AC 2008-1506: CREATIVE PROBLEM SOLVING COURSE – STUDENT PERCEPTIONS OF CREATIVITY AND COMPARISONS OF CREATIVE PROBLEM SOLVING METHODOLOGIES

Andrew Gerhart, Lawrence Technological University

Andrew Gerhart is an Assistant Professor of Mechanical Engineering at Lawrence Technological University. He is actively involved in ASEE, the American Society of Mechanical Engineers, and the Engineering Society of Detroit. He serves as Faculty Advisor for the American Institute of Aeronautics and Astronautics Student Chapter at LTU, and serves as chair for the LTU Leadership Curriculum Committee.

Donald Carpenter, Lawrence Technological University

Donald Carpenter is an Associate Professor of Civil Engineering at Lawrence Technological University. He is actively involved in ASEE, is a Kern Fellow for Entrepreneurial Education, and serves as Director of the Center for Teaching and Learning at LTU. His research interests involve academic integrity, assessment tools, and stream restoration.

Creative Problem Solving Course – Student Perceptions of Creativity and Comparisons of Creative Problem Solving Methodologies

Abstract

A new course in creative problem solving was developed and administered. The course explores the core competencies of creativity through in-class activities and games, as well as assigned work. In addition, the students study and implement various methodologies of creative problem solving through various problems and product development assignments. Teamwork is emphasized and each student is given at least two opportunities to act as a team leader during a problem solving or product development project. All students' leadership skills are both self-assessed and assessed by each team member.

On the first day of the course, the students were surveyed on their general perceptions of creativity, problem solving, teamwork , leadership, the role of creativity in engineering, and their personal view on their own creativity. After the course, the same survey was administered. A comparison of the pre and post-course surveys yields a shift in perceptions.

Six methods of creative problem solving were explored by the students. The methods, which vary in number of steps from four to eight, were compared and broken into five general steps. At the conclusion of the course, the students analyzed the effectiveness of the course.

1. Introduction

Historically, entrepreneurship at Lawrence Technological University (LTU) arose from two separate programs – one in the College of Engineering and the other in the College of Arts and Sciences. In the College of Engineering, it was recognized that graduates play many roles in industry, all of which require business and entrepreneurial skills. In response to this situation, the college developed the entrepreneurial certificate program and founded the Lear Entrepreneurial Center (LEC). The entrepreneurial certificate program provides a mechanism for developing student skills in communications and the business component of the engineering profession. The entrepreneurial program also includes an extensive multi-disciplinary capstone design experience in which students form a "company" and are eligible for student venture grants administered by the institution. The development of the entrepreneurial program was bolstered by the receipt of several multi-year grants. These grants strengthened the entrepreneurial certificate program and promoted innovative teaching on campus by conducting workshops and keynote lectures, awarding faculty curriculum and student venture grants, and providing faculty incentives to work with industry sponsored student teams. Specifically, the College of Engineering received a grant in 2006 as part of a larger initiative to develop the Kern Entrepreneurship Education Network.

The Kern Entrepreneurship Education Network (KEEN) was organized by the National Collegiate Inventors and Innovators Association (NCIIA) with support from the Kern Family

Foundation*. The goal of KEEN is to make entrepreneurship education opportunities widely available at institutions of higher learning, and to instill an action-oriented entrepreneurial mindset in engineering, science, and technical undergraduates. Participation in the network is limited to private institutions with ABET accredited engineering programs and is by invitation only. As of January of 2008, the KEEN program involves fourteen private institutions (primarily in the Midwest) and provides access to vital resources for building quality entrepreneurship education programs that engage engineering and technical students. KEEN provides a synergistic combination of grants, faculty fellowships, capacity building workshops, networking opportunities, and resources. KEEN provided financial and developmental resources to grantee institutions for the development of entrepreneurship curricula, modules, and extracurricular activities like business plan competitions, speaker series, student entrepreneurship clubs, and seminars. At LTU, the grant provided the funding to integrate the existing entrepreneurial programs into a new innovative interdisciplinary program focused on developing the "entrepreneurial mindset" on our campus. The skills associated with the entrepreneurial mindset are communication, teamwork, leadership, ethics and ethical decision-making, opportunity recognition, persistence, creativity, innovation, tolerance for ambiguity, risk analysis, creative problem solving, critical thinking, and business skills (including marketing, financial analysis, and strategic planning). The course described within this paper (EME 4981 Creative Problem Solving) was one of the courses developed as part of this initiative.

The Need for the Creative Problem Solving Course

At LTU and at most institutions, in the freshman year, all engineering students complete an "introduction to engineering" course. The course introduces the engineering design process, teamwork, and many design/build/test projects. These topics all cater toward problem solving and creativity. In the junior year, the students are doing plenty of "real-world" engineering and design in their coursework which also promotes creativity and teamwork. Unfortunately, there is a gap in learning experiences that promote creativity, teamwork and engineering design during the sophomore year when students are busy taking general humanities, mathematics, science, computer applications, and basic foundations of engineering courses (e.g., statics or circuits). At least two consequences result: 1) the students are not well-prepared for the upper-level junior and senior courses, and/or 2) many students lose interest in engineering and either leave the program or slack-off in grades. This gap is not only an issue in engineering curricula, but in many of the academic programs on throughout the campus.

To fill the gap, a sophomore-level problem solving course has been introduced. Being an entrepreneur requires not just problem-solving skills, but creativity and creative problem solving. The most successful entrepreneurs are typically those that have creatively found a niche or need to fill, and they continuously use creative problem solving to stay on the cutting edge and develop new ventures/products/solutions. Therefore, an ordinary problem-solving course was not introduced, but a *creative* problem solving course was (which is not necessarily only focused toward engineering majors).

* In 2007, the Kern Family Foundation brought the KEEN Program under direct supervision of the Foundation and the NCIIA is no longer involved in facilitating the program.

Teaching Creativity and Creative Problem Solving
As with leadership, some wonder if creativity can be taught and or if it is a gift that one either does or does not possess. It has been widely proven that creativity can be taught at all levels of education[1,2,3]. Creativity and creative problem solving have specifically been taught in engineering curricula for many years now[5,6,7,8]. A review of teaching creativity in engineering and the need to do so has been done by Stouffer et al.[1] and is beyond the scope of this paper.

2. The Course Structure and Content

The Creative Problem Solving course is a one credit-hour course. (LTU operates with 15 week semesters.) Since many assignments and exercises took place in class, the course was allotted two classroom hours each week. In fairness to the students, when larger projects were assigned for homework later in the semester, we did not use the full two classroom hours.

It should be noted that, as of the publishing of this paper, the course has been administered only once, and the students who enrolled in that offering of the course were all seniors and not sophomores for whom the course is intended. Although any class-level student was invited to enroll in the course, seniors were mostly encouraged for three reasons: 1) Many senior students had a single credit hour that needed to be earned because of extenuating circumstances with degree curriculum changes. 2) The course developer wanted to try much more material than the final version of the course would actually contain, hence more mature/advanced students could better handle the higher material load than a typical one credit hour course contains. 3) The instructor/course developer needed ample unfiltered comments and criticism of the course (i.e., what worked, what didn't) from experienced students. Seniors are soon graduating and will not have any subsequent courses, so their critical comments are made without feeling that it will be held against them in future courses. Also senior students have been through a lot of courses and can better distinguish what is a good learning environment and what is not.

The objectives of the course are as follows:
Upon completion of the course, the student will be able to:

1. use a variety of creative problem solving methodologies or strategies.
2. use techniques to inspire creativity.
3. approach and analyze unfamiliar situations and open-ended problems while using various methods to define the "true" problem.
4. assess the constraints, benefits, and risks of problems and their various solutions.
5. formulate a plan of action for solving problems following various methodologies.
6. formulate multiple creative solutions to a given problem or design.
7. interact confidently in a variety of roles in a team.
8. take the leadership role on a team which is investigating difficult solutions.
9. use various tools and methods for managing a project.

Various teaching and learning strategies were implemented to reach the course objectives. While there were some classroom lectures, a good portion of the classroom instruction was completed through games and hands-on activites[1,8,9,10]. The games are crafted to emphasize core creativity competencies and/or steps of a creative problem solving methodology. In addition to the in-class games, some individual homework activities were assigned, and many small projects and problem-solving activities were assigned that were completed through teamwork. These out-of-class activities will be described later in the paper. Each student was required to act as team leader twice during the semester.

The course was formatted so that basic skills and tools were developed before moving to subsequent skills that relied upon the previous ones. For example, before creative problem solving can be learned and put to good use, 1) creativity and teamwork must be understood and 2) being creative must be practiced. Therefore the general format of the course was as follows:
Weeks 1 and 2: Define creativity and teams, perform team-building exercises, investigate leadership styles.
Weeks 3 through 6: Investigate the core competencies of creativity (Capturing, Challenging, Broadening, Surroundings)[2] through games, projects, individual homework, and problems.
Weeks 7 through 15: Investigate six creative problem solving methodologies.

During the first two weeks of class, we discussed what creativity is, who is creative, and broke down any myths about creativity. As will be seen in the Student Perceptions section of this paper, these discussions helped change some preconceptions of the students. The team-building exercises emphasized various functions of teams and also required the students to come into physical contact with one another to break down any barriers and quickly "break the ice." This proved to be very valuable as the camaraderie in the class was conducive to a strong learning environment. In addition during the team-building exercises, various students were asked to take a lead role given unusual constraints/circumstances which illustrated good and bad traits of team leaders.

Over the next four weeks, the four core competencies of creativity were investigated and practiced. (A few other worthwhile topics were investigated as well such as Bisociation[8,9].) The creativity competencies were derived from Generative Theory research[11,12] and were summarized for classroom instruction by Epstein[2]. They are:

- Capturing – preserving and producing new ideas
- Challenging – seeking challenges and managing them to spur new ideas
- Broadening – exploring new skills, knowledge and training outside your area of expertise
- Surrounding – changing your physical and social environment

Each competency has one or more accompanying in-class activity (i.e., game) that reinforces the skill. The students commented that the games emphasizing and using these competencies were especially worthwhile, not simply because they were fun, but because they reinforced retention. At the end of the sixth week, the students completed a shortened version of the Epstein Creativity Competencies Inventory for Individuals (ECCI-i)[2]. A full, validated test is available[13], but for the purposes of the course, the shortened version allowed each students a general determination of which creativity competencies were strongest and which need more focus.

During these four weeks, a series of out-of-class team problem-solving exercises were begun. Depending on the scope of the problem, one to two weeks was allowed for solution. In order to solve each problem, various "clues" (i.e., pieces of information) were collected around the LTU campus; therefore the series of exercises were called clue hunts. The objectives of the clue hunts were similar to the objectives of the course but on a smaller scale: the students attempted multi-day problem solving exercises requiring creative problem solving methods, practiced creativity competencies, practiced team problem solving, and applied good leadership practices. The students formed teams of three, and six clue hunts were administered. Examples of the clue hunts are given in Appendix A. For each clue hunt, there was, by design, no single correct solution. Each team had to report to the instructor possible solution methods within 48 hours. Upon approval, the team had the next four days to obtain answers. For their report, the team had to describe 1) the creative competencies used and how they were used and 2) how a creative problem solving methodology was used. Each team member was required to take a turn as team leader. During the first three clue hunts, each team member had the chance to be a leader for the first time. Upon completion of the solution report, each team member including the leader assessed the leader's strengths and weakness without necessarily knowing what exactly constitutes a good leader. This served as a learning experience where each student decided what s/he wanted to see from a leader or what s/he should work on as a leader. For the last three clue hunts, each student was required to serve as leader one more time, but this time a more formal leadership assessment was performed. Various leadership skills were stated on a form and each statement was rated with a 5 point scale. The leader was given the completed forms, which included a self-assessment, to study and keep. In summary, the clue hunts strengthened creative problem solving skills, facilitated the use of creativity competencies, emphasized team-work, and fostered good leadership practices.

While the clue hunts continued, creative problem solving methodologies were studied and practiced during the last nine weeks of the course. While many creative problem solving methodologies exist, the instructor found six popular and commonly used methodologies, which vary in the number of steps from four to eight. Upon investigation, all six methodologies have very similar or identical steps; even the sub-steps overlapped. It should be noted that not all of the methodologies are followed with a step-by-step linear approach. Nonetheless, to facilitate learning of the methodologies, the steps could be organized into one "grand" creative problem solving approach that consisted of five steps. By doing this, repetition was avoided, and the classroom time was used more efficiently. Essentially the steps are A) Planning your approach, B) Defining the correct problem/understanding the challenge, C) Generate Ideas/Alternatives – Brainstorm, D) Decide course of action/Preparing for action/Carry through/Implement, E) Acceptance and Evaluation. Table 1 shows the general steps of the six methodologies studied and references for each method are given. The letters beside each step correspond to steps A-E listed above. Just because the steps are combined does not mean that there is no room for variation or flexibility. Within each step are sub-steps that may or may not be needed for a particular problem. Also, there are instances when you will return to a previous step and repeat it (more than once perhaps). In fact, each team in the class typically followed a slightly different methodology from the others to solve problems even though the overall steps were similar.

Because there are so many sources used for the course, no single textbook was chosen for the students to purchase. Instead short classroom activities, lectures, handouts, homework problems, and the clue hunts were used to teach the creative problem solving methodology. With these methods, excessive note-taking was not necessary. Before the course began, the instructor/course developer had some concern that the material would be confusing without a textbook (or two). In a following section of this paper, the students indicate that the concern was unfounded.

Question and Answer[14,15]	CPS[14,15,16]
A What is wrong? A What do we know? B What is the real problem? C/D What is the best solution? D/E How do we implement the solution?	A Mess Finding A Data Finding B Problem Finding C Idea Finding D Solution Finding E Acceptance Finding
CPS Version 6.1[3]	**Simplex[14,15,17]**
A Planning your approach B Understanding the challenge C Generating Ideas C/D/E Preparing for action	A Problem finding A Fact finding B Problem defining C Idea finding D Evaluating and Selecting D Action planning E Gaining Acceptance D/E Taking Action
Lumsdaine[18,19]	**McMaster 5 point[20, 21]**
A/B Problem definition C Brainstorming C Creative evaluation C/D Judgment D/E Implementation	A/B Define the problem C Generate solutions/alternatives D Decide course of action D Implement solution / carry through E Evaluate solution

Table 1. The six creative problem solving methodologies studied.

Except for the final (sixth) clue hunt, the students did not need to use all steps in creative problem solving; only elements were used. Therefore toward the end of the semester, a capstone team project was assigned that encompassed all creative core competencies and all creative problem solving steps. During the seventh week of the course, the students watched an ABC News Nightline program titled "The Deep Dive." A "think-tank" company, IDEO, was asked by the ABC program's producers to develop a new design for a shopping cart within one week – an extraordinarily tight timeline. A homework assignment was given wherein each student identified the core competencies used by IDEO, the methodology followed by IDEO, and potential problems with the final cart design (likely due to the short timeline). The problems identified by each student were collected (16 total!), and on week ten, a capstone team project was assigned wherein the students had to re-design IDEO's new shopping cart while using the entire creative problem solving method. The students were given four weeks to complete the design and submit a report. Finally, a formal final examination was not administered, but instead, each team orally presented the new shopping cart design to the instructor and other teams (and of course, it was thoroughly critiqued by all!).

3. Students' Perceptions and the Influence of the Course

The public does not commonly perceive engineers as creative professionals. Less than ten years ago, a Harris Poll sponsored by the American Association of Engineering Societies and IEEE-USA "found that only 2 percent of the public associate the word 'invents' with engineering; [and] only 3 percent associate the word 'creative' with engineering."[1, 22, 23] It is likely that this image is also in the minds of engineering students, especially underclassmen that have not yet done much design and open-ended problem work. If the students don't believe they are creative and do not get to practice creativity, enthusiasm for continuing engineering study and retention in engineering education could suffer.

On the first day of the course, the students were asked about their personal view on their own creativity, the role of creativity in engineering, problem solving, teamwork, and leadership. After the course, the same survey was administered. The survey was quantified using a 5-point Likert scale. The course enrollment was low since it was a pilot course, so results compiled in this paper are derived from six student surveys. While this is a small sample size, it should be noted that the deviation between responses was relatively small and the students were of the more dedicated type (which perhaps adds higher credibility to their responses).

<u>Perceptions of Creativity</u>

Table 2 indicates the percentage of students agreeing with statements concerning creativity before the course and after the course. Table 3 presents the same material as Table 2 except with the actual ratings from the 5-point scale, which to some is a bit easier to read and perhaps more meaningful because of the small sample size. The results for statement 1 indicate a slight increase in the student perception of being creative either because the course proved this to them or because the course improved their creative capacity. There was no change in the response to statement 2, but notice that the students strongly understand that creativity is an important part of engineering. Statements 3 and 4 experienced the largest shift in perception. The cause of this upward shift is unknown, but it is speculated that once the students realized that they were creative, then logic would indicate that anyone may be.

	strongly disagree		disagree		no opinion		agree		strongly agree	
	pre	post	pre	post	pre	post	pre	post	pre	post
1: I am a creative person.	0	0	0	0	16.7	0	**50**	50	33.3	50
2: Creativity is important to the engineering profession.	0	0	0	0	0	0	33.3	33.3	**66.7**	**66.7**
3: Artists (painters, musicians, poets, etc.) are creative people.	0	0	16.7	0	0	0	**66.7**	50	16.7	50
4: Engineers are creative people.	0	0	0	0	**50**	0	33.3	**66.7**	16.7	33.3

Table 2. Percentage of students agreeing with the statements concerning creativity before the course and after the course

	Average		Standard deviation	
	pre	post	pre	post
1: I am a creative person.	4.17	4.50	0.75	0.55
2: Creativity is important to the engineering profession.	4.67	4.67	0.52	0.52
3: Artists (painters, musicians, poets, etc.) are creative people.	3.83	4.50	0.98	0.55
4: Engineers are creative people.	3.67	4.33	0.82	0.52

Table 3. Students' ratings of statements concerning creativity before the course and after the course. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

<u>Perceptions of Problem Solving</u>

Table 4 indicates the percentage of students agreeing with statements concerning problem solving before the course and after the course. Table 5 presents the same material as Table 4 except with the actual ratings from the 5-point scale. For statements 5, 6, and 8, it was encouraging to see an upward shift in perception. For statement 7, there was no change, but this is not surprising; the course material presented opportunities for devising multiple solutions, but the skill is unlikely to be changed much from a 15 week course. The responses to statement 9 decreased as was hoped. The activities used for the core creativity competency "challenging" helped the students to realize that solution failure is a necessary part of creating new, better solutions.

	strongly disagree		disagree		no opinion		agree		strongly agree	
	pre	post	pre	post	pre	post	pre	post	pre	post
5: I enjoy solving problems.	0	0	0	0	0	0	**66.7**	33.3	33.3	**66.7**
6: I am a good at solving problems.	0	0	0	0	0	0	**100**	66.7	0	33.3
7: When confronting a new problem, I am good at devising many possible solutions.	0	0	0	0	16.7	16.7	**66.7**	**66.7**	16.7	16.7
8: When solving a problem, I will try many possible solutions.	0	0	0	0	**66.7**	16.7	33.3	**66.7**	0	16.7
9: I am discouraged when my solution to a problem fails.	0	0	**66.7**	**100**	33.3	0	0	0	0	0

Table 4. Percentage of students agreeing with the statements concerning problem solving before the course and after the course

	Average		Standard deviation	
	pre	post	pre	post
5: I enjoy solving problems.	4.33	4.67	0.52	0.52
6: I am a good at solving problems.	4.00	4.33	0	0.52
7: When confronting a new problem, I am good at devising many possible solutions.	4.00	4.00	0.63	0.63
8: When solving a problem, I will try many possible solutions.	3.33	4.00	0.52	0.63
9: I am discouraged when my solution to a problem fails.	2.33	2.00	0.52	0

Table 5. Students' ratings of statements concerning problem solving before the course and after the course. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

Perceptions of Teamwork and Leadership

Table 6 indicates the percentage of students agreeing with statements concerning teamwork and leadership before the course and after the course. Table 7 presents the same material as Table 6 except with the actual ratings from the 5-point scale. For statement 10, the students believed that they were better leaders than first perceived. The opportunities to practice leadership must have been encouraging to these students. On the other hand, one student downgraded the importance of engineers to be an effective leader. Perhaps his/her team performed quite well even without an effective leader. The students only showed a slight upward shift in the importance to work in teams for problem solving. On the other hand, the students showed an increased preference to work in teams. It should be noted that one student may have misread the responses to statement 13 or 14. That student disagreed to working alone, but also disagreed with working on a team.

	strongly disagree		disagree		no opinion		agree		strongly agree	
	pre	post	pre	post	pre	post	pre	post	pre	post
10. I am an effective team leader.	0	0	0	0	33.3	16.7	**66.7**	50	0	**33.3**
11. It is important for engineers to be effective leaders.	0	0	0	0	0	16.7	**66.7**	33.3	33.3	**50**
12. It is important to work in a team to solve problems.	0	0	16.7	16.7	0	0	**66.7**	50	16.7	**33.3**
13. I prefer to work alone when solving a problem.	0	0	**50**	**83.3**	33.3	16.7	0	0	0	0
14. I prefer to work with others when solving a problem.	0	0	0	16.7	**50**	16.7	**50**	50	0	16.7

Table 6. Percentage of students agreeing with the statements concerning teamwork and leadership before the course and after the course

	Average		Standard deviation	
	pre	post	pre	post
10: I am an effective team leader.	3.67	4.17	0.52	0.75
11: It is important for engineers to be effective leaders.	4.33	4.33	0.52	0.82
12: It is important to work in a team to solve problems.	3.83	4.00	0.98	1.10
13: I prefer to work alone when solving a problem.	2.67	2.17	0.82	0.41
14: I prefer to work with others when solving a problem.	3.50	3.67	0.55	1.03

Table 7. Students' ratings of statements concerning teamwork and leadership before the course and after the course. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

Overall Perceptions and Sum Differentials

Table 8 is a bit overwhelming, but is important to include for those that want to carefully investigate each student's perception change and to analyze the overall differential in responses. The major for each student is indicated; five are mechanical engineering students and one is a computer engineering student.

Each student's statement response on the post course survey was subtracted from the pre course survey response and then the differentials were summed. Based on the statements (see tables above), a positive effect is sought for statements 1-8, 10-12, and 13-14 (noted as Sum A). A negative effect is sought for statements 9 and 13 (noted as Sum B). Note that just because there is a zero summed differential does not mean that no student responses changed. In fact in some cases, many of the individual responses changed in both the positive and negative direction and canceled one another out.

One important row to note is the sum differential for each statement at the bottom of the table. The greatest increases were seen in statements 3, 4, 8, and 10. Statement 3 was the perception that artists are creative people and 4 was the perception that engineers are creative people. It is no surprise that spending 15 weeks studying creativity and problem solving will increase the awareness of creativity among others. Statement 8 was posed as "When solving a problem, I will try many possible solutions." Notice the future tense of this statement. This is the only statement posed as future tense and therefore is not surprising that it has one of the greatest increases. The students are responding to the advice given in the course that it is a good idea to try many possible solutions; they perceive that they should or would like to do so in the future. That does not mean that they *actually* will be able to. According to the summed differential for statement 10, the students believed that they were better leaders than first perceived (as was noted in a previous paragraph). There are few engineering courses where a student is given a chance to be a team leader with feedback and then get to lead the same team again while fixing what was negative the first time (and then given more feedback!). Each student honed the skill and discovered, "Hey, I can do this."

For statement 2, a zero summed differential is no surprise; the students believed very strongly before the course that creativity is important to the engineering profession. They probably would not have enrolled in the Creative Problem Solving course if they thought creativity was not important. Statements 7 and 11 also have a zero summed differential. These statements were addressed in previous paragraphs.

The negative summed differentials are seen for statements 9 and 13. In those two instances a negative number is a good result. For statement 9, the activities used for the core creativity competency "challenging" helped the students to realize that solution failure is a necessary part of creating new, better solutions. For statement 13, the students found through the course emphasis on teamwork, that one individual will not solve a problem (or develop a product) as effectively as will many minds working toward a common goal.

Turning attention now to the "Sum A" column, with two exceptions the students showed a considerable positive increase. Student 6 shows little change in responses. Student 2 is the only student with a negative summed differential. That student has three instances where there is a negative differential to a statement where a negative differential is not preferred by the authors (i.e., statements other than 9 and 13).

Finally column "Sum B" reveals zero to small negative differentials. When a student disagreed with statements 9 and 13 before the course, it was not the intention of the course to make the student strongly disagree with these statements. For example, there will be *some* instances when one would get discouraged with a failure to a solution and *some* instances when one prefers to work alone.

Student	Statement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Sum A**	**Sum B**
1 (ME)	Pre	4	4	4	4	4	4	4	3	2	4	4	5	2	4		
	Post	5	5	4	4	4	5	4	4	2	4	4	5	2	4		
	Diff.	1	1	0	0	0	1	0	1	0	0	0	0	0	0	**4**	**0**
2 (ME)	Pre	5	5	4	3	5	4	5	4	2	4	5	4	3	3		
	Post	5	4	5	5	5	4	5	4	2	4	5	2	2	2		
	Diff.	0	-1	1	2	0	0	0	0	0	0	0	-2	-1	-1	**-1**	**-1**
3 (ME)	Pre	4	4	4	3	5	4	4	4	3	3	4	4	2	4		
	Post	4	5	4	4	5	5	4	4	2	3	5	4	2	4		
	Diff.	0	1	0	1	0	1	0	0	-1	0	1	0	0	0	**4**	**-1**
4 (ME)	Pre	5	5	5	5	4	4	4	3	2	4	4	4	2	4		
	Post	5	5	5	5	4	4	4	4	2	5	5	5	2	5		
	Diff.	0	0	0	0	0	0	0	1	0	1	1	1	0	1	**5**	**0**
5 (ME)	Pre	3	5	2	3	4	4	3	3	2	3	5	4	3	3		
	Post	4	4	5	4	5	4	4	5	2	5	3	4	2	4		
	Diff.	1	-1	3	1	1	0	1	2	0	2	-2	0	-1	1	**9**	**-1**
6 (CompE)	Pre	4	5	4	4	4	4	4	3	3	4	4	2	4	3		
	Post	4	5	4	4	5	4	3	3	2	4	4	4	3	3		
	Diff.	0	0	0	0	1	0	-1	0	-1	0	0	2	-1	0	**2**	**-2**
Sum Dif.		**2**	**0**	**4**	**4**	**2**	**2**	**0**	**4**	**-2**	**3**	**0**	**1**	**-3**	**1**	*17*	

Table 8. Student ratings of statements concerning creativity, problem-solving, teamwork, and leadership. Pre-course and post-course survey differentials are included for each student for each statement. Summed differentials are included for each student. Sum differentials are included for each statement. Note column "Sum A" is for statements 1-8, 10-12, and 13-14, while "Sum B" is for statements 9 and 13.

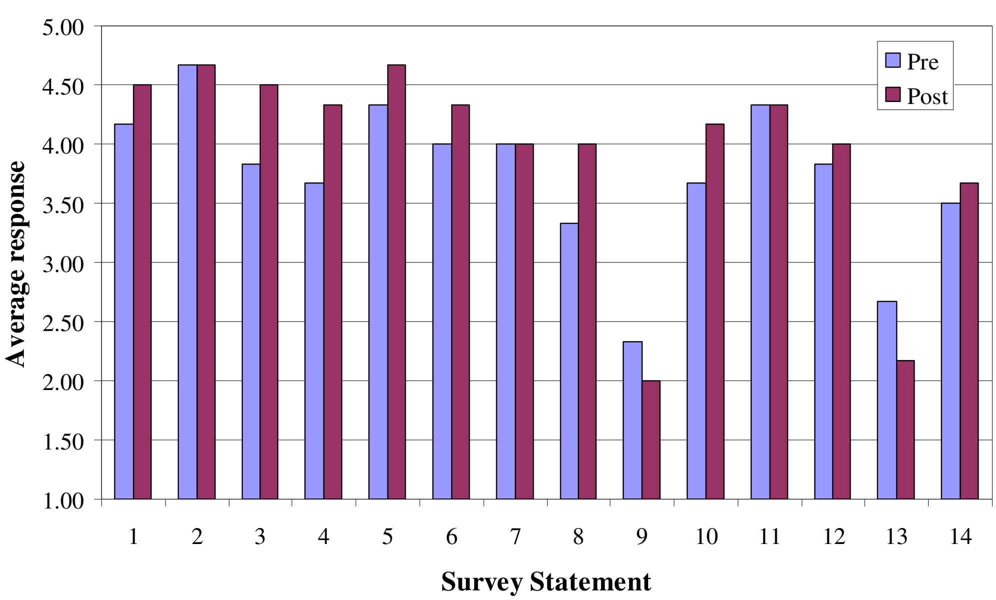

Figure 1. Students' ratings of statements concerning creativity, problem-solving, teamwork, and leadership before the course and after the course. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

Figure 1 presents average student responses to each statement in a bar graph. This information was presented earlier in the paper, but is given in bar graph format to visualize the overall responses and changes from pre course to post course.

4. Students' Opinion of the Course

The students were asked to rate statements concerning their overall perception of the Creative Problem Solving course. Note that the course is 15 weeks long and was worth one credit hour. The classroom hours were approximately 90 minutes per week instead of the traditional 50 minutes, because the in-class activities were given approximately the same weight as out-of-class activities. Table 9 shows the results of the student perceptions, and three conclusions can be drawn. 1) One credit hour is sufficient. 2) The students enjoyed the course. 3) The students found the course worthwhile as it met their expectations.

	Average	Standard deviation
Typically for every one credit hour, 3 to 4 hours per week of student time in and out of the classroom is expected. With this in mind, the one credit hour was properly reflected in the time I spent on this course.	4.00	0.63
How would you rate your experience for the course?	4.17	0.41
I got what I wanted out of this course (the course met my expectations).	4.33	0.52

Table 9. Student ratings of statements about the Creative Problem Solving course. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

At least four textbooks about creative problem solving were found to be appropriate for the course. Unfortunately, each book was specific to one particular problem solving method (all of which are presented in Table 1). Obviously, the students should not be expected to purchase all of the possible textbooks, and there was some repetition in material/topics between the textbooks. It was ultimately decided that no textbook would be required for the students, but the instructor would supply abundant notes and hand-outs. At the conclusion of the course, the students were asked, "Should the students have a textbook for this course (assuming cost is negligible)?" Four of the six students responded "no, note-taking and handouts were fine." Not realizing that this would be the response, the students next rated the statement, "Regardless of your answer for the previous question, assume a textbook was required for this course. I believe that it is within reason to purchase two textbooks to be used for this course if they were each only ~$25." On a scale of 1 to 5, where 1 indicates "strongly disagree" and 5 indicates "strongly agree," the average rating was 3.33 with a standard deviation of 1.51. The results in Table 10 indicate that opinion varied widely, but overall the students mostly agreed that two textbooks would be reasonable. Students then rated the statement, "Regardless of your answer for the previous question, assume a textbook was required for this course. I believe that it is within reason to purchase three textbooks to be used for this course if they were each only ~$25." The average rating was 2.33 with a standard deviation of 1.03. Again, opinion varied widely, but Table 10 indicates that three textbooks would be excessive. Upon reflection, it is never a bad idea for the students to have at least one good reference book, and notes can be messy or undecipherable (especially as time lapsed since completion of the course grows). Therefore because of the low cost, future offerings of the course may require the most general and succinct of the textbooks. (The course developer recommends Fogler and LeBlanc[21].)

	strongly disagree	disagree	no opinion	agree	strongly agree
I believe that it is within reason to purchase <u>two</u> textbooks to be used for this course if they were each only ~$25.	16.7	16.7	0	**50**	16.7
I believe that it is within reason to purchase <u>three</u> textbooks to be used for this course if they were each only ~$25.	16.7	**50**	16.7	16.7	0

Table 10. Percentage of students rating statements regarding textbooks required for the course.

Table 11 shows the percentage of students rating the level of the material of the course. In general, the students found the level to be just right. On a scale of 1 to 5, where 1 is "too advanced", 3 is "just right", and 5 is "too easy", the average LTU student response was 2.83 and the standard deviation was 0.41. All of the students except one rated the course as "just right." The one student that rated the course "somewhat advanced" added the comment, "A lot of similar ideas [were often presented], but different wording/methods got confusing." Probably because of this response, this student was one of only two that believed that there should be a textbook for the course. The student was the only student that "strongly agreed" that there should be *two* textbooks (if ~$25 each) and the only student that "agreed" there should be *three* textbooks (if ~$25 each).

Keep in mind that these level-of-material ratings are from senior students, and the course may be offered for sophomore students. Therefore the course may be more advanced than the responses imply. However, extra material was presented in this first-offering of the course to discover what was and was not successful for future offerings. Therefore, in future offerings, the course will be more refined, the equivalent topics will be better combined, and the pace will be slower. Consequently, it is assumed that the course will be at the proper level for sophomores.

	too advanced	somewhat advanced	just right	somewhat easy	too easy
The level of material for the course was	0	16.7	**83.3**	0	0

Table 11. Percentage of students rating the level of material of the course

To ensure that poor course instruction was not a factor to student perceptions presented in this paper, the students rated statements concerning the course instructor on a scale of 1 to 5, where 1 indicates "strongly disagree" and 5 indicates "strongly agree." Table 12 indicates the instructor performed very well.

	Average	Standard deviation
The instructor's presentations/materials/activities were well prepared.	4.83	0.41
How do you rate the instructor's ability to impart the course material?	4.67	0.52
How would you rate the instructor's overall performance?	4.67	0.52

Table 12. Student ratings of statements concerning the course instructor. On a scale of 1 to 5, 1 indicates "strongly disagree" and 5 indicates "strongly agree."

5. Student Comments Regarding the Course

Students were asked to comment on what they liked about the course. Four of the six students commented that they liked the games and activities (no surprise there). One student noted, "The course shows that everyone can be creative." Another student noted that "most clue hunts were interesting/thought provoking problems (although they did not always involve being 'creative')." The same student also stated, "Long-term teams help form 'bonds,' we know what to expect from each other." Another stated similarly, "The interaction and involvement of the class as team worked out very well." A student noted that "the games stimulated creativity," and another stated "the entire course stimulated the mind." Finally a student "liked being exposed to the multiple techniques used in Creative Problem Solving."

Next the students were asked what should be changed. Note that at the beginning of the semester, the instructor asked the students to keep logbooks to record project notes, team meetings, etc. Three students commented that the logbooks should be eliminated, with one of them stating, "The logbooks seemed to be redundant as the work was mainly done on the PC." Since the classroom games were mostly to reinforce the core creativity competencies, the games were grouped at the beginning of the semester. Therefore, five of the six students stated that the games should be more spread out and interspersed with the lectures during the second half of the semester. Unfortunately, the core competencies should be learned before the creative problem solving, and there are not many in-class games for the second-half material; creative problem solving caters better to out-of-class assignments that are broader than what can be done in-class. Consequently, the games can not interspersed throughout the semester. Finally one student commented that presenting six methods was a bit confusing: "Present just a few methods to keep things simple…and clear…. or even create your own [method] using the ABCDE that you applied, to keep things simple and clear."

The students were asked for any additional comments or observations. The students commented on the lectures: "The later lectures were not so fun with so many notes/handouts/ideas presented continuously." "Some of the lectures got a little long (especially at the end of the semester), but I enjoyed the class and found pretty much all of the material interesting." Many of the comments were very positive: "This class was a great experience. You made it enjoyable to come to every session." "Overall was a good class." "It was fun when we did activities then discussed what they meant." "Overall, the class involved excellent teambuilding and problem solving skills. I would recommend it to anyone."

6. Conclusion

A Creative Problem Solving course has been developed and administered that raises/improves perceptions of creativity, teamwork, leadership, and problem-solving. The coursework included fun activities that encouraged understanding and retention of key entrepreneurial skills. Six creative problem solving methodologies were studied and combined into a single methodology to facilitate practice and learning of the multiple concepts. Although only engineers were enrolled in this first offering of the course, the course content is general enough so that it can be offered in any college major. In conclusion, the course is not only worthwhile for upperclassmen but can be administered at nearly any class-level (e.g., sophomore students).

Acknowledgements
The authors offer thanks to the Kern Entrepreneurship Education Network (KEEN) for supporting the development of the course; Dr. Maria Vaz for support in making the course a reality; Professor Greg Feierfeil for supplemental course materials, his sage advice, and approving the course into the LTU Entrepreneurial Program; and Dr. Steven Howell for allowing the pilot course into the mechanical engineering course offerings.

References

1. Stouffer, W.B., Russell, J.S., and Olivia, M.G. (2004) "Making the Strange Familiar: Creativity and the Future of Engineering Education." *Proceedings of the 2004 American Society for Engineering Education Annual Conference and Exposition*, Salt Lake City.
2. Epstein, R. (2000) *Big Book of Creativity Games – Quick, Fun Activities for Jumpstarting Innovation*. McGraw-Hill.
3. Treffinger, D.J., Isaksen, S.G., and Stead-Dorval, K.B. (2006) *Creative Problem Solving – An Introduction*, 4th Ed. Prufrock Press, Waco, TX. pg. 5.
4. Ghosh, S. (1993) "Exercise in inducing creativity in undergraduate engineering students through challenging examinations and open-ended design problems," *IEEE Transactions on Education*, 36(1) pp. 113-119.
5. Masi, J. V. (1989) "Teaching the process of creativity in the engineering classroom," *Proceedings of 1989 IEEE Frontiers in Education Conference*, pp. 288-292.
6. Richards, L. G. (1998) "Stimulating creativity: Teaching engineers to be innovators," *Proceedings of 1998 IEEE Frontiers in Education Conference*, 3, pp. 1034-1039.
7. Sanoff, A. P. (2003) "Engineers for All Seasons," Prism, 12(5), pp. 30-33.
8. Michalko, M. (2006) *Thinkertoys – a handbook of creative-thinking techniques*, 2nd Ed, Ten Speed Press, Berkeley, CA.
9. Weaver, J. (2007) *Creativity Exercises with a Moral Workshop*, Lawrence Technological University Center for Teaching and Learning, April 13, Southfield, MI.
10. Lumsdaine, E. and Lumsdaine, M. (2004) *How to Teach Creativity and Innovation in Technical and Professional Programs Workshop*, Lawrence Technological University Educational Collaboration Initiative, May 13, Southfield, MI.
11. Pritzker, S.R. and Runco, M.A., Editors. (1999) *Encyclopedia of Creativity*, Academic Press.
12. Epstein, R. (1996) *Cognition, Creativity, and Behavior: Selected Essays*, Praeger Publishers.
13. InnoGen International, 1-877-INNOGEN or www.innogen.com. January 2008.
14. Gomez, A.G., Oakes, W.C., and Leone, L.L. (2004) *Engineering Your Future – A Project-Based Introduction to Engineering*, Great Lakes Press.
15. Oakes, W.C., Leone, L.L., and Gunn, C.J. (2006) *Engineering Your Future – A Comprehensive Introduction to Engineering*, 5th Ed., Great Lakes Press.
16. Isaksen, S.G. and Treffinger, D.J. (1985) *Creative Problem Solving: The Basic Course*, Bearly, Limited Pub.
17. Basadur, M. (1994) *Simplex: A Flight to Creativity*, The Creative Education Foundation Press.

18. Lumsdaine, E. and Lumsdaine, M. (1995) *Creative Problem Solving – Thinking Skills for a Changing World*, McGraw-Hill.
19. Lumsdaine, E., Lumsdaine, M., and Shelnutt, J.W. (1999) *Creative Problem Solving and Engineering Design*, College Custom Publishing Group, McGraw-Hill.
20. Fogler, H.S. and LeBlanc, S.E. (1993) *Strategies for Creative Problem Solving*, self-published.
21. Fogler, H.S. and LeBlanc, S.E. (2007) *Strategies for Creative Problem Solving*, 2nd Ed., Pearson Education, Prentice Hall.
22. Bellinger, R. (1998) "Professional development sessions dominate; new poll on engineers' image released – PACE conference hits 'a year of transition'," Electronic Engineering Times, September 14, 1998.
23. Wulf, W. A. (1998) "Diversity in Engineering," The Bridge, 28(4).

Appendix A

Clue Hunts

1) The small white orb of 2007 world champion Wang Liqin.
   The highest numbered classroom in the easternmost LTU building.
   The number to fill it.

2) On Lawrence Tech's campus exists a geologic display,
   Split down the middle, represents geothermal steam at play.
   Actually water mist, not steam the wind carries away,
   Use two techniques to determine gallons emitted per day.

3) On the far eastern side of the Technology Building, next to the entrance to the loading dock/wood shop/fab lab, there is a stairwell. The outside structure of the stairwell is pointed at the top. There is a small lightening rod at the very top. Using only a mirror, determine the distance in feet from the ground to the top of the lightening rod.
   HINT: Can any of the tools/techniques from geometry be of use?

4) Without consulting any employees of LTU (faculty, staff, administrators, etc.) or contractors for LTU, determine how many meals are served per day on average from the Café Lawrence during the Fall 2007 semester.

5) Determine four ways to increase by 25% the number of classrooms in the engineering building without sacrificing office spaces, research spaces, or the room-size of the existing classrooms. Budget is not a factor.

   With the same stipulations, determine one more way that would cost less than approximately $100,000 (estimated).

6) Due in two weeks, this is a final hunt problem to put the creative problem solving methodology and some of the specific techniques to use:
   LTU students complain about parking on campus. Define the problem, suggest solutions, analyze/judge them, and choose the best solution. Who/What is needed for approval of your solution?