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Investigating Effect of Active Learning Activities through Pre and Post Activity Questionnaires and Student Feedback Surveys

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ABSTRACT

Many courses have been traditionally taught in a conventional way following lecture based techniques with minimal hands-on and interactive activities that involve the students in the learning process. Due to raising market demands, employers are seeking graduates with higher logical thinking level skills, team work skills and leadership, complex problem solving and communication capabilities. This necessitates using more student-centered approaches rather than instructor-based focused learning approaches where students are more engaged in the learning environment in class. A set of activities were applied in Applied Fluid Mechanics course to flip it into a more interactive environment class. The activities were graded based on the instructor observations and students' scores in each activity. The effectiveness of the activities in the proposed course was analyzed using students' feedback through post-activity surveys, students' scores and using pre- and post-activity questionnaires. The study compared the results for three years when the activities were applied against scores when no activities were applied. Based on the overall course grades, students' performance has improved from one year to another. The individual questionnaires showed different improvement levels ranging from 4-75% based on scores in pre-and post-questionnaires. Many other skills showed improvements from the students' perspective in the surveys. The outcomes of the applied activities can help in meeting ABET learning outcomes and course learning outcomes set by the department such as applying engineering knowledge, critical and logical thinking, complex problem solving, communication skills, team work skills in addition to improving students' learning in an interactive learning environment.

Keywords – Project based learning, active learning, student experience and feedback, student development, activity questionnaire, student centered.

1. BACKGROUND

Problem and Project Based Learning "PBL" can be a powerful pedagogical tool, however it has its own benefits and risks. According to Weimer [1], PBL starts with problem introduction and students are asked to solve these problems while learning the concepts in parallel to discovery. The course instructor or students can both participate in structuring and formulating the problem or the question to be solved. Personal previous experience is a key factor in PBL. Different approaches are used by different students based on their prior experiences in the topic they are investigating. Students start with their experiences and build on it. This creates motivation for students to link between what is new with what is already known. In this type of active learning environment, students are expected to do research, make decisions, prepare reports, and present their results. Genareo [2] listed six steps that each project-based learning process should follow: (a) defining the expected outcomes from the case and relating them to the course learning outcomes; if the outcomes fit into a PBL environment, then the instructor should proceed otherwise it might have negative reflections on the students experiences, (b) defining the requirements such as assignments, projects, discussion, reflections, etc., (c) introducing the PBL to students who might be new to this concept and discussing the expectations with them, (d) students do research and brainstorming to define the resources available and check on what is available (in terms of knowledge) and what is needed to be gained and learned. After that students set roles and hypothesis for their work, (e) evaluating the outcomes and presenting them in terms of a poster or minute paper, and (f) assessment which is the final step and is a very vital step for the learning process. Rubrics for each activity or project done are essential as it guides students' work and help them in defining success. Wlodkowski [3] indicated that analyzing and studying real life problems are essential for any problem-based learning environment in order to motivate critical thinking, collaboration, and professional skills. Weber [4] indicated that it is important for PBL to define the rubrics for success in order to meet its goals. It is important to define achievable and reasonable rubrics that the students can follow and achieve successfully. Those rubrics should reflect a safe and successful environment where students are encouraged to participate instead of feeling embarrassed. It should promote an interesting and relevant experience, as well, where the students are allowed to fully engage in a professional role to fulfill the goal they are working on.

Student-centered environments have been known to improve logical thinking skills, communication skills and the ability to work with others in teams, while being innovative and creative [5]. Evidence is also available that shows this kind of learning environment encourages quantitative reasoning and complex problem solving skills as they are routinely practiced in the work involved in this classroom pedagogy [6].

2. INTRODUCTION

Problem-based learning (PBL) is a process oriented, self-directed, and collaborative pedagogical strategy that guides the students' learning process through an active learning environment introducing them to various challenges and techniques that help them succeed in their future careers. PBL can offer a better vehicle through which to teach and retain a concept, providing a richer context in which subject matter can be learned and practiced.

Companies and communities rely on team work to achieve success and are seeking graduates who can work successfully on a team. The current real-world problems are more global and they usually do not fit within the boundaries of a single discipline. The knowledge needed by engineering technology program graduates upon joining an industrial factory is various and comes from different domains and disciplines. Some skills and competencies that current employers are looking for in recent graduates according to a survey done Purdue University [7] are summarized in Table 1. The top requirements were innovation, followed by problem solving in diverse settings, then critical thinking, and complex problem solving. To meet these new challenges and requirements, new modernized teaching paradigms and techniques are needed. Some techniques include design projects, technology driven homework assignments, exercises in the classroom, working problems in small groups, guided/facilitated discussions, online quizzes, online threaded discussions, students presenting new material to the rest of the class, discussion-based learning, and industrial facilities tours.

Table 1 2013 Purdue University's survey for employers' expectation in new graduates [7]

Competency	Employers Agreement Percentage
Innovation is a priority	95% of employers
Broad learning (liberal and sciences)	80%
Liberal and Applied Learning (collaborative problem solving, research, internship, senior projects, community engagement)	Strongly agree
E-Portfolios would add value	83%
Knowledge of Human Cultures and the Physical and Natural World	
* Broad knowledge in the liberal arts and sciences	80%
* Global issues and knowledge about societies and cultures outside the US	78%
* Knowledge about science and technology	56%
Intellectual and Practical Skills	
* Critical thinking and analytical reasoning	82%
* Complex problem solving	81%
* Written and oral communication	80%
* Information literacy	72%
* Innovation and creativity	71%
* Teamwork skills in diverse groups	67%
* Quantitative reasoning	55%
Integrative and Applied Learning	
* Direct experience with community problem solving	86%
* Applied knowledge in real-world settings	78%
Personal and Social Responsibility	
* Problem solving in diverse settings	91%
* Ethical issues/public debates important in their field	87%
* Civic knowledge, skills, and judgement essential for contributing to the community and to our democratic society	82%
* Ethical decision making	64%

Project-based learning has the advantage of converting the learning process from being instructor-centered to student-centered approach. PBL encourages students to challenge their skills and knowledge and develops lifelong learning skills that are not experienced with traditional instructor-centered teaching approaches. However, guidelines and expectations must be set to prevent student failure and negative impacts. Weimer [8] discussed some risks and challenges accompanying PBL environment. Fig. 1 illustrates some of these challenges and reflections on students, instructors, and institutions.

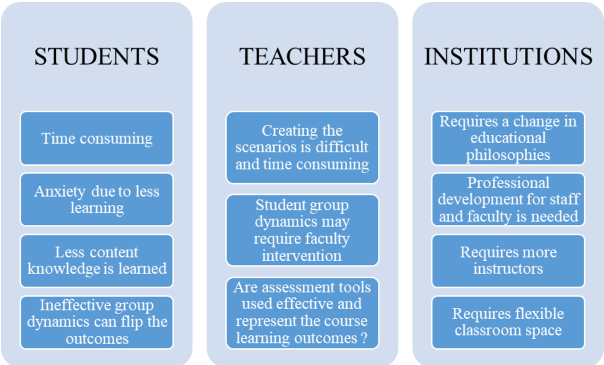


Fig. 1 Negative reflections and challenges arising with project-based learning environments

Fluid mechanics course is a traditional required course in the engineering and engineering technology programs. Students from different majors including mechanical, electrical and civil engineering are required or interested in taking it due to its wide applications in the industry sectors. The course learning outcomes The course learning outcomes (CLOs) for this course are as follows:

1. Describe the fundamental concepts and properties of fluids.
2. State the basic equations of hydrostatics and apply them to static and dynamic fluid cases.
3. State Archimedes' Principle and use it to solve problems with bodies submerged in fluids.
4. Apply the Bernoulli equation to solve problems in fluid flow.
5. Recognize the characteristics of fluid flow in closed conduits: laminar and turbulent flow.
6. Interpret pipe specifications and calculate hydraulic diameter.
7. Compute pressure loss in pipes and fittings for closed conduit flow.
8. Select pumps to optimize the performance of open and closed loop flow systems.
9. Measure and interpret volume and mass flow measurements from a variety of common flow measuring devices.
10. Apply concepts of drag and lift to solve problems involving flow over immersed bodies.

To help meet the new market needs, the author added five activities to Applied Fluid Mechanics (course code removed) to flip it from being instructor based to student based course. The introduced activities were similar to a lab testing environment or were demonstrated by the instructor and the students were asked to analyze the results in teams depending on time and testing stations. Each activity covered certain course learning outcome outlined for the course while engaging the students in a team oriented and active learning environment. Five problem-based activities were embedded in the course. The activities were introduced to students during lecture time since the course is initially designed with no lab time. Thus, students were divided into different teams during lecture time and were asked to work on the different activities. Some activities were easy to reproduce and the teams worked simultaneously, while for other activities it was necessary to do one team at a time or the instructor ran the experiment or activity and the students took measurements and analyzed the results. A survey asking for students' reflections and feedback was collected following each activity. Other surveys were also collected following midterm exams/assessments. The students' responses and grades are presented and analyzed, as well. These activities were repeated 3 times in the same course, with the same instructor teaching the course but the students group being different. During the last year, the instructor checked on the students' knowledge before and after each activity using questionnaires.

3. METHODS

3.1 Research questions

The following questions were the driving questioning behind the questionnaires designed that are presented in this paper:

Q1. How to retain students' interests in the class while covering the curriculum as required by the college and the department?

Q2. What is the effect of each of the added labs/activities on the students' performance?

Q3. How does the overall score look like when using these activities in the course?

Q4. What are the students' interactions and recommendations to such a new pedagogy in class?

The course was mainly modified by dividing the contents into three major sections and by adding problem-based activities that meet the CLOs of the corresponding section. The structure of the flipped course is shown in Table 2 with percent contribution of each category towards the final course score.

Table 2 Flipped course structure with percentage towards final GPA

Section #	**# Homework Sets (20%)**	**# Section-assessment (35%)**	**# PBL activity (30%)**	**Long Term Project (15%)**
1	3	1	1	1
2	4	1	2	
3	3	1	2	

3.2 Modified course structure

The theme of each section was as follows:

Section # 1: *Fluid Properties and Behavior* including fluid properties, fluid statics, and pressures.

Section # 2: *Fluid Flow and Kinematics* including energy equation, mass conservation and continuity, incompressible flows, viscous flow, laminar and turbulent flows, and frictional losses.

Section # 3: *Pipe Network* including major and minor frictional losses in pipes, modified Bernoulli's equation, pump head calculations, pump performance and requirements, pump selection, and finally pump and system curves.

Each of the evaluation categories used in the new course structure are as follows:

Homework Assignments: Homework assignments contributed to 20% of the final GPA.

Section-Assessment: at the end of each section, students were asked to do a micro-assessment for the topics covered. This assessment varied between an open ended question, to a minute paper or presentation. These were designed to check on students' understanding of the material and their competency level in the topics of each module. The total contribution of all assessments was 35%.

Semester Long Projects: Students were asked to build or perform a complete design and analysis for topics of their choice. The topics had to be related to fluid mechanics in its core. Students' projects were done in teams. The students' performance for this category was evaluated using progress reports, final presentation and final report. The progress reports included: proposal (week # 3), progress report 1 (week # 9), and progress report 2 (week # 12).

PBL Activities: five activities were added to the course content to improve its delivery to the students. The activities and the relation of each one to the CLOs and to ABET outcomes are all summarized in Table 3. ETAC ABET [9] outcomes measures that are reported in Table 3 are: (a) applying knowledge to engineering technology activities, (b) selecting & applying knowledge of mathematics, science, engineering and technology to engineering technology, (c) conducting standard tests and measurements, and interpret experiments, (d) designing systems and components, (e) function in a team, (f) solve broadly-defined engineering technology problems, and (g) communication skills. The activities were designed to be conducted during class time since the course is originally scheduled as a 3 credit hours lecture with no lab commitment.

3.3 Introduced activities and questionnaires

The five activities are summarized in Table 3. The objectives of the each of the five activities were:

Activity 1 (Buoyancy): The activity investigated the buoyancy effects of tap and salty water on an object immersed in it. A balance, weight scale, beakers and other needed equipment were provided to students. The students had the freedom to decide on the volume of water and quantity of salt used. There were some directing questions to lead the students testing decisions and analysis. A schematic of the assembly for this activity is shown in Fig. 2. The pre- and post-activity questionnaires given to the students before and after conducting this activity are shown in Figs. 3 and 4, respectively.

Table 3 Introduced activities and their relation to CLOs and ABET outcomes

Activity	Course Learning Outcomes								ABET Outcomes
	1	3	4	5	6	7	8	9	
1) Buoyancy	X	X							
2) Mass Flow Determination			X		X			X	
3) Pressure Drop			X	X	X			X	a, b, c, d, e, f, g
4) Time to Empty Tank	X		X					X	
5) Friction Loss vs. Reynold's #			X	X	X	X	X		

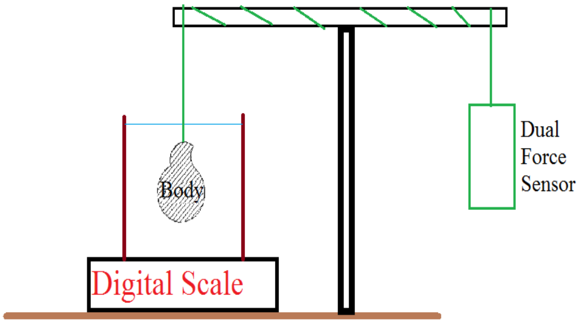
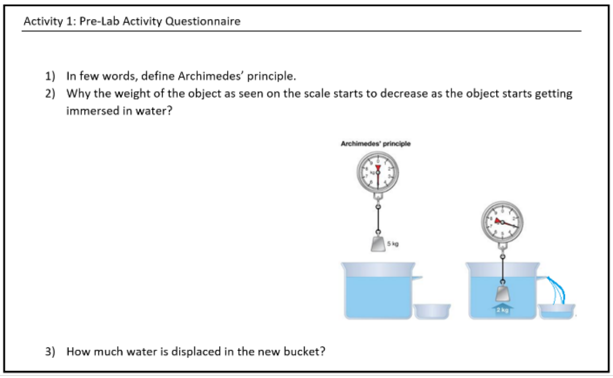


Fig. 2 Activity 1: Buoyancy testing station

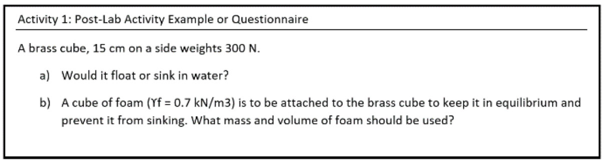


Activity 1: Pre-Lab Activity Questionnaire

1) In few words, define Archimedes' principle.
2) Why the weight of the object as seen on the scale starts to decrease as the object starts getting immersed in water?

3) How much water is displaced in the new bucket?

Fig. 3 Activity 1 pre-activity questionnaire



Activity 1: Post-Lab Activity Example or Questionnaire

A brass cube, 15 cm on a side weights 300 N.

a) Would it float or sink in water?
b) A cube of foam (Yf = 0.7 kN/m3) is to be attached to the brass cube to keep it in equilibrium and prevent it from sinking. What mass and volume of foam should be used?

Fig. 4 Activity 1 post-activity questionnaire

Activity 2 (Mass Flow Measurements): Using the venture duct shown in Fig. 5, a fan was used to supply air into the duct where the pressure was measured using air nozzles. The velocity could be measured using a pitot-static tube and a hot wire anemometer. The pre- and post-activity questionnaires are shown in Figs. 6 and 7, respectively.

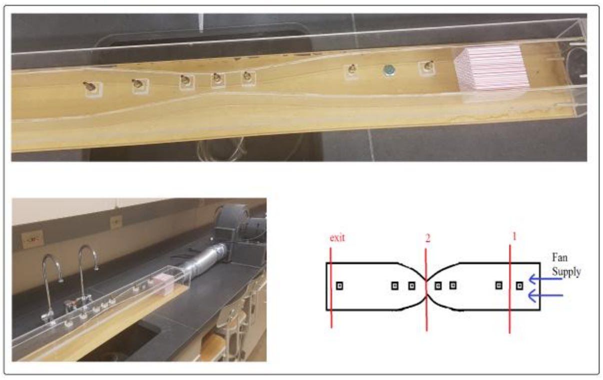
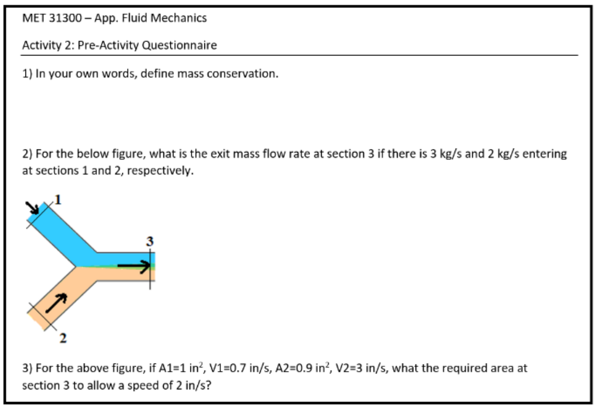


Fig. 5 Venture duct used to allow mass flow measures and pressure drop inside a duct



MET 31300 – App. Fluid Mechanics

Activity 2: Pre-Activity Questionnaire

1) In your own words, define mass conservation.

2) For the below figure, what is the exit mass flow rate at section 3 if there is 3 kg/s and 2 kg/s entering at sections 1 and 2, respectively.

3) For the above figure, if A1=1 in², V1=0.7 in/s, A2=0.9 in², V2=3 in/s, what the required area at section 3 to allow a speed of 2 in/s?

Fig. 6 Activity 2 pre-activity questionnaire

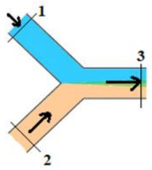
Activity 3 (Pressure drop measurements): The same apparatus used for Activity 2 was used to investigate pressure drops inside the duct. The pressure drop inside the duct was investigated while the duct was laid horizontally and at an angle. The students measured pressure differences between different points along the duct. The pre- and post-activity questionnaires are shown in Figs. 8 and 9, respectively.

MET 31300 – App. Fluid Mechanics

Activity 2: Post-Activity Questionnaire

1) If the system is steady state, fill in the blank:

$\dot{m}_1 + \dot{m}_2 - \dot{m}_3 =$ ______________



2) In Lab # 2, what are some causes for not having the mass flow rate at section 1 and at exit equal (name at least two)

3) Which method used in today's lab is the most accurate for measuring the mass flow rate? (anemometer, pitot-static tube or U-tube manometer?)

Fig. 7 Activity 2 post-activity questionnaire

MET 31300 – App. Fluid Mechanics

Activity 3: Pre-Activity Questionnaire

1) Why does the pressure drops as a fluid pass through a duct or pipe?

2) A Fluid passes through a duct; if P1 – P2 is negative, which section is upstream and which one is downstream (section 1 and 2)

3) Is the pressure drop measured using a U-tube manometer gage or absolute pressure? Explain.

Fig. 8 Activity 3 pre-activity questionnaire

MET 31300 – App. Fluid Mechanics

Activity 3: Post-Activity Questionnaire

1) What are the factor that affect the pressure drop?

2) What is the effect of the fluid velocity on static pressure drop?

3) Name two instruments used in this lab to measure the pressure drop and name one challenge (kinds of cons and pros) for each unit selected

Fig. 9 Activity 3 post-activity questionnaire

Fig. 10 Tank emptying measurement apparatus

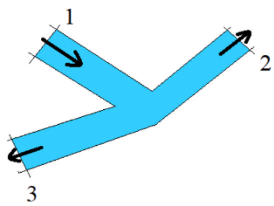
Activity 4 (Transient Bernoulli): This activity was one of the activities used to meet CLO # 1, 4 and 9. The objective of the activity was to investigate the transient effect of Bernoulli's equation. Two tanks were used on top of each other with the upper tank having three identical nozzles. The nozzles were used to allow water to exit the upper tank to the lower one. Stop-watches and measuring devices were used to complete this activity. Fig. 10 shows the apparatus used for this activity. Figs. 11 and 12 show the pre- and post-activity questionnaires.

MET 31300 – App. Fluid Mechanics Name:

Activity 4: Pre-Activity Questionnaire

1) Name two restrictions when you can't apply Bernoulli's equation.

2) A fluid enters port 1 and is split into two ports as shown. Write down the mass conservation or continuity equation for the system if it is under steady state.



3) How would the continuity equation in question 2 look like if the system is unsteady?

Fig. 11 Activity 4 pre-activity questionnaire

MET 31300 – App. Fluid Mechanics Name:

Lab 4: Post-Activity Example or Questionnaire

1) Write the mass conservation for a system under unsteady state conditions.

2) If a tank is draining water from its lower end, then the drop in height (or change in volume) is linear with time.

True ___________

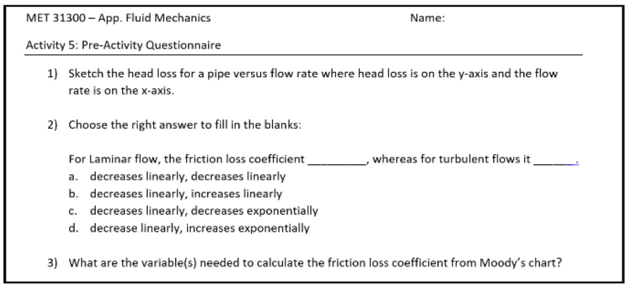
False ___________

3) After completing Lab # 4, do you expect the drop in height as a function of time to follow the same trend despite the number of nozzle being opened ?? (i.e. is it the same curve and divided or multiplied by a certain factor which is a function of the number of nozzles?). Explain.

Fig. 12 Activity 4 post-activity questionnaire

Activity 5 (friction loss determination): This apparatus has multiple pipes with different pipe sizes and material. It also has multiple types of elbows and valves. With the aid of "3D printed" pressure nozzles, the students were able to measure pressure drops across multiple pipe, valves and elbows and were able to estimate the friction loss coefficients for the various pipe materials and compare it to text book values and other sources. The students were also asked to investigate the relation between the head loss and the flow rate. The apparatus is shown in Fig. 13 whereas the pre- and post-activity questionnaires are shown in Figs. 14 and 15, respectively.

Fig. 13 Pipes, valves and fittings friction loss activity apparatus



MET 31300 – App. Fluid Mechanics Name:

Activity 5: Pre-Activity Questionnaire

1) Sketch the head loss for a pipe versus flow rate where head loss is on the y-axis and the flow rate is on the x-axis.

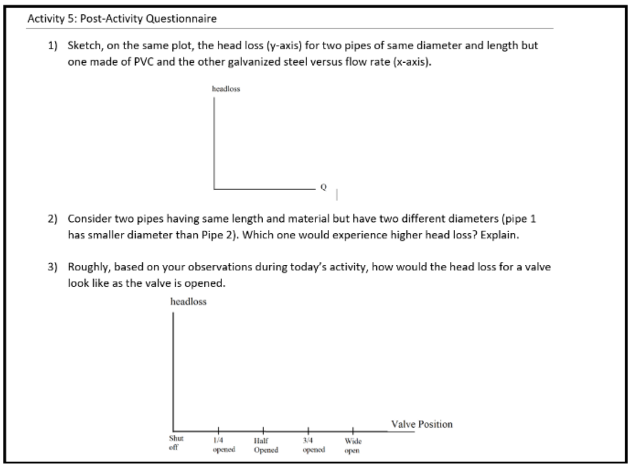
2) Choose the right answer to fill in the blanks:

For Laminar flow, the friction loss coefficient ________, whereas for turbulent flows it ______.

a. decreases linearly, decreases linearly
b. decreases linearly, increases linearly
c. decreases linearly, decreases exponentially
d. decrease linearly, increases exponentially

3) What are the variable(s) needed to calculate the friction loss coefficient from Moody's chart?

Fig. 14 Activity 5 pre-activity questionnaire



Activity 5: Post-Activity Questionnaire

1) Sketch, on the same plot, the head loss (y-axis) for two pipes of same diameter and length but one made of PVC and the other galvanized steel versus flow rate (x-axis).

2) Consider two pipes having same length and material but have two different diameters (pipe 1 has smaller diameter than Pipe 2). Which one would experience higher head loss? Explain.

3) Roughly, based on your observations during today's activity, how would the head loss for a valve look like as the valve is opened.

Fig. 15 Activity 5 post-activity questionnaire

3.4 Survey by students

Following each of the five activities, students were provided with a survey asking for their feedback in knowledge gain and improvement experienced an improvement in: 1) team work skills, 2) critical logical thinking, 3) complex problem solving, 4) written and oral communication skills, and 5) analytical reasoning. The survey also asked for guidance provided during lab time and whether they were lost and to what degree. The responses for this section were based on 10-points Likert scale with 10 being very satisfied and 0 not satisfied at all. In addition to these scaled questions, an open ended feedback question was also provided to give the students an opportunity to write about any suggestions to further improve their experiences and learning techniques.

Another survey was also collected following exams/assessments 1 and 2. No data was available after exam 3 as it was done during final exams and students were either too busy or could not be reached out. These surveys asked the students to report: 1) the time spent to prepare for each exam/assessment, 2) how prepared the student feels he/she was, 3) how helpful were the activities in preparing them for the exam/assessment and 4) how helpful were the Powerpoint slides in bridging the information. The results of this survey along with the pre- and post- activity questionnaires were used to check on the effectiveness and the impact of the activities on students' knowledge gain.

The author of the paper collected data for Fall 2016 when no activities were applied. In Fall 2017, Fall 2018 and Fall 2019 the activities were introduced and data from the students' surveys were recorded and analyzed. During the last cycle in Fall 2019, the pre- and post-activity questionnaires were used to help in further assessments. The number of students in each class ranged between 11 and 18 students.

4. RESULTS AND DISCUSSION

The responses for each category in the students' feedback surveys following each activity were averaged over the number of students. The survey responses for Activities 2 and 3 were combined together as they shared the same apparatus. The averages for each category in each activity and the average of all activities in each category are shown in Fig. 16. The responses were all based on 10-points Likert scale with 0 being the lowest and 10 as highest. However, the scale for the last category "Felt Lost" worked in a reverse way where a low score indicated good results as it would mean "being less lost". The lowest average of all categories was for Team Work Skills with an average of 6.7/10. The response averages for Activity 5, where the friction loss unit was used, scored the highest, or close enough to the highest, among all the 5-activities covered and the lowest for feeling lost item. The first reason for that could be that the students in got used after 4 activities to the activities' policy and the way it works. Also the students seemed to feel more comfortable with this learning environment as the semester progressed and thus by the time they conducted this activity, they showed progress. The students were also introduced to this apparatus in previous course although the objectives were different but the students seemed to enjoy working on it, felt least lost compared to other activities, and thus the response averages for this activity were the highest. Also it was noted that all categories' averages, for post activity surveys, were above 6.7 on a scale of 10 except the last category "Felt Lost" which was a flipped scale where the lower the score, the better the impact. The lowest average was for "Team Work Skills".

The students' responses from the post-activity surveys indicates that the most impacted skill for the students out of the 5-activities was analytical reasoning (8.2/10), followed by critical thinking (8.1/10), logical thinking (8.1/10), complex problem solving (7.85/10), written and communication skills (7.77/10) and lastly team work skills (6.7/10).

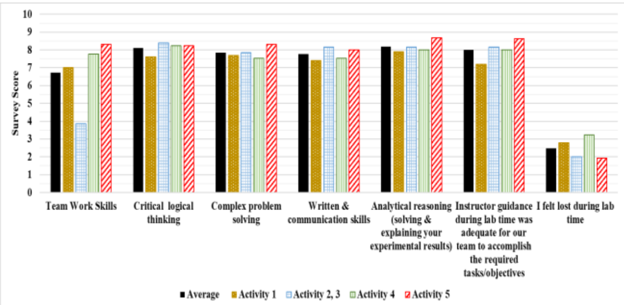


Fig. 16 Students' responses to post activity surveys

On the other hand, Fig. 17 shows the average responses for post exams surveys along with the average of each category. The categories used for post exam surveys were on a scale 0-10. The highest the score, the better the impact was except for the first category "Time Spent" which meant students had to put too much time to understand the material. The post exam surveys showed satisfaction among students in categories related to exam preparation with average response score of 7.4/10, except for the time needed to prepare for the exam which was 6.2. However, the time spent scale should be flipped, 0 as best and 10 as worst, as it would be better if students spend less time to prepare for exams while maintaining good scores. A score of 4 or 5 out of 10 for the time spent was thought to be ideal while keeping good grades.

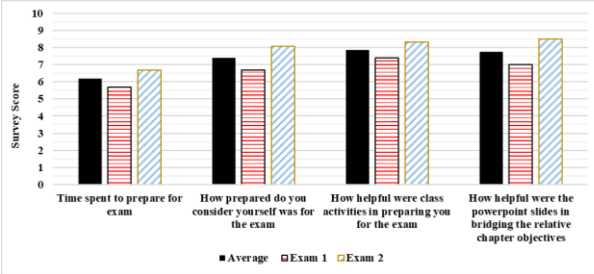


Fig. 17 Students' responses to post exam surveys

The pre- and post-activity questionnaires were collected and graded for each activity/exercise and the average of all students' scores for each questionnaire are shown in Table 4 along with improvement in each activity when looking into the post- versus pre-activity questionnaires. As can be seen the students were able to improve their skills after conducting each activity and this improvement reached as high as 75%. It is worth mentioning that Activity 3 had the highest improvement because it had the lowest assessment scores in the pre-activity questionnaire. This was mainly due to the fact that the questions were new to the students and a bit challenging specially when asked them to determine the upstream and downstream sections. However, the post-questionnaire for this activity showed that the students picked up the concepts and scored 70 out of 100 resulting in 75% improvement. The same discussion could be said but in a reverse order for the lowest improvement in Activity 4 where the pre-activity scores were too close to the post-activity scores. Regardless of how high or low the improvement is, but there has been a good improvement trend in the post-activity questionnaires over the pre-activity ones.

Thus, the discussion yielded from student surveys after each activity came into agreement with the improvement in questionnaires shown in Table 4 with Activity 3 and Activity 5 having the highest scores for students' satisfaction and for improvement in the questionnaires scores.

A better picture for the effect of these applied activities would be by looking into the overall student performance and the final scores including exams and homework assignments. Averages of students' scores after each exam and averages of the total course scores were collected and compared to previous records. In Fall 2016, the course was taught with no added activities, and the first time the activities were added was in Fall 2017. The scores for 3-consecutive years has been collected and shown for Fall of 2017, 2018 and 2019 in Fig. 18. The figure shows gradual jump in the scores of all categories. In Fall 2017, when the activities were introduced, the improvement was not significant, but then throughout continuous improvement made to the activities, significant rise in the scores was seen in 2018 and 2019. The final exam scores are usually lower that mid-term exams due to the fact that students have other exams being conducted at the same time, more material to be tested in, other assignments and commitments. However, in 2019 the final exam scores were comparable to the midterm exams which can be and outcome of the activities embedded.

Table 4. Questionnaires average scores and the percent improvement between pre- and post-questionnaire

	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5
Pre-activity average scores (100 possible points max.)	60	67	40	67	52
Post-activity average scores (100 possible points max.)	73	85	70	70	87
% increase in score	**22%**	**27%**	**75%**	**4%**	**67%**

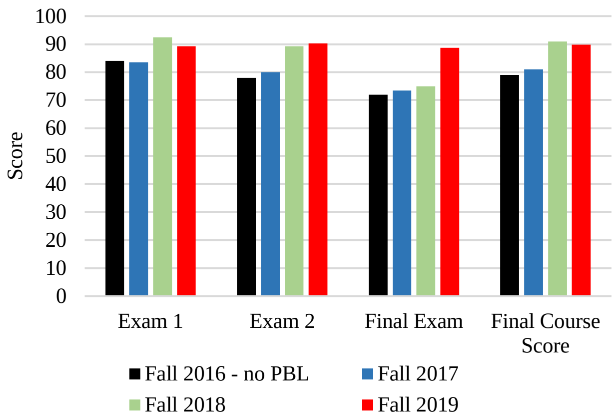


Fig. 18 Averages for students' scores in different categories considered throughout the course

5. CONCLUSION

A This paper analyzed the performance of students in Applied Fluid Mechanics course and their interactions when changing the delivery method of the course from being instructor-centered to student-centered. The core objective of the activities or the study was not to have an increase in the overall score, which is preferred, but it was more directed toward students' interest retention while meeting the course learning outcomes. The results shown in Fig. 18 show that the students not only kept the same level of proficiency when following these active learning techniques but in fact they performed better. Continuous improvement to the way these activities are conducted from year to year, helped the students perform even better. At the same time the students showed good and high levels of satisfactions in regards to time spent to prepare for exams, logical thinking, and complex problem solving which are high stacks for employers when looking into new graduates. On the hand, many ABET outcomes would be met using such activities as shown in Table 3.

There were couple challenges worth mentioning when conducting these activities in similar courses. First and most importantly is that these type of flipped courses and active learning environments are time wasters; they require a lot of effort and time to design the activities, the surveys, and the questionnaires. Analyzing the collected data also takes too much time. Sometimes, there are many data collected but the lack of resources to secure support of undergraduate and graduate students limits the ability to explore. Thus financial resources and support is critical in such environments. The second challenge that the authors had when applying such paradigm was proper assessment for all students; since these activities were done in groups, some students may not be involved in the testing or analysis as others do. Third, the presented questionnaires which were applied for the first time in this class in Fall 2019 were designed so they could be answered within 5 minutes each or less. This was a major challenge for the authors. From the instructors' perspective, this would double his challenge as they'll need to design the activities and the two questionnaires, preceding and following each activity, to be all completed in 75 minutes or less which is the total class time in a day. Lastly, team work skills were shown to have the least scores from the students' perspective. The authors recommend doing pre-selection screening for students' interests and building teams based on the students' preferences by combing those with similar interests and backgrounds which could lead to better cooperation among the teams.

In conclusion, some introductory background, as was done in Activity 5, or providing the students with a demonstration prior to conducting the activity can help the students perform better as was seen in [10], as well. The flipped course presented in this paper indicates that students' interests can be retained with more hands-on activities. This came into agreement with other studies such as [11], [12] and [13]. Compared to conventional, instructor-centered based courses, PBL learning techniques offer a better vehicle to retain concept, providing richer context in which a topic can be learned and practiced at the same time. This not only retains students' interests and helps them understand the concept, but also helps prepare them succeed rapidly in their future careers as most companies rely on team work, critical-logical thinking, complex problem solving in their employees. The relation between each of the activities' objectives and the course learning outcomes (CLOs) shows that this type of class teaching can cover the same context as in a traditionally offered course. All the activities showed higher level of learning by students as defined by the Bloom's Learning measures. Most of the activities require the students to apply, analyze and synthesize a solution to the problem introduced in order to reach the deemed objective. These characteristics are the upper levels of the Bloom's Learning pyramid. The paper also showed that many of the ABET outcomes can be satisfied with the project learning paradigm. However, the way the project is designed needs to focus on meeting those outcomes and other course outcomes.

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