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Student Engagement and Learning Experience Enhancement through an Interactive Pedagogy in Structural Analysis

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CONTEXT

The implementation of this educational project is to take an initiative to shift from the traditional teacher-led approaches to the student-centred approaches in order to increase students' engagement, collaboration, their confidence and communication skills, and motivate students' interest in learning CSE30301 Structural Analysis through a bridge model competition. A plastic stick bridge challenge is hosted in an academic year as one of the physical experiments to foster creativity, teamwork, and problem-based learning in a laboratory setting.

PURPOSE OR GOAL

The educational project is to engage and challenge civil engineering students and increase their confidence and communication skills through the use of active learning pedagogies such as problem/ project-based learning of CSE30301 Structural Analysis, definitely aligning with the programme, departmental and university strategic goals in teaching and learning to further enhance the student learning experience. The goal is to ascertain how well CSE30301 students learn more about academic contents from participating in a plastic stick bridge challenge.

APPROACH OR METHODOLOGY/METHODS

The methodology included conducting pre- and post-experience surveys to solicit views of CSE30301 students to evaluate the impact of the teaching methodology on them. 32 participants of CSE30301 class completed the students' feedback form of pre- and post-experience surveys on the plastic stick bridge challenge via Microsoft Forms. The surveys were designed in the form of questionnaires to solicit their views. A 5-point Likert scale was used in the questionnaires. The results of the loading test were recorded. The student performance in final examination of CSE30301 was observed as well. The loading test results were gauged against the final examination to establish correlation to see whether students performing better in bridge competition were the same ones performing better in final examination.

ACTUAL OR ANTICIPATED OUTCOMES

The findings in four domains such as students' learning experience, creativity, teamwork and problem-solving ability are reported and interpreted from the pre-and post-surveys. It is found that the mean differences between pre-survey and post-survey scores in four domains are statistically significant at 0.01 level. The findings also show that there are statistically significant positive correlations between the loading test result and the final examination result.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The mean differences between pre-survey and post-survey scores in four domains are statistically significant at 0.01 level. There are statistically significant positive correlations between the loading test result and the final examination result.

KEYWORDS
Structural Analysis, Student Learning Experience, Problem-based Learning

Introduction

Generally, subject instructors prefer to use traditional teacher-led approaches in delivering lectures, tutorials, laboratory classes, and other teaching and learning activities as they can implement their lesson plans and control the pace of teaching in a traditional way more easily. These are quite common approaches for lecturing in large classes (Lee, 2009; Mulryan-Kyne, 2010). In response to the current instructional challenges such as inattentive, disengaged and less motivated students in classes (Fredricks, 2014; Macklem, 2015; Sullivan et al.,2014), the implementation of this educational project is to take an initiative to shift from the traditional teacher-led approaches to the student-centred approaches in order to increase students' engagement, collaboration, their confidence and communication skills, and motivate students' interest in learning these core subjects such as Structural Mechanics and Structural Analysis through bridge model competitions (Chuang, 2014; National Research Council, 2003; Qureshi et al., 2023; Wu et al., 2013).

The objectives of this project are to implement active learning pedagogies and interactive activities highlighted as follows:

to create student-led and problem-based learning environments as parts of teaching & learning activities and assessment tools for civil engineering students who are learning structural mechanics, mechanics of materials and structural analysis in the context of structural engineering

to host a plastic stick bridge challenge in an academic year as one of the physical experiments to foster creativity, teamwork, and problem-based learning in a laboratory setting

The educational project is to engage and challenge civil engineering students and increase their confidence and communication skills through the use of active learning pedagogies such as problem-based learning in civil engineering subjects such as CSE30301 Structural Analysis, definitely aligning with the programme, departmental and university strategic goals in teaching and learning to further enhance the student learning experience.

The project aims to enable students of CSE30301 Structural Analysis to collaborate with each other to acquire basic knowledge of both structural mechanics and structural analysis including static equilibrium, support reactions, external forces on structures, statically determinate and indeterminate structures, analysis of statically determinate pin-jointed trusses and influence lines for simple trusses, beams, and frames through problem-based learning.

To increase students' engagement and challenge them in a collaborative problem-based learning environment, the plastic stick bridge challenge is hosted to enable students to acquire the above concepts and knowledge among peer groups to foster peer-to-peer learning, teamwork, and collaboration (Hara, 2008; Stigmar, 2016; Yang, 2006). These generic attributes are the key pre-requisites for their further career developments in civil engineering profession. This problem-based approach in such a collaborative environment definitively makes a positive and far-reaching impact on enhancing students' learning experiences and outcomes in the context of structural mechanics and analysis as well.

Problem-based Learning Activity

The model competition involves design, fabrication and testing of a bridge structure which spans a fixed distance without interior supports. The model is assembled/ fabricated with plastic sticks only which are reusable and provided by the project leader. The design of the bridge structure should be innovative and aesthetic. It should be structurally stable and effective. The supports of the bridge structure are located on both sides as illustrated in Figure 1. This problem-based activity aims to enhance the learning outcomes of students, particularly creativity and teamwork, through construction of physical models in a laboratory setting for CSE30301 Structural Analysis.

Each team performs the loading test by loading top of the bridge structure using standard weights. Ten minutes are given to each team for setting up and performing the loading test. The bridge structure should hold the load for 5s before successive loads can be added. Final loads are recorded when time is up. Final loads are the cumulative load added before its collapse.

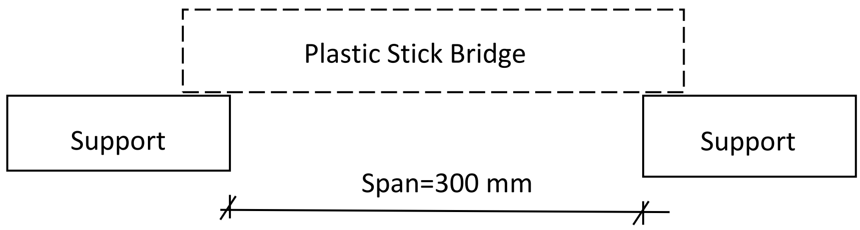

Figure 1: Plastic stick bridge on supports

The group performance is assessed based on the following judging criteria.

Judging Criteria

1. Strength and Lightness

Each bridge structure which can sustain the final load is recorded. The bridge structure before loading is weighted. The bridge structure which can achieve the highest strength to lightness ratio is also recorded.

2. Aesthetic and Innovation

The bridge structures are assessed in terms of aesthetic and innovation. The subject leader ranks the structures based on the free space inside the bridge structure, the aesthetic overall outlook and innovation.

Methodology

The research methodology included conducting pre- and post-experience surveys to solicit views of CSE30301 students for capturing behaviours of participants and examining the impact of the teaching methodology on them. 32 students of a CSE30301 tutorial class completed the students' feedback form of pre- and post-experience surveys on the plastic stick bridge challenge via Microsoft Forms. The class participants are 31469 and 31469-SY year 3 students currently studying CSE30301 Structural Analysis. The surveys were designed in the form of questionnaires to solicit their views. A 5-point Likert scale was used in the questionnaires. The results of the loading test were recorded. The student performance in final examination of CSE30301 was observed as well.

The loading test results were gauged against the student performance in final examination in order to establish correlation to see whether students performing better in bridge competition are the same ones performing better in final examination. Quantitative data were analyzed at the end of course. Testing the hypothesis H_o: $\rho=0$ versus H_1: $\rho>0$ was conducted where ρ is the population correlation. The sample correlation, r, between the loading result and the final examination result was computed. The standardized test statistic $U = r/\sqrt{(1-r^2)/(n-2)}$ following a Student's t distribution with n-2 degrees of freedom was then determined. The P-value was finally determined and checked if its value is less than the level of significance α of being 0.01 or not.

Students worked in groups to gain the hand-on experience on the assembly and loading test of bridge model as shown in Figure 2, and related the bearing on theoretical concepts in the context of structural engineering.

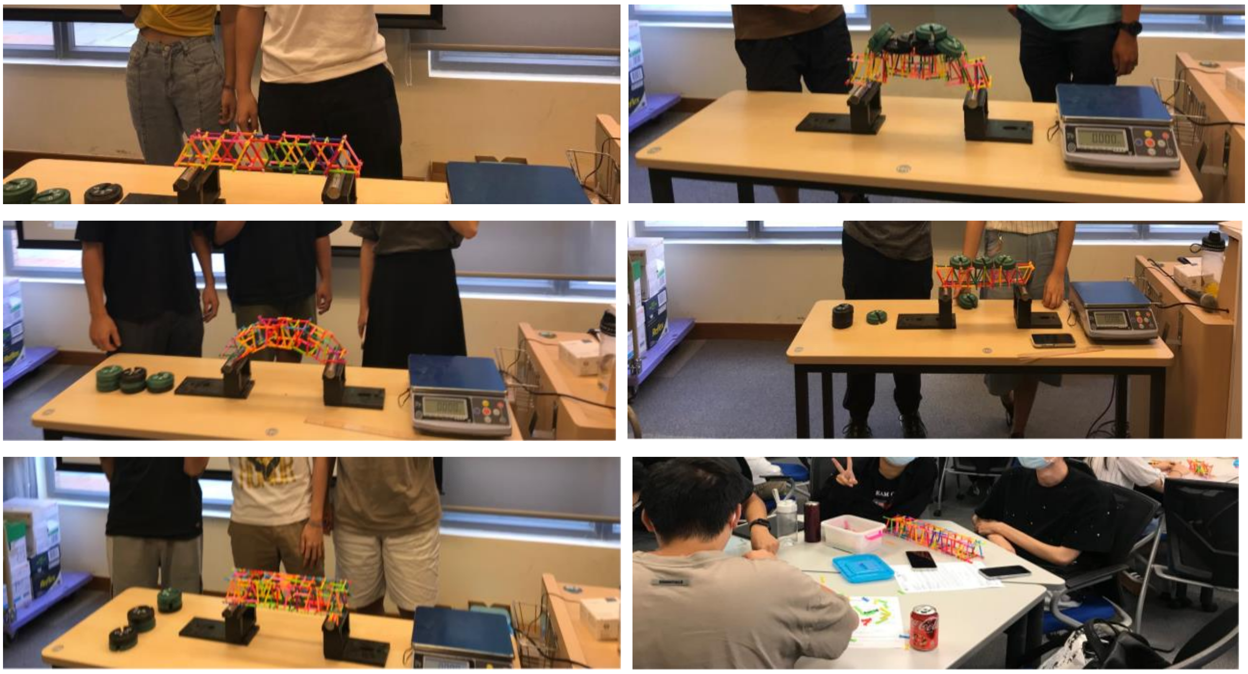

Figure 2: Assembly and loading test of plastic stick bridge challenge

Result

The findings in four domains such as students' learning experience, creativity, teamwork and problem-solving ability are reported and interpreted from the pre- and post-surveys on the plastic bridge competition. A 5-point Likert scale is used in the questionnaires designed to measure these four domains as constructs from a list of questions or statements as indicators before and after the competition. The pre-post survey results are summarized in Table 1. It is found that the mean differences between pre-survey and post-survey scores in four domains are statistically significant at 0.01 level.

The findings also show that there are statistically significant positive correlations between the loading test result and the final examination result based on the result of the the hypothesis testing for correlation. For the test, the sample correlation r is 0.812. The standardized test statistic U is computed to be 7.62 with 30 degrees of freedom, yielding the P-value of being much less than 0.01. The null hypothesis H_o is thus rejected and there is enough evidence to support the claim H_1.

Table 1: Pre-post survey results of four domains

Domain	N	Mean	Mean Difference
Students' learning experience	32	3.3 4.5	1.2** (**: sig. at 0.01 level)
Creativity	32	3.1 4.3	1.2** (**: sig. at 0.01 level)
Teamwork	32	3.2 4.5	1.3** (**: sig. at 0.01 level)
Problem solving	32	3.3 4.4	1.1** (**: sig. at 0.01 level)

Conclusion and Recommendation

The mean differences between pre-survey and post-survey scores in four domains such as students' learning experience, creativity, teamwork and problem-solving ability are statistically significant at 0.01 level.

There are statistically significant positive correlations between the loading test result and the final examination result as the computed test statistic U of 7.62 with 30 degrees of freedom yields the P-value of being much less than 0.01 from the hypothesis testing for the positive correlation.

The plastic stick bridge competition is recommended to be embedded in the current subject curriculum as parts of the assessments for adoption in view of statistically significant domains such as students' knowledge application, learning experience, engagement, and collaboration.

The deliverables such as the plastic stick bridges are sustainable and reusable in subject offering semesters of subsequent years. The project leader is also responsible for reviewing the problem-based learning activity which is well aligned with the subject intended learning outcomes. The plastic stick challenge on different kinds of structural design problems such as load bearing towers/structures is proposed to be held every year.

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