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Osaka University Students Use English to Carryout a Creative Engineering Project about Tsunamis

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Abstract

Osaka University's engineering students listened to a lecture in English about the Importance of Engineering Education and Creativity to help promote their creative thinking skills. Then they successfully carried out a creative problem-based learning (PBL) project about tsunamis. They were asked how to protect the coasts of Japan from future tsunamis. The participants brainstormed in groups and tested their ideas using simulated tsunamis in a laboratory setting. After performing some experiments with waves and various barriers, etc. the class generated many creative ideas for addressing this problem.

1. Introduction

Osaka University students listened to a general lecture in English about the importance of creative engineering education and about ways to improve their creative thinking skills. Participants included undergraduate and graduate level engineering students. The talk (presented by a visiting instructor from the US) started by stating the essential needs for engineering education: 1. to educate and provide competitive and innovative engineers to detect and solve challenging world problems, and 2. to prepare engineers to creatively design items, processes, and services to satisfy human needs as well as help sustain our global society [1]. Next a discussion about creativity and creative thinking followed [2]. It included the barriers to creative thinking and suggestions for overcoming them. Creativity is the ability to produce original work and ideas. It also includes the combining of existing work and objects to create new items like a motorcycle composed of a motor and a bike. Creativity starts with a creative person, such as an engineer, using a creative thinking process to end up with a creative product. This person is usually energetic and full of ideas.

Barriers exist to creative thinking and creativity for engineers and engineering students [3]. One is a lack of knowledge, which is needed to create solutions to practical problems. Another is a perceptual block, which means that a person is not able to clearly see the problem that needs to be solved. Fear of failure is an emotional block. An example of a cultural block is where resistance to change exists at the workplace. In addition, engineers may have an expressive block. This means that they are not able to affectively communicate a problem or its possible solutions with others. Engineering instructors can help students overcome these barriers. They should be more like facilitators (than lecturers) and encourage students to express innovative ideas. The instructors should be open-minded, value originality, and seek imaginative solutions to problems. They also need to promote higher levels of thinking such as synthesis (the act of creating ideas) in Bloom's Taxonomy [4]. After the lecture, the students carried out some mental exercises in creative thinking. Then they participated in a creative engineering design project using problem-based learning (PBL), [5]. Problem-based learning is a powerful tool for engineering design education. It provides students with challenging problems that relate to their daily lives. Students receive guidance from their instructors and work cooperatively in a group to seek solutions to the problems.

2. Creative engineering design project using problem based learning (PBL)

Background Information: Students carried out an activity about tsunamis (harbour waves) which are mainly caused by earthquakes, landslides, and volcanic eruptions. This project related well to Japan because on March 11, 2011, a big earthquake and huge tsunami caused much destruction in Japan. The tsunami caused massive flooding, erosion, deaths, and major damage to the Fukushima Nuclear Power plants. This problem-based learning lesson was designed to give the engineering students an opportunity to address the problem of tsunamis. They were actually asked to create a plan (with potential solutions) for protecting Japan from future tsunamis.

Tsunamis are harbour waves that can be over 100 feet high. Generally speaking the speed of a tsunami is proportional to the square root of the ocean's depth. An estimate of the speed of a tsunami using 4,000 meters as the depth of an ocean is as follows [6]. The estimated speed is 3.13 times the square root of 4000 which equals 198 meters per second. When the wave approaches the shore it slows down. It has less kinetic energy because some is lost to friction with the mud, etc. and a lot is conserved as gravitational potential energy. Higher waves are a result because the kinetic energy of water near the bottom changes to potential energy of the water at the top. Refer to the pictures of a tsunami (Figure 1) and of the labeled diagram of waves (Figure 2).

The students were provided with a problem to solve. They were asked the following question. How will the coastal areas of Japan be protected from future tsunamis? They were also given an engineering design model (outline) to follow, and a survey form to complete. All of their work was done using the English language.

3. Engineering design model (outline)

Hints: Redesign the seawall (examples: size & shape). However, the seawall alone is not enough. Reduce the energy of the waves. Do other things too.

Figure1. Tsunami

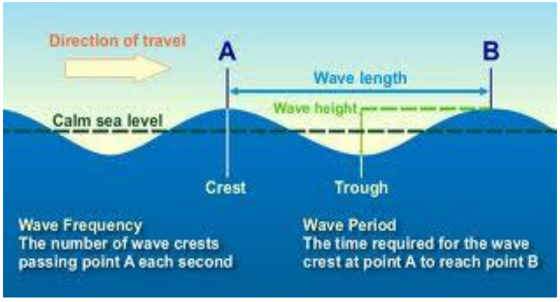

Figure 2. Wave Information

Materials: The following items are needed in order to make a simple simulation of a tsunami hitting the shore: a plastic container at least 12 inches long, about 6 inches wide and a few inches high; a thin piece of wood about 4 inches long to initiate the tsunami; and another piece of wood that is about 4 inches long and several inches thick to represent the shore. The wood representing the shore should be dense so that it does not float when the waves are generated. If so, then metal weights should be placed on the wood. Also some modeling clay (that is basically water resistant) is needed to create models of seawalls and of any other necessary items (such as special barriers). Obtain data by using calculators and measuring devices like a ruler, a stopwatch, etc. to estimate wave heights, speeds, etc.

Directions

1. Work in groups of two to four individuals.

2. Brainstorm about possible solutions to this problem and about design requirements and design limits.

3. Identify Design Requirements. (Write them in the space below.)

4. Identify Design Limits. (Write them in the space below.)

5. List Your Ideas (possible solutions to the problem) in the space below.

6. Evaluate the Possible Solutions. Test some of your ideas using the simulation for a tsunami and any other materials that are available. (Write your data in the space below.)

7. Select the Best Solution(s) to Solve the Problem. List them below.

8. Create a Plan for Protecting the Coastal Area of Japan from Future Tsunamis. Write the steps for your plan in the space provided.

9. Draw a Sketch (on a piece of paper) to Represent the Components of Your Plan. Label your diagram and list the dimensions of your newly designed seawall, etc.

10. Communicate the Design (Plan). Share it with the audience.

4. Project discussion

The students brainstormed in groups about the problem and possible ways to solve it. They discussed various topics including creative designs for seawalls (protective barriers from tsunamis) and methods for reducing the energy of a tsunami. The wave's Kinetic Energy (energy of motion) was considered. By reducing the mass and / or speed of the wave, one can reduce the wave's energy.

Kinetic Energy = $0.5\ mv^2$

(m = mass, v = speed / velocity)

Next the students tested their ideas by using simulations for tsunamis and other available materials. Some designed seawalls with modeling clay and exposed them to simulated tsunamis. Others created and tested different types of barriers (items they made out of clay to represent trees, tall structures, etc.). They discovered that the barriers slowed down the wave speed, that vertical seawalls reflected the wave energy, and that curved seawalls allowed the waves to dissipate energy and to repel waves back to sea. See Figures 3 and 4. After carrying out the experiment, each group designed a specific plan for protecting the coasts of Japan from future tsunamis. Finally their creative ideas were shared with the class.

Figure 3. Students use modeling clay to design a seawall.

Figure 4. Students use simulated tsunamis to test a variety of barriers.

5. Results

Twenty-seven engineering students at Osaka University participated in the PBL, engineering activity involving tsunamis. They worked in groups of four to six members and had only several hours to complete the entire project, which was carried out in English. A summary of the participants' Design Requirements and Limits (for this project) are provided.

Summary of design requirements

1. Reduce the energy of the tsunami.

2. Block the tsunami.

3. Change the direction of the tsunami.

4. Increase the land elevation and construct tall buildings in the coastal areas.

5. Construct underwater buildings for coastal people to inhabit.

6. Require coastal people to live in boats (houseboats).

7. Develop early detection and warning systems for the tsunami.

8. Devise and implement emergency escape plans from the tsunami.

Summary of design limits

1. Money

2. Other Resources

3. Time

The students have creative ideas for protecting Japan from future tsunamis. Many of their plans involve barriers of various types (differing sizes, shapes, material makeup, etc.).

Natural barriers: Some students encouraged the growth of natural barriers (such as coral reefs) because they form a protective undersea wall.

Trees for barriers: It was suggested that rows of trees be planted along Japan's coast in hopes of reducing the impact of the tsunami. To start, rows of mangroves should be planted in the shallow water of the saline coastal region. These trees have shallow roots and grow fairly fast (up to 25 meters in several years). Next many rows of pine trees should be planted behind the mangroves.

Seawalls: The students mentioned various types of seawalls. Some were vertical while others were curved. Others were shaped like a house with a peaked roof (which came to a point like a wide inverse letter V). One group of students designed a seawall that had a tunnel system and gigantic holes behind it. The holes were to provide a place for the water to go and the tunnels were to help redirect the water back to sea. Another group envisioned a seawall made of both hard and soft layers. The soft layers were to absorb energy from the waves.

Several students expressed concern about determining the best materials (examples: boulders, steel reinforced concrete, etc.), the optimum size (height and thickness), and appropriate shape (vertical, curved, etc.) for building seawalls. Additional comments were made. Seawalls should be continuous and not have gaps if possible. Inner and underwater seawalls should be built. Also higher and stronger seawalls are needed, especially near nuclear power plants.

Other barriers: Other barrier plans were shared. A group proposed placing large square pyramid pillars (in rows) before the coastline to slow down the waves. Another designed a system to counter the force of the tsunami. Their scheme consists of solid rectangular barriers placed vertically underwater in rows. Each rectangular barrier has a water-resistant material (with elastic properties) attached to it. The other end of these flexible materials (example: springs) is attached to a floatable block. This setup allows the floatable blocks to rise (when the waves push on them) and to somewhat counter the force of the tsunami. The blocks later return to their original positions. Other students

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created a number of arched (curved) walls to place in the water at various locations with the curves facing in different directions. The purpose of their plan is to reduce wave energy, block waves, and change the direction of the waves. See Figure 5.

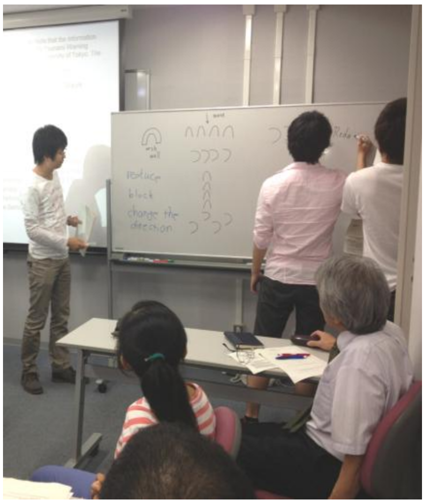

Figure 5. Students place curved-shaped walls (at various locations in the water) with the curves facing in different directions. The goals of this plan are to reduce wave energy, block the waves, and to change the direction of the waves.

Several students designed a big unique wall to put in front of the coast. This special wall includes huge propellers. Its purpose is to change the energy of the tsunami into kinetic energy for the propellers. Another student wanted to use many large heated nets to vaporize the water. Still others suggested having strong nets of rope attached to towers placed in the water. In the case of a tsunami, the nets would be raised to a high position to help reduce the wave energy.

Different ideas: In addition to barrier protection from tsunamis, the following creative ideas were shared. Elevate the land near the coast and construct tall buildings there to provide shelter during a tsunami. Have various structures under the water for people to inhabit. Also individuals along the coasts of Japan could live in houseboats.

Some students said that early detection and warning systems, as well as escape plans, should be developed for threats from tsunamis. For example, one could monitor changes in tides to find out if a tsunami has been generated. Also deep sea sensors could be designed to detect (measure) the weight of the column of water above them. Changes in weight could indicate that the crest of a tsunami has just passed by.

More information for this PBL, engineering project was obtained from the students' completed survey forms (which they filled out at the end of the activity). The survey form and results are provided.

Survey form for the activity about tsunamis

1. Did you enjoy the overall activity? #1: Very much #2: Pretty much #3: Neutral, #4: Not so much #5: Not at all

2. Were you able to communicate affectively with your group members? #1: Very much #2: Pretty much #3: Neutral, #4: Not so much #5: Not at all

3. Did your group come up with any ideas for solving the problem? #1: Very much #2: Pretty much #3: Neutral, #4: Not so much #5: Not at all

4. What was the most enjoyable? #1: Communicating #2: Generating Ideas #3: Simulating a Tsunami #4: Creating the Design (the plan for solving the problem) #5: other (   )

5. What was the most difficult task? #1: Communicating #2: Generating Ideas #3: Simulating a Tsunami #4: Creating the Design (the plan for solving the problem) #5: other (   )

6. Was your instructor friendly? #1: Very much #2: Pretty much #3: Neutral, #4: Not so much #5: Not at all

7. Do you want to join such a project again in the future? #1: Very much #2: Pretty much #3: Neutral, #4: Not so much#5: Not at all

8. Do you feel that today's lecture and activity helped develop your creative thinking skills? #1: Very much #2: Pretty much #3: Neutral, #4: Not so much#5: Not at all

9. Briefly describe your possible solution (creative plan) for solving the problem.

10. Feel free to write your comments. Thanks! / Domo Arigatou!

Survey form results: Students' answers are provided and discussed. The percentages used in this paragraph represent all neutral through very positive responses for each question. As for question 1, the team members enjoyed the activity (96%). They said the instructor was friendly (question 6, 100%) and that they would like to join such a project again in the future (question 7, 96%). The students felt that the lecture and activity about tsunamis helped develop their creative thinking skills (question 8, 100%). Most of the participants felt that they were able to affectively communicate with their group members (question 2, 89%) and to come up with ideas for solving the problem (question 3, 78%). For questions 2 and 3 several students indicated that it was difficult for them to understand and communicate in English. There were a variety of answers for questions 4 and 5. Question 4 asked what was the most enjoyable. The students' answers are expressed as a percent for those selecting each choice. Their answers are as follows: choice #1: Communicating (about 18.5%), choice #2: Generating Ideas (about 14.8%), choice #3: Simulating a Tsunami (about 29.6%), choice #4: Creating the Design, the plan for solving the problem, (about 29.6%) and choice #5: Other (about 7.4%). For the two students selecting the choice of "Other," one enjoyed trying to learn English and the other one enjoyed testing ideas and discussing the results of those tests. Question 5 asked what was the most difficult. The students' answers are expressed as a percent for those selecting each choice. Their answers are as follows: choice #1: Communicating (about 11.1%), choice #2: Generating Ideas (about 33.3%), choice #3: Simulating a Tsunami (about 29.6%), choice #4: Creating the Design, the plan for solving the problem, (about 18.5%), and choice #5: Other (about 7.4%). For the two students selecting the choice of "Other," one found it difficult to clearly understand the problem to solve and the other one found it difficult to evaluate the possible solutions to the problem.

In regards to question 9, the students' creative ideas (for protecting the coasts of Japan from future tsunamis) have already been discussed. As for question 10, only 21 students (of the 27 participants) wrote comments. Eighteen (about 86% of those who wrote comments) said thank you and that they enjoyed the lecture and activity very much. Two other students mentioned that it was difficult for them to understand and communicate in English. However, they expressed great interest in learning English. The final student wished for a smaller group (with fewer members) for discussing ideas during the PBL, engineering activity.

6. Conclusions

After listening to a lecture in English about the Importance of Engineering Education and Creativity, engineering students at Osaka University successfully carried out a problem-based learning (PBL) activity involving tsunamis. They were asked to solve the following problem. How will the coastal areas of Japan be protected from future tsunamis? The students were provided with an engineering design model (outline), a survey form, materials to simulate tsunamis, etc. and background information about waves and tsunamis (including the one that caused major destruction to Japan in March 2011). The participants began by brainstorming in groups about the problem and possible ways to solve it. Next they tested their ideas by using simulations for tsunamis. As a result of their experiments, many creative ideas were generated. Some included reducing the energy of the tsunami, blocking the tsunami with barriers such as seawalls and trees, developing early detection and warning systems for tsunamis, and devising as well as implementing emergency escape plans from the tsunami. It should be mentioned that Japanese is the main language for these students and that they do not usually have an opportunity to hold brainstorming sessions in class. Also they were required to complete this activity in a couple of hours. The optimum situation would have been to provide ample time for further experimentation, simulations, etc. Overall the participants enjoyed this project very much, would like to join a similar one again, and felt that the lecture and activity helped develop their creative thinking skills. They liked simulating a tsunami and creating the design (a plan for solving the problem) the best. The most difficult task was the initial generation of ideas.

7. Acknowledgements

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