



Building a Physical Model to Teach Creative Problem-solving Skills in Online and Live Courses

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Abstract

Many faculty, especially new faculty, sometimes feel overwhelmed by having to teach both online and live courses while simultaneously pursuing scholarship and service activities. An effective way for faculty to improve their teaching efficiency is by creating assignments that can be taught in both online and face-to-face classes. An assignment the author has developed involves teaching creative problem solving skills for both online and face-to-face courses, by having students build a physical model of a problem and solution.

In today's competitive work environment, faculty need to provide students with the creative thinking skills that can help prepare them to deal with complex and unstructured problems that they will encounter in the workplace. At the same time, while developing their courses, sometimes faculty lose sight of the possible application of assignments for multiple modes of delivery. Faculty need to recognize the opportunities to create assignments and structure them for both online and face-to-face class delivery.

In the paper, the author will describe the major components of the Creative Problem Solving Assignment. The paper will identify the benefits derived from using this assignment to develop creative thinking skills. In the paper, the author will assess the assignment on promoting creative problem solving skills using a pretest/posttest and an assignment evaluation. Also, the author will provide ideas for technology and engineering faculty on how they can develop assignments for both online and face-to-face course delivery. Finally, the author will compare the evaluation results of the assignment between his online and face-to-face classes.

Key Terms: Brief, Creative Problem Solving Assignment (CPS Assignment), imagination, online and face-to-face course delivery, physical model, visualization, whole brain thinking.

Introduction

In the 2015 movie "The Martian," the main movie character (Matt Damon), stranded on the planet Mars, spoke about how problem solving enabled him to survive and get rescued [1]. In the movie, the actor stated, "you begin by solving one problem, then the next problem and if you solve enough problems you get to go home." For movie-goers, The Martian movie helped to illustrate the importance of problem solving. However, for most people in general, the importance of problem solving goes beyond outer space. For people to be successful in their careers, relationships and lives, they must be effective problem solvers [2]. For students to achieve both personal and career success, they need to develop their problem solving skills. Unfortunately, our educational system is not providing students with the required training for developing their imaginations and problem solving skills to generate creative ideas to solve complex problems [3].

Components of the Creative Problem Solving Assignment

Recognizing the importance of problem solving, the author has endeavored to educate students on how to develop their creative problem solving skills. Over the years, he has experimented with various course assignments to promote the use of imagination and creativity. One major course assignment the author has created, the subject of this paper, is the CPS Assignment which is designed to promote student imagination in solving either a personal or work related problem.

The Creative Problem Solving Assignment provided students with the opportunity to apply the components of the Creative Problem Solving Process, which the author taught throughout the semester [4, 5, 6]. In a nutshell, the Assignment required each student to identify a personal or work related problem and construct a physical model that represented the problem and its creative solution. Specifically, the Assignment is composed of 3 sub-assignments or components.

(1) First, students were required to develop a Brief, which is a general outline of the problem and process for solving the problem. Table 1 provides a summary of the requirements for the Brief.

Table 1: The 9 components of the Brief [3, 6, 7].

- | |
|---|
| <ul style="list-style-type: none">• A creative title for the assignment/problem.• Background information on the problem.• The “Problem Statement” (state the problem as a set of facts).• The “Creative Challenge” (state the problem as a question).• The best creative solution to the problem.• The alternative solution (second best solution) to the problem.• A written description of the physical model representing the problem and solution.• The main idea generation technique(s) used to stimulate the imagination for solving the problem.• A sketch of the physical model. |
|---|

(2) Second, students were required to visualize and create a Physical Model (made primarily of Popsicle Sticks) representing the problem and solution to that problem. The requirements for the Model:

1. 70%-100% of the Model must be composed of 4” or 6” Popsicle Sticks.
2. 0%-30% of the Model can be composed of other materials, such as:
 - Arts & Craft Materials (LEGOS).
 - Machine parts or tools.
 - Rocks, wood, and other objects from nature.
 - Cardboard, wooden blocks, clay, etc.

The purpose of the Model was to provide students with the opportunity to use their imaginations to visualize a problem in such detail that they can build a physical model representing the problem and solution [4, 8, 9].

(3) Third, students were required to develop a PowerPoint Presentation on the Assignment [8].

Course Learning Objectives and the CPS Assignment

The course, OLS 35000 (Creativity in Business and Industry), had 5 learning objectives that were listed in the course syllabus and summarized in Table 2. At a minimum, the CPS Assignment was designed to satisfy Learning Objectives 1, 2 and 5. The assignment also satisfied some of the ABET criterion required by program accreditation. Incidentally, the learning objectives were the same for both the online and face-to-face courses.

Table 2: (OLS 35000) Course Learning Objectives.

| |
|---|
| This course satisfies ABET criterion c, e, g, h and j- The Course Objectives are: |
| 1. List and explain 5 reasons why creative thinking and problem-solving are important in today's global economy. (h, j) |
| 2. Describe the 5 components of the Creative Problem Solving Process. (c, e) |
| 3. Create a Mandala. (c, e, g) |
| 4. List 5 major barriers to creativity. |
| 5. Apply the components of the Creative Problem Solving Process. (c, e, g) |

Preparation for the CPS Assignment

During the first 8-10 weeks of the semester, students learned about visualization, mental barriers to creativity and the phases of the Creative Problem Solving Process [4, 5, 6, 7]. The CPS Assignment provided an opportunity for students to apply what was learned during the first 8-10 weeks of the semester by developing a Brief, Physical Model and PowerPoint Presentation (the 3 sub-assignments or components of the CPS Assignment).

After developing the Brief, Model and Presentation, each student evaluated and provided feedback on the CPS Assignment and the 3 sub-assignments. Tables 5-10 provide a summary of student responses to selected questions related to the CPS Assignment and 3 sub-assignments.

Implementation of the CPS Assignment in the Online and Face-to-Face Courses

The author implemented the CPS Assignment in stages and according to similar time schedules for both the online and face-to-face classes. The different due dates for the components (sub-assignments) were designed to give students time to incubate and develop the assignment.

Students in the face-to-face class were required to bring their physical models to class and provide a 5 minute PowerPoint Presentation on the assignment. For the online class, students were required to submit photos of their physical model and a PowerPoint Presentation.

Although the CPS Assignments could be implemented using teams, the author chose to have students complete the assignment individually. He wanted the students to develop their individual imagination and visualization skills. Table 3 provides a summary and timeline of the due dates for the different components of the CPS Assignment.

Table 3: Summary of the CPS Assignment Implementation Stages for the Online and Face-to-Face Classes.

| OLS 35000-02 (Fall 2017): Online Class | OLS 35000-01 (Fall 2017): Face-to-Face Class |
|--|---|
| <ul style="list-style-type: none"> • Week 1: Instructor provided information on the CPS Assignment and Posted the Pretest on Blackboard. • Weeks 1-10: Instructor provided information on creative problem solving concepts. • Week 9: Students submitted the Brief through Blackboard. • Week 9: Student submitted the evaluation of the Brief through Blackboard. • Week 12: Students submitted the PowerPoint Presentation with Model photos through Blackboard. • Week 12: Students submitted the evaluation of the CPS Assignment. • Week 16: The Posttest was posted on Blackboard (the last week of the semester). | <ul style="list-style-type: none"> • Week 1: Instructor explained the CPS Assignment, posted additional information on the assignment on Blackboard and administered the Pretest to the class (Course Orientation). • Weeks 1-10: Instructor provided information and described creative problem solving concepts. • Week 11: Class submitted the Brief. • Week 11: Students submitted the evaluation of the Brief. • Week 12: Class submitted photos of the Physical Model through Blackboard. • Week 13: Students provided an in-class 5 minute PowerPoint Presentation. • Week 13: Students submitted the evaluation on the CPS Assignment. • Week 16: The Posttest was administered to the class (the last week of the semester). |

Benefits of Using the CPS Assignment to Teach Creative Problem Solving Skills

The CPS Assignment involved whole brain thinking, where students were able to integrate both left brain and right brain thinking. Generally speaking, assignments that involve whole brain thinking provide students with the opportunity to expand and focus their thinking, think logically and imaginatively, and lets them see relationships between different aspects of a problem [4].

The author noted that the CPS Assignment, where students had the opportunity to use their imaginations and creative problem solving skills, created excitement and inspired student interest and learning. Also, using student personal problems raised the level and quality of student participation in the course [10, 11]. By integrating problem solving assignments into a course, including personal problems, an instructor can effectively promote a positive learning environment.

Based on the assessment results (Tables 5-10), the author identified the benefits associated with the Assignment. Table 4 lists the major benefits derived from the CPS Assignment.

Table 4: Major Benefits Derived from the CPS Assignment.

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| <ul style="list-style-type: none"> • Encouraged students to play with ideas and concepts. • Promoted the concept that creativity is a process that can be learned and developed. |
|--|

- Identified the advantages associated with different idea generation techniques.
- Promoted the use of incubation when problem solving.
- Can be used to illustrate creative problem solving and other course-related concepts.
- Provided insight and perspective for understanding problems.
- Promoted the use of intuition when problem solving.
- Encouraged the search for multiple solutions for problems.
- Highlighted the importance of building a physical model to promote creative problem solving.
- Promoted the use of sketching when problem solving.
- Can be used with most engineering/technology courses.
- Provided an opportunity for students to interact/collaborate with classmates and non-students (family/friends) while generating and developing ideas for the model.
- Highlighted the importance of defining the problem as a question (Creative Challenge) to promote creative problem solving.
- Promoted the use of visualization when problem solving.
- Created a positive, fun and interesting class environment that promoted student participation.
- Provided students with the opportunity to use and develop their communication skills.
- Stimulated the imaginations of students.

Assessment of the Creative Problem Solving Assignment

The author took a comprehensive approach to evaluating the Creative Problem Solving Assignment by using a variety of assessments [9]. The overall conclusion from student responses to selective questions was that the Assignment was an effective teaching method for promoting creative problem solving skills. The results from student responses on the various aspects of the Assignment are listed in Tables 5-10, along with a summary of those tables.

Table 5 provides a summary and comparison of student responses to selected questions related to promoting creative problem solving skills from the online and face-to-face classes on the Pretest and Posttest.

Table 5: Summary of Student Responses to the Pretest and Posttest on Selected Questions from the Online and Face-to-Face Class Related to Promoting Creative Problem Solving.

| OLS 35000 (Fall 2017) | Pretest -> Posttest | Pretest -> Posttest |
|--|---|---|
| T=True, F=False, I=I don't know the answer | Online Class Average Score (Correct Answers) | Face-to-Face Class Average Score (Correct Answers) |
| 1. Most people remember and/or understand what they see better than what they hear | 91% -> 100% (+9%) | 92% -> 92% (0%) |
| 2. Humor and play should be avoided when we are generating ideas to help solve problems. | 64% -> 85% (+21%) | 80% -> 83% (+3%) |

| | | |
|---|--------------------|-------------------|
| 3. It is easier to turn wild/unusual ideas into practical solutions than to turn routine/obvious ideas into innovative solutions. | 55% -> 80% (+25%) | 64% -> 83% (+19%) |
| 4. Creativity is a personal characteristics that only a select few possess. | 91% -> 90% (-1%) | 92% -> 83% (-9%) |
| 5. I frequently sketch a problem that I am trying to solve. | 59% -> 80% (+21%) | 60% -> 75% (+15%) |
| 6. Creativity is a process involving a sequence of several steps or phases. | 86% -> 100% (+14%) | 56% -> 71% (+15%) |
| 7. I understand a problem better if I can see and examine/touch it, instead of just thinking about the problem. | 91% -> 90% (-1%) | 88% -> 71% (-17%) |
| 8. I am familiar with the benefits associated with different idea generation techniques. | 68% -> 85% (+17%) | 72% -> 96% (+24%) |
| 9. Generating creative ideas for problem-solving is relatively easy for me. | 64% -> 85% (+21%) | 52% -> 88% (+36%) |
| 10. I frequently use my imagination when I'm engaged in creative problem-solving. | 91% -> 100% (+9%) | 84% -> 88% (+4%) |
| 11. Incubation is an effective way to understand and/or develop ideas. | 45% -> 79% (+34%) | 84% -> 83% (-1%) |
| 12. I frequently use visualization to help me understand and solve problems. | 91% -> 100% (+9%) | 76% -> 96% (+20%) |
| 13. I am familiar with at least 3 idea generation techniques. | 45% -> 100% (+55%) | 40% -> 96% (+56%) |
| 14. When solving problems or making decisions we should avoid using intuition. | 64% -> 79% (+15%) | 76% -> 71% (-5%) |
| 15. When I find a solution to a problem, I usually continue looking for additional solutions for that problem. | 63% -> 84% (+21%) | 80% -> 92% (+12%) |
| Number of Students | 20 | 24 |

Table 5 Summary: Compare Online and Face-to-Face Classes Pretest and Posttest

Analysis of Questions 1, 2, 3, 4, 8, 11, 13, 14. The Pretest/Posttest questions were designed to make students aware of major concepts that would be discussed in the course, the relevancy of the concepts and how those concepts were related to creative problem solving. The author was also

interested in monitoring improvements or changes in student responses (behavior) before and after taking the course.

Question 1: This question had mixed results over the importance of visualization, since the online class had a 9 percentage point improvement and the face-to-face class showed no change from the Pretest to the Posttest.

Question 2: For this question, the author was encouraged that both classes realized an improvement on the Posttest for responses on the importance of humor and play. The online class had the largest improvement of 21 percentage points and the face-to-face class had a 3 percentage point improvement.

Question 3: The author was pleased to see an improvement in test scores for the Posttest on encouraging and refining wild ideas for both the online class (a 15 percentage point improvement) and the face-to-face class (a 19 percentage point improvement).

Question 4: The results from the student responses concerning whether creativity was a personal characteristic were not encouraging to the author. Especially for the face-to-face class which had a 9 percentage point decrease from the Pretest to Posttest results. The online class had a 1 percentage point decrease from 91% to 90%.

Question 8: The author was encouraged that both classes improved on being familiar with the benefits of idea generation techniques. The online class had a 17 percentage point increase while the face-to-face class had a 24 percentage point increase from the Pretest to the Posttest.

Question 11: The author was pleased to see an improvement on the importance of incubation for the online class test score (a 34 percentage point increase). Unfortunately, the face-to-face class saw a 1 percentage point decline from 84% to 83%.

Question 13: Both the online and face-to-face classes improved their Posttest scores on familiarity with idea generation techniques by 55 percentage points and 56 percentage points, respectively. These results indicated that students understood the idea generation techniques.

Question 14: This question, concerning intuition, had mixed results since the online class had a 15 percentage point improvement and the face-to-face class had a 5 percentage point decline from the Pretest to the Posttest.

Analysis of Questions 5, 9, 12, 15. The author recognized that some of the questions in Table 5 (Questions 5, 7, 9, 10, 12 and 15) could not be adequately answered with true/false responses. However, as was true with all the questions in the test, the author was also interested in monitoring improvements or changes in student responses (behavior) and/or creating awareness of the importance of the concepts stated in each questions. Some of these test questions were designed to encourage students to think about how they would or should go about solving problems.

Question 5: The author was encouraged by the test results on the importance of sketching. The online class scored 21 percentage points higher on the Posttest (compared to the Pretest) and the

face-to-face class Posttest scored 15 percentage points higher compared to the Pretest. The author considered the higher scores as a positive indication that students recognized the importance of sketching when problem solving.

Question 9: The author was pleased with the results of the Posttest concerning the ease of generating ideas. The online class had a 21 percentage point improvement and the face-to-face class had a 36 percentage point improvement.

Question 12: The importance of visualization when problem solving was recognized since there was a 9 percentage point improvement for the online class and 20 percentage point improvement for the face-to-face class from the Pretest to the Posttest.

Question 15: Both the online and face-to-face classes saw a positive change on the question dealing with searching for multiple solutions. The online class went from 63% to 84% between the Pretest and Posttest (a 21 percentage point change), and the face-to-face class went from 80% to 92% between the Pretest and Posttest (a 12 percentage point change).

Analysis of Questions 6, 7, and 10.

Question 6: Throughout the semester, creativity was defined as a process involving a sequence of several stages or phases. The analysis of the test scores for Question 6 between the Pretest and Posttest, for both the online and face-to-face classes, showed an improvement in scores. The online class score went from 86% to 100% and the face-to-face class score went from 56% to 71% (a 14 percentage point difference and 15 percentage point difference for the online and face-to-face classes, respectively). However, the author was disappointed that the face-to-face class didn't score higher since he continuously emphasized the stages of the Creative Problem Solving Process throughout the semester. Also, the Creative Problem Solving Process was not only a course objective (as stated in the syllabus), but the basis for the CPS Assignment.

Question 7: Both classes didn't realize an improvement in scores between the Pretest and Posttest for Question 7, concerning the benefits of seeing, examining and/or touching a problem. As previously stated, the author recognized that Question 7 (and the subsequent Question 10) could not be adequately answered with a right or wrong response. Nevertheless, the results were especially disappointing since a major purpose of the CPS Assignment was to promote building a physical model of a problem to better understanding the problem. For both the online and face-to-face classes, there was actually a decline in scores for the Posttest, compared to the Pretest scores. The online class had a 1 percentage point decline and the face-to-face class experienced a 17 percentage point decline between the Pretest and Posttest.

Question 10: This question sought to create awareness of the importance of imagination when problem solving. Also, the author wanted to determine whether students would increase the use of their imaginations for problem solving after completing the course. Both classes showed an improvement in test scores of 9 percentage points for the online class and 4 percentage points for the face-to-face class. Although the author was pleased that there was improvement in scores, he was surprised the classes, especially the face-to-face class, didn't score higher on the use of imagination.

Although the Pretest and Posttest had some mixed results, overall, the author was pleased with the changes/improvements. Also, the test were just one evaluation tool for the CPS Assignment.

Two Assessments of the Brief

Recognizing the importance of the Brief in creative problem solving, the author used two assessment tools (with different questions) to evaluate the effectiveness of the Brief. One evaluation focused on assessing the different components of the Brief as they related to promoting creative problem solving skills and the second evaluation compared the Brief with the Model and Presentation concerning its effectiveness for promoting creative problem solving skills.

Table 6 provides a summary and comparison of student responses to selected questions related to promoting creative problem solving skills and the effectiveness of the components of the Brief for the online and face-to-face classes.

Table 6: Evaluation on how important each Component of the Brief was in promoting Creative Problem Solving.

| OLS 35000 (Fall 2017) | Brief | Brief |
|--|-------------------------------------|---|
| Scale: 1. Strongly Disagree, 2. Disagree, 3. Neither Agree/Disagree, 4. Agree, 5. Strongly Agree | Average Score (Online Class) | Average Score (Face-to-Face Class) |
| 1. A creative title for the project/problem- is important in promoting creative problem solving. | 4.0 | 4.26 |
| 2. Background information on the project/problem- is important in promoting creative problem solving. | 4.6 | 4.65 |
| 3. The "Problem as Stated"- is important in promoting creative problem solving. | 3.75 | 4.18 |
| 4. The "Problem as Understood"- is important in promoting creative problem solving. | 4.15 | 4.43 |
| 5. The creative solution (best solution) to the problem- is important in promoting creative problem solving. | 4.75 | 4.52 |
| 6. The alternative (2 nd best) solution to the problem- is important in promoting creative problem solving. | 3.90 | 4.0 |
| 7. The written description of the 3-D physical model the student created/constructed using Popsicle Sticks- is important in promoting creative problem solving. | 4.25 | 4.09 |
| 8. Identifying the main idea generation technique(s) used to stimulate your imagination for the Project solution/creative problem solving- is important in promoting creative problem solving. | 3.72 | 3.70 |

| | | |
|---|------|------|
| 9. A sketch of the 3-D model- is important in promoting creative problem solving. | 4.25 | 3.91 |
| Aggregate Average Score | 4.15 | 4.19 |
| Number of Students | 20 | 23 |

Table 6 Summary: Online and Face-to-Face Classes Evaluations of the Brief Components

Table 6 showed that out of 9 selected questions on the components of the Brief, the face-to-face class scores exceeded those of the online class in 5 out of 9 questions. The author was surprised that Question 8 on idea generation techniques (3.72 for the online class and 3.70 for the face-to-face class) and Question 9 on the sketch (4.25 for the online class and 3.91 for the face-to-face class) didn't score higher, since both questions dealt with major tools for creative problem solving. At the same time, the author was pleased that Question 2 (score of 4.6 for the online class and 4.65 for the face-to-face class) on background information and Question 5 (score of 4.75 for the online class and 4.52 for the face-to-face class) on identifying the best solution, received the highest scores for the Brief. Based on the aggregate average scores (4.15 for the online class and 4.19 for the face-to-face class) and student responses to each question on the components of the Brief, the author concluded that the Brief assignment was effective in promoting both the CPS Assignment and creative problem solving skills for both the online and face-to-face classes.

Table 7 provides a summary and comparison of student responses to selected questions related to promoting creative problem solving skills for the online and face-to-face classes on the Brief.

Table 7: Evaluation on the effectiveness of the Brief in promoting Creative Problem Solving.

| COLS 35000 (Fall 2017) | Brief | Brief |
|--|-------------------------------------|---|
| Scale: 1. Strongly Disagree, 2. Disagree, 3. Neither Agree/Disagree, 4. Agree, 5. Strongly Agree | Average Score (Online Class) | Average Score (Face-to-Face Class) |
| 1. Allowed me to use humor and play when generating ideas/solutions for the project problem. | 4.24 | 4.42 |
| 2. Allowed me to express my creativity. | 4.48 | 4.60 |
| 3. Allowed me to use the sketch to better understand the problem and/or generate ideas/solutions for the project problem. | 4.33 | 4.27 |
| 4. Allowed me to use the steps or phases in the CPSP. | 4.38 | 4.54 |
| 5. Seeing and/or physically examining the project problem, allowed me to better understand the problem and generate ideas/solutions. | 4.24 | 4.58 |
| 6. Allowed me to recognize the benefits associated with different idea generation techniques. | 4.52 | 4.65 |

| | | |
|---|------|------|
| 7. Made it relatively easy for me to generate creative ideas/solutions for the project problem. | 4.33 | 4.58 |
| 8. Allowed me to use my imagination when generating ideas/solutions for the project problem. | 4.81 | 4.58 |
| 9. Allowed me to use incubation to understand the problem and/or generate ideas/solutions for the project problem. | 4.38 | 4.46 |
| 10. Allowed the use of visualization to help me to better understand the problem and/or generate ideas/solutions for the project problem. | 4.38 | 4.58 |
| 11. Allowed me to become familiar with different idea generation techniques. | 4.57 | 4.54 |
| 12. Allowed me to use intuition when generating ideas/solutions for the project problem. | 4.38 | 4.58 |
| 13. Allowed me to look for additional solutions for the project problem. | 4.29 | 4.73 |
| Aggregate Average Score | 4.41 | 4.55 |
| Number of students | 21 | 26 |

Table 7 Summary: Online and Face-to-Face Classes Evaluations of the Brief

The second Brief evaluation showed that the face-to-face class had the highest scores for Questions 2 (4.60), 6 (4.65) and 13 (4.73). The online class also had the highest scores for Questions 6 (4.52), 8 (4.81) and 11 (4.57). All of the scores for both the online and face-to-face classes were 4.0 or above. Overall, both the online and face-to-face classes had aggregate average scores of 4.41 and 4.55, respectively. Based on the aggregate scores and student responses to each question on the Brief, the author concluded that the (second) Brief assignment was effective in promoting creative problem solving skills for both the online and face-to-face classes.

Table 8 provides a summary and comparison of student responses to selected questions related to promoting creative problem solving skills from the Physical Model for the online and face-to-face classes.

Table 8: Evaluation on the effectiveness of the Physical Model assignment in promoting Creative Problem Solving.

| OLS 35000 (Fall 2017) | Model | Model |
|---|-------------------------------------|---|
| Scale: 1. Strongly Disagree, 2. Disagree, 3. Neither Agree/Disagree, 4. Agree, 5. Strongly Agree | Average Score (Online Class) | Average Score (Face-to-Face Class) |
| 1. Allowed me to use humor and play when generating ideas/solutions for the project problem. | 4.24 | 4.69 |

| | | |
|---|------|------|
| 2. Allowed me to express my creativity. | 4.67 | 4.96 |
| 3. Allowed me to use the sketch to better understand the problem and/or generate ideas/solutions for the project problem. | 4.29 | 4.69 |
| 4. Allowed me to use the steps or phases in the CPSP. | 4.38 | 4.58 |
| 5. Seeing and/or physically examining the project problem, allowed me to better understand the problem and generate ideas/solutions. | 4.24 | 4.58 |
| 6. Allowed me to recognize the benefits associated with different idea generation techniques. | 4.38 | 4.62 |
| 7. Made it relatively easy for me to generate creative ideas/solutions for the project problem. | 4.33 | 4.58 |
| 8. Allowed me to use my imagination when generating ideas/solutions for the project problem. | 4.48 | 4.77 |
| 9. Allowed me to use incubation to understand the problem and/or generate ideas/solutions for the project problem. | 4.24 | 4.73 |
| 10. Allowed the use of visualization to help me to better understand the problem and/or generate ideas/solutions for the project problem. | 4.57 | 4.77 |
| 11. Allowed me to become familiar with different idea generation techniques. | 4.48 | 4.62 |
| 12. Allowed me to use intuition when generating ideas/solutions for the project problem. | 4.10 | 4.65 |
| 13. Allowed me to look for additional solutions for the project problem. | 4.29 | 4.62 |
| Aggregate Average Score | 4.36 | 4.68 |
| Number of Students | 21 | 26 |

Table 8 Summary: Online and Face-to-Face Classes Evaluations of the Physical Model

The physical model was the essence of the CPS Assignment. Therefore, the author was pleased that both the online and face-to-face classes scored over 4.0 on all 13 questions. The highest scores for both the online and face-to-face classes were on Question 2 (the model allowed for the expression of creativity), with scores of 4.67 and 4.96, respectively. Also, comparing student responses on evaluating the Model, the face-to-face class scored higher than the online class on all 13 questions related to promoting creative problem solving skills. The aggregate average score for

the online class was 4.36, while the face-to-face class had an aggregate average score of 4.68. Based on the aggregate scores and student responses to each question on the Model, the author concluded that the Model assignment was effective in promoting creative problem solving skills for both the online and face-to-face classes.

Table 9 provides a summary and comparison of student responses to selected questions related to promoting creative problem solving skills from the PowerPoint Presentation for the online and face-to-face classes.

Table 9: Evaluation on the effectiveness of the Presentation assignment in promoting Creative Problem Solving.

| OLS 35000 (Fall 2017) | Presentation | Presentation |
|---|-------------------------------------|---|
| Scale: 1. Strongly Disagree, 2. Disagree, 3. Neither Agree/Disagree, 4. Agree, 5. Strongly Agree | Average Score (Online Class) | Average Score (Face-to-Face Class) |
| 1. Allowed me to use humor and play when generating ideas/solutions for the project problem. | 4.0 | 4.54 |
| 2. Allowed me to express my creativity. | 4.33 | 4.76 |
| 3. Allowed me to use the sketch to better understand the problem and/or generate ideas/solutions for the project problem. | 4.0 | 4.27 |
| 4. Allowed me to use the steps or phases in the CPSP. | 3.86 | 4.46 |
| 5. Seeing and/or physically examining the project problem, allowed me to better understand the problem and generate ideas/solutions. | 3.76 | 4.50 |
| 6. Allowed me to recognize the benefits associated with different idea generation techniques. | 4.05 | 4.46 |
| 7. Made it relatively easy for me to generate creative ideas/solutions for the project problem. | 4.14 | 4.46 |
| 8. Allowed me to use my imagination when generating ideas/solutions for the project problem. | 4.14 | 4.69 |
| 9. Allowed me to use incubation to understand the problem and/or generate ideas/solutions for the project problem. | 4.05 | 4.62 |
| 10. Allowed the use of visualization to help me to better understand the problem and/or generate ideas/solutions for the project problem. | 4.05 | 4.65 |
| 11. Allowed me to become familiar with different idea generation techniques. | 4.14 | 4.58 |

| | | |
|--|------|------|
| 12. Allowed me to use intuition when generating ideas/solutions for the project problem. | 3.95 | 4.62 |
| 13. Allowed me to look for additional solutions for the project problem. | 3.86 | 4.65 |
| Aggregate Average Score | 4.03 | 4.56 |
| Number of Students | 21 | 26 |

Table 9 Summary: Online and Face-to-Face Classes Evaluation of the Presentation

Comparing student responses on evaluating the PowerPoint Presentation, the face-to-face class scored higher than the online class on all 13 questions related to promoting creative problem solving skills. Questions 2, with a score of 4.76 (allowed students to express their creativity) and Question 8, with a score of 4.69 (allowed the use of imagination) were the highest scored questions for the face-to-face class. Also, the face-to-face class had scores of over 4.0 for all 13 questions. On the other hand, the online class had 4 questions with less than a 4.0 score. Nevertheless, both the face-to-face and online classes had aggregate average scores of 4.56 and 4.03, respectively. Based on the aggregate scores and student responses to each question on the Presentation, the author concluded that the Presentation assignment was effective in promoting creative problem solving skills for both the online and face-to-face classes.

Free-Form Student Comments on the CPS Assignment

The evaluation of the CPS Assignment allowed students the opportunity to provide free-form comments for changing or improving the assignment. The author noted that some student comments were difficult to interpret. Also, some students didn't have a response for improving the assignment. Table 10 provides a summary of selected (and edited for grammar) free-form student comments on the CPS Assignment from the online and face-to-face classes. For the most part, the student comments were consistent between the online and face-to-face classes. For example, both classes identified:

- Consistent positive comments that no change was necessary and on how much the students enjoyed completing the assignment, especially the belief and the model.
- The desire to use other materials for building the physical model and/or that the instructor should provide examples of previous semester models.
- The PowerPoint presentation needed more guidelines and/or the presentation time length should be less than 5 minutes (for the face-to-face class).
- Allow the use of a video, instead of requiring a PowerPoint Presentation.

Table 10: Summary of Free-Form Student Comments on the CPS Assignment from the Online and Face-to-Face Classes.

| OLS 35000-02 (Fall 2017: 18 students) Student Comments (Online Class) | OLS 35000-01 (Fall 2017: 26 students) Student Comments (Face-to-Face Class) |
|--|---|
| <p>7 responses were positive comments:</p> <ul style="list-style-type: none"> • No improvement needed. • A good way to use creativity in problem-solving. • (2 students) A good way to generate ideas and solutions for problems. • The model helped me to understand the Creative Problem Solving Process. • The assignment was direct and understandable. • I enjoyed the hands-on way to solve the problem. <p>4 responses concerning the Popsicle Sticks:</p> <ul style="list-style-type: none"> • (2 students) The requirement of using Popsicle Sticks limited my creativity or was frustrating to build the model. • (2 students) I would have liked to use other material to build the model. <p>5 responses concerning the model:</p> <ul style="list-style-type: none"> • (4 students) The instructor should provide demo models/examples/photos of the model to promote an understanding of the assignment. • The instructor should provide pictures of constructing the model (instead of requiring a sketch). <p>4 responses on the PowerPoint Presentation:</p> <ul style="list-style-type: none"> • Make the presentation a larger component of the assignment. • I was unsure what to include in the PowerPoint Presentation. • The PowerPoint Presentation should not require so many slides. • Use an alternative to a PowerPoint, such as a video of the model. | <p>11 responses were positive comments:</p> <ul style="list-style-type: none"> • (5 students) No change necessary. • (2 students) I had fun/enjoyed completing the assignment. • The model and presentation were good. • I liked the Popsicle Sticks and learned new skills. • The presentation improved my English. • I learned about different cultures (cultural problems/approaches). <p>8 responses concerning the Popsicle Sticks:</p> <ul style="list-style-type: none"> • (3 students) Less use of Popsicle Sticks to build the model. • (5 students) We should be allowed to use other material to build the model. <p>11 responses on the PowerPoint Presentation:</p> <ul style="list-style-type: none"> • (2 students) We need guidelines for the presentation. • The presentations were good. • (6 students) The 5 minute requirement was too long for the presentation. • A PowerPoint Presentation should not be required. • We should use a video presentation. • We need to limit the number of slides required for the PowerPoint Presentation. • Students should not use notes during the presentation. |

Future Changes for the CPS Assignment

Overall the author was pleased with the results of the evaluations on the CPS Assignment, including the 3 sub-assignments: (1) Brief (2) Physical Model and (3) PowerPoint Presentation. However, as is true with all of his courses and assignments, the author constantly strives to improve them.

1. Changes for the CPS Assignment:

- Revise and develop more accurate questions for the Pretest/Posttest, including more response options and creativity concepts for evaluating the CPS Assignment. The author recognized that true or false responses for some questions in Table 5 (Questions 5, 7, 9, 10, 12 and 15) were not the best choices for evaluating some student responses.
- Develop other problem solving assignments with some of the components used in the CPS Assignments, especially the building of a physical model.
- Consider allowing other types of presentation modes, such as video presentations.

2. With some of the suggestions made for improving the assignment, the author identified concerns associated with those suggestions:

- Suggestion: Allow for the use of other types of material to build the model, instead of only Popsicle Sticks. Concern: The Popsicle Sticks allowed for consistent criteria for building and evaluating the physical models. Also, restricting the use to certain materials for building the model was designed to simulate real world constraints that students may encounter in workplace problem solving.

Incidentally, other materials for building the model were allowed. A minimum of seventy percent of the physical model had to be composed of Popsicle Sticks and other materials were allowed to build 0-30 percent of the model.

- Suggestion: Consider other alternatives (to the PowerPoint) for allowing students to present the assignment. Concern: PowerPoint Presentations were established to provide consistent criteria (PowerPoint) for presenting and evaluating the assignment. Also, a PowerPoint Presentation was required instead of allowing students (especially, the face-to-face class) to use their discretion on how to make their presentations, which sometimes led to substandard results.
- Suggestion: Provide examples of previous semester physical models. Concern: The author is worried that providing examples of previous semester physical model might stifle the imaginations of students. In the past, the author provided many verbal examples or ideas for models to the face-to-face class over the course of the semester. However, the author noted that the online students (who had no or one example/idea provided) built models that were superior in quality/detail compared to the face-to-face class.

Ideas for Faculty on How to Develop Assignments for Online and Face-to-Face Course Delivery

Faculty need to look for every opportunity to create assignments for different modes of delivery. To help other engineering and technology faculty develop assignments for online and/or face-to-face course delivery, the author has identified the following set of guidelines.

1. Integrate One Assignment or All Assignments

One question that should be addressed when considering the development of assignments for online and/or face-to-face course delivery is whether to put all assignments online or only a few assignments. In other words, a faculty can start the integration for different course delivery of assignments with one or a few assignments, or all the assignments at one time. The author has done both. Since the course that is the subject of this paper has an online and face-to-face section, the author was able to experience both types of course delivery simultaneously.

2. Recognize that Problem-Solving has Universal Application for Every Course

One type of assignment that has universal application, especially for engineering and technology courses, are problem solving assignments [4]. These types of assignments can be readily integrated into online and/or face-to-face course delivery. Since most engineering and technology courses deal with problems, problem solving can be integrated into almost every engineering and technology course without altering the course content. Consequently, integrating problem solving assignments from face-to-face and into online delivery or vice versa is a relatively easy modification for most courses.

3. Develop Assessment Instruments

Along with evaluating every course, faculty need to assess individual assignments to determine their effectiveness with online and/or face-to-face course delivery [11]. Some assessment tools that can be used to evaluate individual assignments for different modes of delivery can include those that were described in this paper: Pretest and Posttest, and student surveys of an individual assignment where different components of the assignment were evaluated.

4. Hybrid Course

Hybrid or Blended courses are a type of course delivery that integrates learning features of online and face-to-face course delivery [12]. Hybrid course assignments can be implemented either formally or informally. With the formal approach, the course can be designed and publicized by the academic department as a Hybrid course. As a result, students will be provided with advance notice of the assignment delivery. Using the informal approach, the individual faculty member can use his/her discretion to offer some assignments online.

5. Analyze the Components of an Assignment

One of the most difficult parts of problem solving is getting started. A problem may initially seem overwhelming, but if it is broken down into sub-assignments or its components, that will make getting started easier. In other words, most problems are often made up of a series of smaller problems. Different aspects of a (larger) problem can be submitted online and later discussed face-to-face. For example:

- Students can be required to provide responses online to specific questions about a problem that were developed by the instructor and later discuss those questions face-to-face in class.
- Students can be required to define the problem (Creative Challenge) and submit it online, and later discuss the problem face-to-face in class.
- Students can be required to submit the introduction section of a problem (relevant facts of a problem) online and later discuss the introduction section face-to-face in class.

Conclusion

Creative problem solving skills can benefit society, businesses and students when dealing with challenges presented by today's complex world. The author developed an assignment to teach students creative problem solving skills that will prepare them to deal with future challenges they will encounter after graduation. Based on the assessments described in the paper, he found that the CPS Assignment provided an effective method for promoting creative problem solving skills.

In the paper, the author described the major components of the Creative Problem Solving Assignment. The paper identified the benefits derived from using the Assignment as a way to promote imagination and creative problem solving. Also, the author provided the results of the Assignment assessments related to developing problem solving skills. Finally, the paper identified guidelines that can be used by other technology and engineering faculty to develop assignments for different modes of course delivery.

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