.97	5.31	4.58	4.78	A>CEF B>CDEF F<ABCD
Use creative techniques to overcome at least one	4.77	4.94	4.93	5.21	5.03	5.31	C<DEF F>ACE

project difficulty.							
When I set a goal, I keep going after it no matter what the obstacles.	5.54	5.54	5.54	5.69	5.32	5.69	C<F
I enjoy developing technical tools that improve the quality of life for people.	4.78	4.68	4.71	4.66	5.04	5.07	E>C
I intend to develop new products/processes during my career as an engineer.	4.91	4.85	4.88	4.85	5.42	5.28	E>ABCD
I prefer improving products/processes that already exist instead of developing something new.	4.58	4.57	4.65	4.75	4.92	5.07	
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	4.29	4.46	4.50	4.72	4.81	4.53	E>AC
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	4.57	5.86	4.25	4.90	4.96	5.47	A<BE C<BDE

Table 6 compares the baseline "Hands-0n" data obtained during the spring of 2006-07 with the values from the new LWTL curriculum. Examination of Table 6 indicates that the LWTL hands-on application is statistically greater in 7/15 items in ENGR 120; 15/15 items in ENGR 121 and 15/15 items in ENGR 122. There is only one item in which the old curriculum reported a higher average activity: sawing. Adding all hands on activities gives a total of 13.52 for the old ENGR 120 as compared to 60.93 for the LWTL ENGR 120. This indicates that the "LWTL results in a 451% increase in the number of "hands-on" applications in ENGR 120. A similar analysis indicates that there is a 1,973% increase for ENGR 121 and a 383% increase in the value for ENGR 122. If the average activities from all three courses are tabulated, the total for the old curriculum is 43.91. The total for the new curriculum is 242.49. **This represents an increase of approximately 550%.**

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

Item	ENGR 120	ENGR 120	ENGR 121	ENGR 121	ENGR 122	ENGR 122
	Old	LWTL	Old	LWTL	Old	LWTL
	N=29	N=538	N=42	N=433	N=64	N=300
Assembly	2.15	2.85	.55*	6.52*	3.10*	10.46*
Bending	1.04	.72	.18*	2.25*	4.62	4.77
Cutting internal or external threads	.23*	1.31*	.02*	4.99*	.53*	1.96*
Drilling	1.81	2.90	.55*	6.75*	4.26*	9.50*
Implementing circuits on a breadboard	.04*	12.37*	.49*	12.20*	.60*	12.77*
Layout	1.35	2.45	.63*	6.63*	2.18*	10.34*
Milling	.34*	2.27*	.00*	4.05*	.09*	2.93*
Rapid Prototyping	.21	.77	.00*	1.64*	.71*	2.46*
Sawing	1.52*	.46*	.15*	1.61*	2.11*	5.39*
Soldering	.14*	1.39*	.05*	4.25*	2.14*	6.18*
Using a dial indicator	.07*	4.29*	.02*	4.09*	.16*	3.90*

Using a lathe	.24	.42	.02*	2.20*	.06*	1.48*
Using a multimeter	.26*	7.45*	.33*	5.75*	2.24*	5.25*
Using a scale	4.12	3.93	1.06*	7.11*	3.48*	11.47*
Writing PBASIC programs	.00*	17.35*	.05*	10.85*	.01*	11.81*
Totals	13.52	60.93	4.10	80.89	26.29	100.67
% Increase		451		1973		383
Total of Hands-On Activities Averages for Old Curriculum					43.91	
Total of Hands-On Activities Averages for LWTL Curriculum						242.49

*Indicates a statistically significant difference between old and new curriculum for a course

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 LWTL 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 22 items:***

1. Present the results of assignments and projects using oral communication.
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. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
7. Explain the origin of electric charge and define electric current, voltage, resistance, and power.
8. Compute current, resistance, voltage and power for circuits composed of resistors and DC power sources using Ohm’s law and Kirchhoff’s laws.
9. Identify and describe the purpose of each component on the BASIC Stamp II microcontroller.
10. Identify and describe the purpose of each component on the Board of Education.
11. Identify and describe the purpose of each component on Boe-Bot.
12. Convert between decimal numbers and binary numbers.
13. Explain how programs and variables are stored in EEPROM and RAM on the BASIC Stamp II microcontroller.
14. Implement whisker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
15. Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
16. Implement LED and piezospeaker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
17. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
18. Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.

19. Program a BASIC Stamp II microcontroller using the PBASIC language to control the frequency and duration of sound output from piezospeakers.
20. Fabricate a centrifugal pump driven by a DC motor with an impeller drawn in Solid Edge and printed on a rapid prototyping machine.
21. Utilize a multimeter to troubleshoot circuits and to measure the current, voltage and power usage of an electric pump.
22. Compute the efficiency and evaluate the performance of a centrifugal pump using DC circuit analysis, conservation of energy, and linear regression analysis.

The items that are statistically different between the old curriculum and LWTL have been highlighted in green. It is not surprising that students have more confidence in their ability to perform tasks that are included in the LWTL curriculum that were not included in the old curriculum. **However, the first five statistically significant items on the list were included in the old curriculum.** It appears that the method of delivery for the LWTL curriculum allowed the students to gain more confidence in those items as well.

The differences between years and the honors sections were examined to see if there was any pattern. No pattern was observed.

The survey indicates that the LWTL 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. 19 of the 22 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	Baseline 06-07 N=33 A	LWTL 07-08 N=255 B	Honors 07-08 N=35 C	LWTL 08-09 N=179 D	Honors 08-09 N=73 E	*Sig
Utilize the prescribed solution format when solving problems.	5.00	5.13	5.49	4.95	5.12	C>D
Work collaboratively with one or more other students.	5.41	5.30	5.34	4.94	5.05	B>D
Present the results of assignments and projects using written communication.	4.85	5.00	5.31	4.77	4.93	D<BC
Present the results of assignments and projects using oral communication.	4.39	4.59	4.86	4.42	4.56	A<ALL E<B
Generate 3D models of engineering components and assemblies using Solid Edge.	2.55	4.37	4.89	4.51	4.81	
Present technical data in tables and on graphs in a professional manner.	4.76	5.20	5.69	4.88	5.12	C>ALL D<B
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	4.56	4.70	A<ALL D<BC
Use linear regression analysis as appropriate in class projects.	3.58	4.85	5.46	4.95	5.12	A<ALL C>BD
Utilize MathCAD to assist in solving engineering problems.	1.67	4.93	5.60	4.70	5.15	A<ALL C>BD E>D

Utilize MathCAD to build functions, to solve sets of linear equations and to create plots.	1.61	4.65	5.29	4.57	4.89	A<ALL C>BD
Utilize Excel to assist in solving engineering problems.	4.85	5.37	5.71	5.00	5.44	A<BCE D<BCE
Create Excel spreadsheets using formulas and built-in functions and generate plots of the spreadsheet data.	5.00	5.39	5.77	4.99	5.51	C>AD D<BCE
Use creative techniques to overcome at least one project difficulty.	4.61	4.82	5.20	4.49	4.71	D<BC
When I set a goal, I keep going after it no matter what the obstacles.	4.97	5.11	5.29	4.90	5.10	
I enjoy developing technical tools that improve the quality of life for people.	4.88	5.17	5.35	5.00	5.14	
I intend to develop new products/processes during my career as an engineer.	4.82	5.07	5.23	4.92	4.97	
I prefer improving products/processes that already exist instead of developing something new.	4.28	4.59	4.46	4.20	4.00	B>DE
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	3.25	4.44	4.89	4.48	4.48	A<ALL
Explain the origin of electric charge and define electric current, voltage, resistance, and power.	2.76	5.00	5.40	4.71	4.93	A<ALL D<BC
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	4.92	5.22	A<ALL D<BC
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	5.16	5.66	5.00	5.22	C>ABD
Identify and describe the purpose of each component on the BASIC Stamp II microcontroller.	1.30	4.29	4.83	4.28	4.27	A<ALL
Identify and describe the purpose of each component on the Board of Education.	1.56	4.20	4.91	4.24	4.30	A<ALL C>BD
Identify and describe the purpose of each component on Boe-Bot.	1.21	4.30	5.06	4.42	4.41	A<ALL C>BDE
Convert between decimal numbers and binary numbers.	2.79	4.78	5.66	4.82	4.97	A<ALL C>BDE
Explain how programs and variables are stored in EEPROM and RAM on the BASIC Stamp II microcontroller.	1.55	4.27	4.51	4.19	4.07	A<ALL
Implement whisker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.33	4.81	5.49	4.57	4.79	A<ALL C>BDE
Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.42	4.47	5.23	4.27	4.37	A<ALL 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	4.69	4.88	A<ALL C>BD
Program a BASIC Stamp II microcontroller	1.28	4.81	5.54	4.58	5.01	A<ALL

using the PBASIC language to control the speed and direction of servos.						C>BDE D<CE
Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.	1.23	4.86	5.66	4.60	4.96	A<ALL 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	4.85	5.51	4.56	4.97	A<ALL D<BCE C>B
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	5.08	5.23	4.78	5.11	A<ALL
Utilize a mulitmeter to troubleshoot circuits and to measure the current, voltage and power usage of an electric pump.	1.58	4.79	5.26	4.44	4.45	A<ALL D<BC C>E
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	4.53	4.70	A<ALL C>D

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 (LWTL) reveals ***22 statistically significant*** items:

1. Generate 3D models of engineering components and assemblies using Solid Edge.
2. Present technical data in tables and on graphs in a professional manner.
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. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
7. Explain the origin of electric charge and define electric current, voltage, resistance, and power.
8. Compute current, resistance, voltage and power for circuits composed of resistors and DC power sources using Ohm's law and Kirchhoff's laws.
9. Identify and describe the purpose of each component on the BASIC Stamp II microcontroller.
10. Identify and describe the purpose of each component on the Board of Education.
11. Identify and describe the purpose of each component on Boe-Bot.
12. Convert between decimal numbers and binary numbers.
13. Explain how programs and variables are stored in EEPROM and RAM on the BASIC Stamp II microcontroller.
14. Implement whisker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
15. Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
16. Implement LED and piezospeaker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.
17. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
18. Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.
19. Program a BASIC Stamp II microcontroller using the PBASIC language to control the frequency and duration of sound output from piezospeakers.

20. Fabricate a centrifugal pump driven by a DC motor with an impeller drawn in Solid Edge and printed on a rapid prototyping machine.
21. Utilize a multimeter to troubleshoot circuits and to measure the current, voltage and power usage of an electric pump.
22. Compute the efficiency and evaluate the performance of a centrifugal pump using DC circuit analysis, conservation of energy, and linear regression analysis.

As noted above, there is a link between confidence and frequency of performance. 19 of the 22 statistically significant items in performance were also significant in confidence.

Table 8
ENGR 120 Specific Course Outcome Means - Performance

Item	Baseline 06-07	Robotics 07-08	Honors 07-08	Robotics 08-09	Honors 08-09	*Sig
	N=33	N=255	N=35	N=179	N=73	
	A	B	C	D	E	
Utilize the prescribed solution format when solving problems.	5.66	5.65	5.83	5.51	5.55	
Work collaboratively with one or more other students.	5.36	4.99	5.31	5.02	5.18	
Present the results of assignments and projects using written communication.	4.79	5.20	5.57	5.37	5.51	
Present the results of assignments and projects using oral communication.	3.91	4.08	4.41	4.04	3.96	
Generate 3D models of engineering components and assemblies using Solid Edge.	2.41	4.77	5.34	4.74	4.89	A<ALL
Present technical data in tables and on graphs in a professional manner.	4.53	5.31	5.80	5.29	5.22	A<ALL
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	3.15	4.02	4.54	4.04	3.49	A<BCD E<BCD
Use linear regression analysis as appropriate in class projects.	3.58	4.88	5.23	5.20	5.11	A<ALL
Utilize MathCAD to assist in solving engineering problems.	1.32	5.24	5.86	5.16	5.45	A<ALL C>BD
Utilize MathCAD to build functions, to solve sets of linear equations and to create plots.	1.44	4.86	5.40	4.70	4.73	A<ALL C>D
Utilize Excel to assist in solving engineering problems.	5.26	5.66	5.97	5.53	5.77	A<CE C>D
Create Excel spreadsheets using formulas and built-in functions and generate plots of the spreadsheet data.	5.24	5.69	5.94	5.52	5.64	A<C
Use creative techniques to overcome at least one project difficulty.	4.47	4.76	5.29	4.84	4.78	A<C
When I set a goal, I keep going after it no matter what the obstacles.	5.59	5.49	5.71	5.61	5.45	
I enjoy developing technical tools that improve the quality of life for people.	4.76	4.98	5.48	4.48	4.32	D<BC E<BC
I intend to develop new products/processes during my career as an engineer.	4.35	5.07	5.30	4.80	4.64	
I prefer improving products/processes that	4.12	4.62	4.64	4.60	4.53	

already exist instead of developing something new.						
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	2.88	4.23	4.66	4.63	4.37	A<ALL B<D
Explain the origin of electric charge and define electric current, voltage, resistance, and power.	2.29	5.11	5.60	5.01	4.86	A<ALL
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	5.49	5.94	5.58	5.70	A<ALL
Compute the mean, median, standard deviation, and variance of a data set.	4.65					
Determine the best fit equation for a set of (x,y) data points, considering linear, power, polynomial and exponential functions.	4.82	5.25	5.71	5.47	5.60	A<CDE
Identify and describe the purpose of each component on the BASIC Stamp II microcontroller.	1.18	4.38	4.71	4.55	4.36	A<ALL
Identify and describe the purpose of each component on the Board of Education.	1.15	4.28	4.77	4.47	4.22	A<ALL
Identify and describe the purpose of each component on Boe-Bot.	1.18	4.34	4.89	4.51	4.47	A<ALL
Convert between decimal numbers and binary numbers.	2.47	4.53	5.11	4.55	4.30	A<ALL
Explain how programs and variables are stored in EEPROM and RAM on the BASIC Stamp II microcontroller.	1.53	4.23	4.37	4.39	3.89	A<ALL
Implement whisker circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.18	4.71	5.31	4.74	4.62	A<ALL
Implement photoresistor circuits on the Board of Education breadboard based on circuit diagrams provided by the instructor or in the Robotics book.	1.24	4.59	5.11	4.42	4.30	A<ALL C>DE
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	4.90	5.54	5.02	5.01	A<ALL C>B
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	1.18	5.02	5.86	5.10	5.26	A<ALL C>BD
Program a BASIC Stamp II microcontroller using the PBASIC language to control the illumination of LEDs.	1.18	4.98	5.57	5.01	5.08	A<ALL
Program a BASIC Stamp II microcontroller using the PBASIC language to control the frequency and duration of sound output from piezospeakers.	1.15	4.90	5.51	4.90	5.01	A<ALL C>B
Fabricate a centrifugal pump driven by a DC motor with an impeller drawn in Solid Edge and printed on a rapid prototyping	1.15	4.71	4.71	4.33	3.86	A<ALL E<BC

machine.						
Utilize a mulitmeter to troubleshoot circuits and to measure the current, voltage and power usage of an electric pump.	1.39	4.68	5.03	4.57	4.48	A<ALL
Compute the efficiency and evaluate the performance of a centrifugal pump using DC circuit analysis, conservation of energy, and linear regression analysis.	1.21	4.61	4.89	4.70	4.63	A<ALL

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 9. In Table 9, the Spring 06-07 data represents the old curriculum and the other sections (B & C & D) represent the LWTL sections. Section D represents the honors sections from 07-08 and 08-09. These two sections were added together to obtain statistical significance. There appear to be 3 patterns:

1. The old curriculum is statistically lower than the LWTL sections. These occurrences are indicated in light green. (A<ALL)
2. The honors sections of LWTL are statistically higher than the other sections. These occurrences are indicated in yellow. (D>ALL)
3. Both 1 and 2 above are true. These occurrences are highlighted in mauve. (A<ALL and D>ALL)

The LWTL sections reported statistically higher confidence in ***15 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. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
4. 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.
5. 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.
6. Apply conservation of mass to batch and rate problems to compute the inputs, outputs and changes of system constituents.
7. 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.
8. 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.
9. Implement cascaded switching circuits consisting of transistors and relays to allow the BASIC Stamp II microcontroller to turn external components on and off.
10. Implement RC circuits and PBASIC programs to interface the BASIC Stamp II microcontroller with sensors.
11. Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.

12. Design a nickel-based RTD by computing the width and length of the resistor and by drawing the chosen resistor layout using Solid Edge.
13. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
14. Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.
15. Troubleshoot, test, and validate a system where the temperature and salinity of a small fluid volume are measured and controlled.

The honors sections of LWTL reported statistically higher confidence in 5 areas:

1. Present technical data in tables and on graphs in a professional manner.
2. Compute the molarity, concentration, and mass of the constituents in a salt water mixture.
3. Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.
4. Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.
5. Troubleshoot, test, and validate a system where the temperature and salinity of a small fluid volume are measured and controlled.

There is not an apparent reason that the honors sections reported a higher confidence in these 5 items. It is important to note that the LWTL curriculum improved the confidence of both regular and honors sections.

Table 9
ENGR 121 Specific Course Outcome Means - Confidence

Item	Baseline 06-07 N=56 A	LWTL 07-08 N=153 B	LWTL 08-09 N=214 C	Honors 07-09 N=52 D	*Sig
Utilize the prescribed solution format when solving problems.	5.14	4.98	5.05	5.38	
Work collaboratively with one or more other students.	5.20	5.18	5.05	5.27	
Present the results of assignments and projects using written communication.	4.88	4.89	4.84	5.10	
Present the results of assignments and projects using oral communication.	4.50	4.57	4.64	4.90	
Generate 3D models of engineering components and assemblies using Solid Edge.	4.54	4.78	4.76	5.02	
Present technical data in tables and on graphs in a professional manner.	4.66	4.99	4.90	5.42	D>ALL
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	3.17	4.88	4.73	4.87	A<ALL
Use linear regression analysis as appropriate in class projects.	3.98	4.85	4.65	5.25	A<ALL D>C
Utilize MathCAD to assist in solving engineering problems.	4.11	4.49	4.48	4.85	D>A
Utilize Excel to assist in solving engineering problems.	4.64	5.16	4.92	5.42	A<BD D>C
Use creative techniques to overcome at least one project difficulty.	4.45	4.70	4.62	5.06	D>AC
When I set a goal, I keep going after it no matter	5.05	5.10	4.84	5.17	

what the obstacles.					
I enjoy developing technical tools that improve the quality of life for people.	4.77	5.18	5.03	5.40	A<BD D>C
I intend to develop new products/processes during my career as an engineer.	4.57	4.99	5.06	5.15	A<CD
I prefer improving products/processes that already exist instead of developing something new.	4.63	4.29	4.18	4.21	
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	3.51	4.68	4.58	4.69	A<ALL
Compute the molarity, concentration, and mass of the constituents in a salt water mixture.	4.33	4.73	4.73	5.23	D>ALL
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	4.33	4.60	4.81	A<ALL
Apply conservation of mass to batch and rate problems to compute the inputs, outputs and changes of system constituents.	3.94	4.53	4.54	4.83	A<ALL
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	4.55	4.70	5.08	A<ALL
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	4.26	4.50	4.25	A<ALL
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	4.41	4.66	4.75	A<ALL
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	4.52	4.34	4.94	A<ALL D>C
Implement RC circuits and PBASIC programs to interface the BASIC Stamp II microcontroller with sensors.	1.60	4.36	4.47	4.75	A<ALL
Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.	1.48	4.66	4.64	5.10	A<ALL D>ALL
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	4.73	4.72	5.02	A<ALL
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	1.52	4.63	4.60	4.81	A<ALL
Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.	1.54	4.62	4.68	5.12	A<ALL D>ALL
Troubleshoot, test, and validate a system where the temperature and salinity of a small fluid volume are measured and controlled.	1.70	4.46	4.46	4.94	A<ALL D>ALL

The reported frequency of performance for all 29 outcomes is listed below in Table 10. The frequency for the LWTL sections is statistically higher than the old curriculum for the following **22 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. Utilize Excel to assist in solving engineering problems.
5. Use creative techniques to overcome at least one project difficulty.
6. When I set a goal, I keep going after it no matter what the obstacles.
7. I intend to develop new products/processes during my career as an engineer.
8. I prefer improving products/processes that already exist instead of developing something new.
9. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
10. Compute the molarity, concentration, and mass of the constituents in a salt water mixture.
11. 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.
12. Apply conservation of mass to batch and rate problems to compute the inputs, outputs and changes of system constituents.
13. 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.
14. 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.
15. 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.
16. Implement cascaded switching circuits consisting of transistors and relays to allow the BASIC Stamp II microcontroller to turn external components on and off.
17. Implement RC circuits and PBASIC programs to interface the BASIC Stamp II microcontroller with sensors.
18. Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.
19. Design a nickel-based RTD by computing the width and length of the resistor and by drawing the chosen resistor layout using Solid Edge.
20. Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.
21. Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.
22. 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 15 items where students reported statistically greater confidence in their ability in the "LWTLs" sections. 14 of those items were statistically greater in the frequency of performance table as well.

Table 10
ENGR 121 Specific Course Outcome Means - Performance

Item	Baseline 06-07 N=56 A	Robotics 07-08 N=153 B	Robotics 08-09 N=214 C	Honors 07-09 N=52 D	*Sig.
Utilize the prescribed solution format when solving problems.	5.71	5.41	5.62	6.00	D>B
Work collaboratively with one or more other students.	5.46	5.59	5.52	5.44	
Present the results of assignments and projects using written communication.	5.04	5.32	5.36	5.45	
Present the results of assignments and projects using oral communication.	3.91	4.27	4.38	4.38	
Generate 3D models of engineering components and assemblies using Solid Edge.	4.27	4.64	4.72	4.65	A<C
Present technical data in tables and on graphs in a professional manner.	4.29	4.95	4.98	5.27	A<ALL
Locate specifications and prices for the supplies, parts and systems used in course projects from manufacturers and on-line retailers.	2.11	4.60	4.71	4.73	A<ALL
Use linear regression analysis as appropriate in class projects.	3.65	4.72	4.90	5.17	A<ALL
Utilize MathCAD to assist in solving engineering problems.	4.71	4.53	4.55	4.88	
Utilize Excel to assist in solving engineering problems.	4.11	5.09	5.12	5.31	A<ALL
Use creative techniques to overcome at least one project difficulty.	3.95	5.07	5.09	5.25	A<ALL
When I set a goal, I keep going after it no matter what the obstacles.	4.89	5.72	5.59	5.67	A<ALL
I enjoy developing technical tools that improve the quality of life for people.	4.21	4.74	4.82	4.58	A<C
I intend to develop new products/processes during my career as an engineer.	4.17	5.05	4.93	4.75	A<BC
I prefer improving products/processes that already exist instead of developing something new.	4.10	4.73	4.73	4.69	A<BC
Given a current societal concern explain the trends and assess the implications in a broad engineering context.	3.04	4.76	4.65	4.69	A<ALL
Compute the molarity, concentration, and mass of the constituents in a salt water mixture.	3.85	5.16	5.00	5.10	A<ALL
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	4.74	4.88	4.63	A<ALL
Apply conservation of mass to batch and rate problems to compute the inputs, outputs and changes of system constituents.	3.76	4.97	4.97	4.98	A<ALL
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	4.62	4.88	4.77	A<ALL
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	1.90	3.76	4.31	3.17	A<ALL C>ALL

length of a segment wire.					
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	4.93	4.91	5.12	A<ALL
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	4.84	4.88	5.06	A<ALL
Implement RC circuits and PBASIC programs to interface the BASIC Stamp II microcontroller with sensors.	1.40	4.79	4.79	5.04	A<ALL
Explain the microfabrication steps and processes used to fabricate a resistance temperature detector – RTD.	1.34	4.50	4.62	4.33	A<ALL
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	4.13	4.38	3.83	A<ALL D>C
Program a BASIC Stamp II microcontroller using the PBASIC language to control the speed and direction of servos.	1.32	4.45	4.34	4.24	A<ALL
Design and fabricate a system where the temperature and salinity of a small fluid volume are measured and controlled.	1.28	4.41	4.85	4.56	A<ALL C>B
Troubleshoot, test, and validate a system where the temperature and salinity of a small fluid volume are measured and controlled.	1.34	4.64	4.97	4.87	A<ALL

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 11 and 12 respectively.

Table 11 shows the comparison between the old curriculum for ENGR 122 (A: Spring 06-07) and the LWTL (B, C, D, E, F) curriculum on all course outcomes. The honors sections from 06-07, 07-08, and 08-09 have been analyzed separately as shown in the table. Students in the new curriculum have confidence means that are statistically higher for the following ***13 items*:**

1. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
2. 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.
3. Implement an infrared LED/receiver circuit (IR pair) to detect objects.
4. Implement a Hall-effect sensor circuit as a proximity sensor.
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 no observed pattern in the honors sections in ENGR 122. There are no occurrences where the means for B, D, and F are greater than the other sections.

Table 11
ENGR 122 Specific Course Outcome Means - Confidence

Item	Baseline 06-07	Honors 06-07	LWTL 07-08	Honors 07-08	LWTL 08-09	Honors 08-09	*Sig.
	N=66	N=24	N=56	N=28	N=154	N=44	
	A	B	C	D	E	F	
Utilize the prescribed solution format when solving problems.	5.33	5.63	5.38	5.75	5.31	5.91	E<F
Work collaboratively with one or more other students.	5.51	5.63	5.36	5.36	5.22	5.50	
Present the results of assignments and projects using written communication.	4.91	5.00	5.11	5.32	5.03	5.23	
Present the results of assignments and projects using oral communication.	4.88	5.13	4.93	5.21	4.79	5.05	
Generate 3D models of engineering components and assemblies using Solid Edge.	4.52	4.38	4.88	5.07	4.82	5.07	
Generate 3D models of an innovative product using Solid Edge.	4.47	3.54	4.68	4.71	4.57	4.73	
Present technical data in tables and on graphs in a professional manner.	4.89	5.58	5.14	5.50	4.97	5.41	A<BDF B>E
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	5.06	5.09	
Purchase supplies and parts for an innovative product.	5.23	4.92	4.98	5.18	4.93	5.05	
Use linear regression analysis as appropriate in class projects.	4.05	5.13	4.80	5.11	4.51	4.84	A<BCDF
Utilize MathCAD to assist in solving engineering problems.	4.92	5.08	4.96	5.21	4.76	5.30	E<F
Utilize Excel to assist in solving engineering problems.	5.06	5.63	5.15	5.43	5.07	5.52	E<BF
Use creative techniques to overcome at least one project difficulty.	4.97	5.00	4.91	5.29	4.89	5.16	
When I set a goal, I keep going	5.28	5.04	5.18	5.25	5.05	5.23	

after it no matter what the obstacles.							
I enjoy developing technical tools that improve the quality of life for people.	4.77	5.00	5.40	5.29	5.10	5. 81	A<CF
I intend to develop new products/processes during my career as an engineer.	5.11	4.00	5.29	5.11	5.09	5.07	
I prefer improving products/processes that already exist instead of developing something new.	4.65	4.83	4.00	4.54	4.52	4.34	C<ABE
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	4.77	4.75	A<ALL
Apply statics to determine resultants of force systems.	4.92	5.43	4.89	5.14	4.79	5.09	B>E
Apply statics to determine unknown forces and moments for concurrent and non-concurrent force systems.	4.79	5.22	4.69	5.11	4.73	4.91	
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	4.71	4.86	A<ALL
Compute present worth, future worth, and annuity schedules to perform engineering economic analyses.	5.36	4.00	4.93	4.71	4.91	4.98	A>DE B<ACEF
Implement an infrared LED/receiver circuit (IR pair) to detect objects.	1.95	5.39	4.78	5.18	4.72	4.66	A<ALL
Implement a Hall-effect sensor circuit as a proximity sensor.	1.68	4.83	3.07	2.71	3.64	3.41	A<ALL B>ALL D<E
List the specifications and PBASIC commands to interface selected sensors to the BASIC Stamp II microcontroller.	1.30	5.17	4.85	5.00	4.66	4.81	A<ALL
Explain the physics behind how sensors function.	1.86	4.74	4.51	4.46	4.49	4.52	A<ALL
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	4.46	4.36	A<ALL
Create a Mind Map to organize ideas around a central topic.	2.67	3.96	5.07	4.82	4.86	5.05	A<ALL B<CEF
Apply the Pugh method to evaluate concept ideas.	1.48	4.87	4.38	4.39	4.61	4.48	A<ALL
Conceive a functional prototype of an innovative product that utilizes one or more sensors, actuators or other output devices,	1.62	5.09	5.00	5.00	4.78	5.16	A<ALL

and the BASIC Stamp II microcontroller.							
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	4.82	5.00	A<ALL
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	4.83	4.95	A<ALL
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	4.86	5.02	A<ALL
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	4.86	5.09	A<CDEF

Table 12 shows all course outcome means for frequency of performance in ENGR 122. The LWTL curriculum (B, C, D, E, F) is significantly higher than the old curriculum (A) for the following ***15 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. Utilize Excel to assist in solving engineering problems.
4. Given a current societal concern explain the trends and assess the implications in a broad engineering context.
5. 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
6. Implement an infrared LED/receiver circuit (IR pair) to detect objects.
7. List the specifications and PBASIC commands to interface selected sensors to the BASIC Stamp II microcontroller.
8. Explain the physics behind how sensors function.
9. Explain the roles of the ten "Faces of Innovation" as discussed in "The Ten Faces of Innovation" by Tom Kelley.
10. Create a Mind Map to organize ideas around a central topic.
11. Apply the Pugh method to evaluate concept ideas.
12. 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.
13. 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.
14. 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.
15. 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. 12 of the 13 items that are statistically significant in Table 11 are also statistically significant in Table 12.

Table 12
ENGR 122 Specific Course Outcome Means - Performance

Item	Baseline 06-07	Honors 06-07	Robotics 07-08	Honors 07-08	Robotics 08-09	Honors 08-09	*Sig.
	N=66	N=24	N=56	N=28	N=154	N=4	
	A	B	C	D	E	F	
Utilize the prescribed solution format when solving problems.	5.23	6.25	5.75	5.96	6.02	6.36	A<BDEF F>C
Work collaboratively with one or more other students.	5.98	6.08	5.70	5.57	5.82	6.00	
Present the results of assignments and projects using written communication.	4.50	5.25	5.32	5.54	5.50	5.80	A<CDEF
Present the results of assignments and projects using oral communication.	4.11	5.00	4.73	4.82	4.95	5.25	A<BCEF
Generate 3D models of engineering components and assemblies using Solid Edge.	4.14	3.54	4.38	4.32	4.50	4.64	A<EF
Generate 3D models of an innovative product using Solid Edge.	3.59	3.42	4.07	3.64	4.24	4.30	A<E
Present technical data in tables and on graphs in a professional manner.	4.00	5.38	4.78	5.07	5.16	5.32	A<ALL
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	4.98	5.05	A<ALL
Purchase supplies and parts for an innovative product.	4.23	4.25	4.35	4.46	4.75	5.89	
Use linear regression analysis as appropriate in class projects.	3.25	4.43	4.00	3.86	4.36	4.32	A<BEF
Utilize MathCAD to assist in solving engineering problems.	4.97	4.96	4.82	5.25	5.16	5.48	
Utilize Excel to assist in solving engineering problems.	4.44	5.46	5.13	5.21	5.23	5.32	A<ALL
Use creative techniques to overcome at least one project difficulty.	4.56	5.00	5.04	5.39	5.34	5.61	A<DEF
When I set a goal, I keep going after it no matter what the obstacles.	5.53	5.33	5.55	5.75	5.69	5.82	
I enjoy developing technical tools that improve the quality of life for people.	4.11	4.92	5.00	5.00	5.07	5.30	A<CEF
I intend to develop new products/processes during my career as an engineer.	4.60	4.91	5.42	5.29	5.31	5.39	A<CEF
I prefer improving products/processes that already exist instead of developing something new.	4.46	4.35	5.05	5.18	5.24	5.11	E>AB
Given a current societal concern explain the trends and assess the	3.28	4.87	4.58	4.46	5.01	4.89	A<ALL

implications in a broad engineering context.							
Apply statics to determine resultants of force systems.	4.91	5.35	5.25	5.29	5.44	5.59	A<EF
Apply statics to determine unknown forces and moments for concurrent and non-concurrent force systems.	4.73	5.00	5.18	5.25	5.31	5.48	A<EF
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	5.09	4.85	A<ALL
Compute present worth, future worth, and annuity schedules to perform engineering economic analyses.	5.14	4.65	5.09	5.00	5.30	5.27	
Implement an infrared LED/receiver circuit (IR pair) to detect objects.	1.71	5.35	4.36	4.39	4.57	4.36	A<ALL
Implement a Hall-effect sensor circuit as a proximity sensor.	1.52	4.30	2.31	2.14	3.49	2.91	A<BEF B>CDF E>CD
List the specifications and PBASIC commands to interface selected sensors to the BASIC Stamp II microcontroller.	1.27	5.04	5.27	5.46	5.35	5.48	A<ALL
Explain the physics behind how sensors function.	1.56	5.04	4.55	4.32	4.60	4.61	A<ALL
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	4.45	4.41	A<ALL
Create a Mind Map to organize ideas around a central topic.	2.09	2.96	4.11	3.71	4.52	4.34	A<CDEF B<CEF
Apply the Pugh method to evaluate concept ideas.	1.35	3.65	3.69	3.25	4.22	4.11	C<E
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	5.03	5.05	A<ALL
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	5.01	5.07	A<ALL
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	4.98	5.07	A<ALL
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	5.08	5.16	A<ALL
Develop a work plan to manage	3.61	4.39	4.82	4.68	5.06	5.14	

your time and resources to successfully produce a prototype of an innovative product.							A<CDEF

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 13 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 13
Professional Society Meetings and Student-Led Functions

	Count		
Course	07-08 AY	08-09 AY	Meeting/Function
120	9	0	American Chemical Society (ACS)
121	3	1	
122	8	0	
120	11	1	American Institute of Chemical Engineers (AIChE)
121	4	2	
122	5	1	
120	18	1	American Society of Civil Engineers (ASCE)
121	5	1	
122	2	1	
120	14	1	American Society of Mechanical Engineers (ASME)
121	3	2	
122	3	2	
120	7	1	COES project meetings/workdays (Steel Bridge, Concrete Canoe, etc)
121	3	1	
122	3	1	
120	3	0	Biomedical Engineering Society (BMES)
121	4	1	
122	0	1	
120	20	1	COES Events (Christmas Party, Gumbofest, etc.)
121	3	1	
122	0	1	
120	3	1	COES Speaker
121	3	2	
122	3	2	
120	3	0	Engineering and Science Association (ESA)
121	8	1	
122	0	1	
120	4	0	Institute of Electrical and Electronics Engineers (IEEE)
121	0	1	

122	4	1	
120	3	0	Institute of Industrial Engineers (IIE)
121	0	1	
122	1	1	
120	5	0	National Society of Black Engineers (NSBE)
121	0	1	
122	2	0	
120	3	1	Society of Automotive Engineers (SAE)
121	2	1	
122	2	0	
120	4	0	Society of Nanosystems Engineers (SNES)
121	2	1	
122	2	0	
120	4	0	Society of Women Engineers (SWE)
121	1	1	
122	2	0	
120	2	2	University Meetings (SGA, Union Board, etc)
121	4	1	
122	1	2	
120	1	0	University Service Projects (ES Day, The Big Event, etc)
121	0	1	
122	1	1	
120	1	1	Meeting Outside of University (Kiwanis, Church, etc)
121	2	2	
122	4	2	
120	8	3	Other Meetings
121	6	3	
122	21	3	

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 LWTL 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 2010)

Student Work Analysis-Design Symposium

The design project for ENGR 122 required students to prepare YouTube videos explaining their design. Although the quality of the videos varied, the best videos were amazing. In addition, students were required to use different media and approaches to explain their projects. All 44 students groups were able to create working projects. Among the 44 projects there were 40 distinct ideas. There were clear demonstrations of technical ability and team pride in the YouTube videos. Links to superior videos should be given to next year's class so that they have a better idea of the attributes of good presentations. It may be worthwhile to have next year's class evaluate several videos from this year. The faculty can select a range of videos for the students to review.

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 LWTL 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.

Robotics-Centered Curriculum (Summer 2010)

Faculty/Staff Interviews

A second site visit was conducted 28-June, 2010. The purpose of the site visit was to examine institutional support for LWTL and to determine if faculty who teach the courses immediately following the LWTL noticed any differences between students who participated in LWTL and those who did not.

Observations:

1. LWTL is completely institutionalized at Louisiana Tech: The LWTL sequence is required for all engineering majors. Faculty members from all programs participate in teaching in the sequence. Information about the program is used in recruiting students to Louisiana Tech. In addition, current students and alumni are excited about the program.
2. LWTL is sustainable. The costs of administering the program are paid for by charging the students for hardware and software. The costs to the students are reasonable. The costs are comparable to the cost of a textbook for three quarters.
3. LWTL gives students a better introduction to engineering than the old curriculum provided. Students can make a more informed decision about whether or not engineering is what they want to do.
4. LWTL is a powerful recruiting tool. Potential students like the idea of doing engineering immediately with real components.
5. Several faculty members feel that teaching LWTL is more difficult than a traditional course the first time that they teach it. After the first time, teaching LWTL is comparable to a traditional course. Even with the additional overhead the first time teaching the course, all faculty members felt the benefits to the students made up for the additional work.
6. The faculty members teaching LWTL are enthusiastic, motivated, and have a passion for the curriculum. They believe that the hands-on activities are vital to preparing students for an engineering career. The LWTL faculty members are dedicated to providing their students with a quality education.
7. Presentations on LWTL have been recognized at the ASEE National Conference.
    a. "LWTL: A Curriculum to Prepare Freshman Students to Meet the Attributes of "The Engineer of 2020"" by David Hall[1], Stan Cronk[1], Patricia Brackin[2], Mark Barker[1] and Kelly Crittenden[1]; [1]Louisiana Tech University; [2]Department of Mechanical Engineering, Rose-Hulman Institute of Technology. Received 2nd Place Award for the Best Paper for the Freshman Program Division at the ASEE 2008 Annual Conference and Exposition in Pittsburgh, PA.
    b. "LWTL: Sustainable Lab Experiences for Freshman Engineering Students" by Kelly Crittenden[1], David Hall[1], and Patricia Brackin[2]; [1]Louisiana Tech University; [2]Department of Mechanical Engineering, Rose-Hulman Institute of Technology. Received Best Paper Award from Division of Experimentation and Laboratory Oriented Studies at the ASEE 2010 Conference and Exposition in Louisville, KY.

8. The perceptions of the effect of the LWTL curriculum on students in the sophomore year were mixed.
    a. Students in ENGR 222 appeared the same or worse.
    b. The deviation in the preparation of students for ENGR 220 improved. The best students remained the same, but the preparation of poorer students improved significantly. This had the overall effect of raising the average preparation of students.
    c. Students in ENGR 221 were significantly better prepared. Their preparation in reading schematics and wiring circuits put the LWTL ahead of students in the old curriculum and allowed the faculty to save approximately one week.
9. There is a course champion who organizes the course materials including lecture notes, hardware, software, lab equipment, and the help desk. A course champion is needed to ensure the smooth running of LWTL. Currently there is one champion for ENGR 120, 121, and 122. There are additional champions for ENGR 220, 221, and 222.
10. The lecture notes, required hardware, consumable materials, required classroom space, requirements for the help desk have all been so well organized the overall LWTL can be easily described and disseminated to interested parties.

Suggestions:

1. Use peer evaluations to address the concern that 1 or 2 students may be doing the majority of work in the group. There is a free, validated instrument available at www.catme.org. In addition to peer evaluations there are various published approaches for encouraging group accountability: group tests; group homework; giving each group member the same grade which is equal the lowest grade attained by any group member on the tests; and giving a bonus grade to the group if all group members attain a certain score.
2. Students indicated that the help desk is sometimes closed unexpectedly. Establishing a method for notifying students is desirable. The method could be as simple as putting a message on a whiteboard or it could take the form of having a message displayed on the course web page.
3. Faculty members expressed the desire to engage students in discussions about ethics, globalization, and other pressing current issues. Consider having a LWTL seminar once each quarter. Attending this seminar could count as one of the professional development seminars required.
4. Consider having a dedicated space for ENGR 221 to facilitate hands-on activity. Assembling and disassembling equipment required for hands-on takes too much valuable class time.
5. The desire to seek Phase III funding should be pursued.
6. Consider non-traditional ways for advertising LWTL: billboards, Facebook, Twitter, in addition to the videos posted on YouTube.

The goals for the assessment efforts during the grant period 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. It is recommended that the surveys be shortened significantly and that questions about attending professional society meetings and student led functions be dropped. Students do not seem to be accurate in their recollection at the end of the quarter.

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. As the YouTube videos are developed, these videos could be viewed by external evaluators and rated based on a rubric. The student accomplishments are amazing and capturing these accomplishments can be beneficial for recruiting and accreditation purposes.

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 LWTL curriculum.

Questioning faculty members who teach sophomore courses revealed a net positive effect of the LWTL curriculum. It would be interesting to conduct interviews with faculty members who teach juniors and seniors to see if they detect any difference in the students who have been in the LWTL curriculum.

Quantification of Differences between Old Curriculum and New Curriculum

One of the major assumptions of the LWTL is that students' ownership and maintenance will result in students obtaining more hands-on practice. This assumption is dramatically demonstrated by examining Table 6. The data from that table, which indicates the "hands-on" application by class, indicates that the hands-on practice is ***more than 5 times greater than the "Old" curriculum over the course of the year.***

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.

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 22 items where the LWTL students reported a statistically greater confidence than the students in the old curriculum and 22 items where they reported a statistically greater frequency of performance than students in the old curriculum.

In addition, in ENGR 120 students reported a greater confidence in the following 5 items which were addressed in the old curriculum:

1. Present the results of assignments and projects using oral communication.
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.

It is assumed that the educational pedagogy employed in LWTL allowed students to develop a greater confidence in these areas. There is a possibility that developing a greater confidence will improve the retention statistics between ENGR 120 and ENGR 121 as compared to the retention statistics in the old curriculum and should be investigated.
For ENGR 121, there were 15 items where the LWTL students reported a statistically greater confidence and 22 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 LWTL reported a statistically greater confidence than students in the old curriculum and 15 items where they reported frequency of performance was statistically higher.

The preponderance of evidence indicates that the LWTL 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. Methods for exploring this relationship could be explored in later research.

Faculty interviews indicate that the LWTL curriculum better prepares students in ENGR 220 and ENGR 221. Consider following the performance of the LWTL students at internships and after graduation.

Items of Interest outside the Scope of the Project

The LWTL 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.

The infrastructure developed at Louisiana Tech is well documented. The lecture notes, required hardware, consumable material, requirements for the help desk, and required classroom space have all been so well organized that the overall LWTL can be easily described and disseminated to interested parties.

The effect of enthusiastic, dedicated and excellent faculty cannot be underestimated. The LWTL faculty members remain dedicated to preparing their students to be successful. In addition, the engineering administration supports the LWTL effort completely. In fact, the engineering administration would like to encourage the use of a technology platform to implement concepts in the upper division courses.

Attachment A

ENGR 120 Survey

ENGR 120 Survey Hardcopy.pdf

Attachment B

ENGR 121 Survey

ENGR 121 Survey Hardcopy.pdf

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.