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Issues and Proposed Solutions to Team Based Assessment in University Physics Labs

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ISSUES AND PROPOSED SOLUTION TO TEAM BASED ASSESSMENT IN UNIVERSITY PHYSICS LABS

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INTRODUCTION

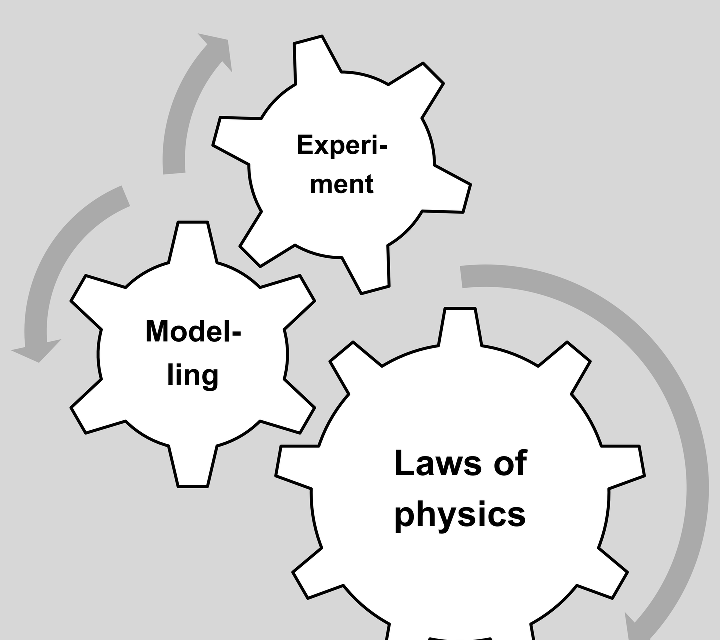
Many education experts considers peer-to-peer education as the most effective way for students to learn (Peersdom, 2014). Western Michigan University (WMU) physics laboratories embraces this philosophy and has designed the assessment to be based on the team report. The assumption is that every team member contributed (not necessarily equally) to the work submitted by the team hence every team member should receive the same grade. This is a ubiquitous assessment philosophy in education, and some forms of additional individual assessment in team projects are strongly discouraged (David Boud et al, 1999).

There is no doubt on the effectiveness of peer-to-peer education, but what is questionable is whether David Boud is correct in discouraging a supplementary individual assessment. Team based only assessment has many issues of which some will be discussed in this investigation. Here are three issues we have observed in WMU physics laboratories that affect assessment design:

1. How can we ensure that all students meet the imperative learning objectives of the laboratory?
2. How can we avoid passing "spectator" students who are not reported by their team members?
3. How can we increase student engagement in an already active learning environment?

BACKGROUND

In this section we will outline the context of our investigation. The data and observations presented here are made from PHYS2060 and PHYS2080 University Physics I & II Laboratories offered in WMU. The main learning objective of the labs are; *to investigate the laws of physics through experimentation and computational modelling.*



The labs have 4 to 5 projects in a semester, where each projects runs for 2 to 3 lab meetings. Students work in teams of threes with the following roles in each team:

- **Principal Experimenter**: responsible for leading the set-up of lab equipment and data collection.
- **Principal Modeler**: responsible for leading the work on analyzing the data and making computational models to fit the data.
- **Principal Writer**: responsible for leading the write-up of the team's hypothesis, observations, and conclusions in a lab report.

Note that students are required, as per lab rules, to rotate roles every lab meeting. However, students tend to ignore this rule and fix roles according to their strengths and weaknesses. Hence not every student gets to have hands on experience of every part of the lab.

RESEARCH DESIGN

Our goal is to investigate the three issues posed in the introduction and propose a solution. We will focus our design on the first question and then make inferences on the other questions based on the results found by measuring if each individual student in a team meet the most important learning objectives.

The traditional assessment of physics laboratories is that each student's final grade is all based on their team report grade. The exception to this assessment rule is when a student receives penalties for lab ethics violation due to: (i) joining the lab more that 30min late, (ii) misses lab without valid excuse, (iii) does not do pre-lab assignments (not graded), (iv) shows a negative and/or unprofessional attitude towards the lab team or instructor, (v) is disengaged and/or does not contribute towards the team. We modified this and employed a mix assessment strategy, where 90% of their grade is from the team report grade, and the remaining 10% from individual post lab quiz grade. The final individual grade for each project is calculated as follows:

- **Traditional**: Final = (100% – penalties)x (team report grade)
- **Modified:** Final = (100% – penalties)x (0.9 x team report grade + 0.1 x individual post-lab quiz)

Below is a description of the assessment objectives of the team report and the post-lab individual quiz.

Mixed Assessment Technique (90% Team + 10% Individual)

Team Report (out of 27 points)

- Construct a scientific hypothesis for the experiment
- Run the experiment to collect data
- Analyze the data and display it using appropriate plots
- Answer analysis questions based on the data
- Create or modify a computational model to fit the data
- Make plots of the computational model along with the data
- Answer analysis questions based on the computational model
- Write a summary and conclusions of observations

Post Lab Individual Quiz (out of 3 points)

All questions are multiple choice

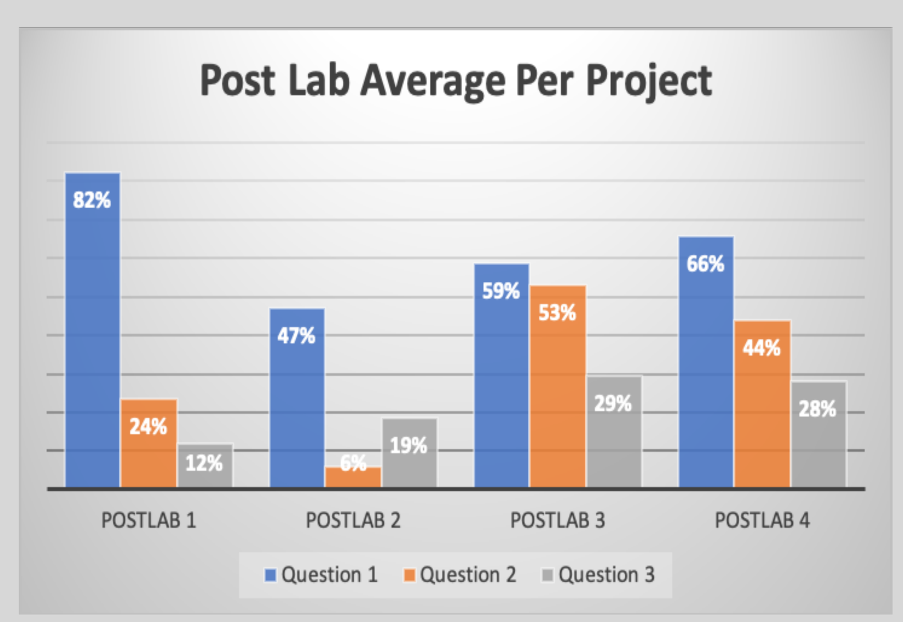
- Question 1: recalling of facts, definitions, or procedure from the tasks performed in the project
- Question 2: calculation similar (and sometimes identical) to one that was done in the project and included in the report
- Question 3: application of concepts investigated in the project on a new but similar problem

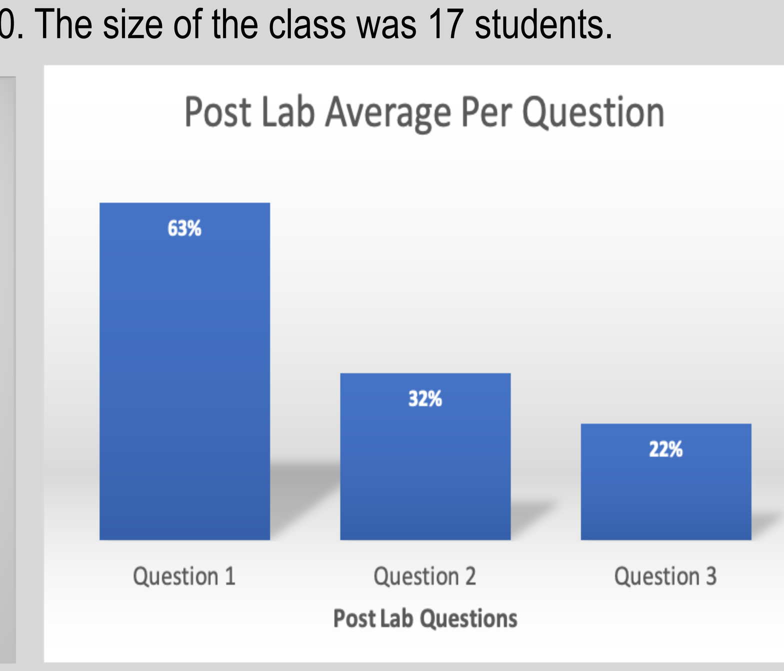
PRELIMINARY RESULTS

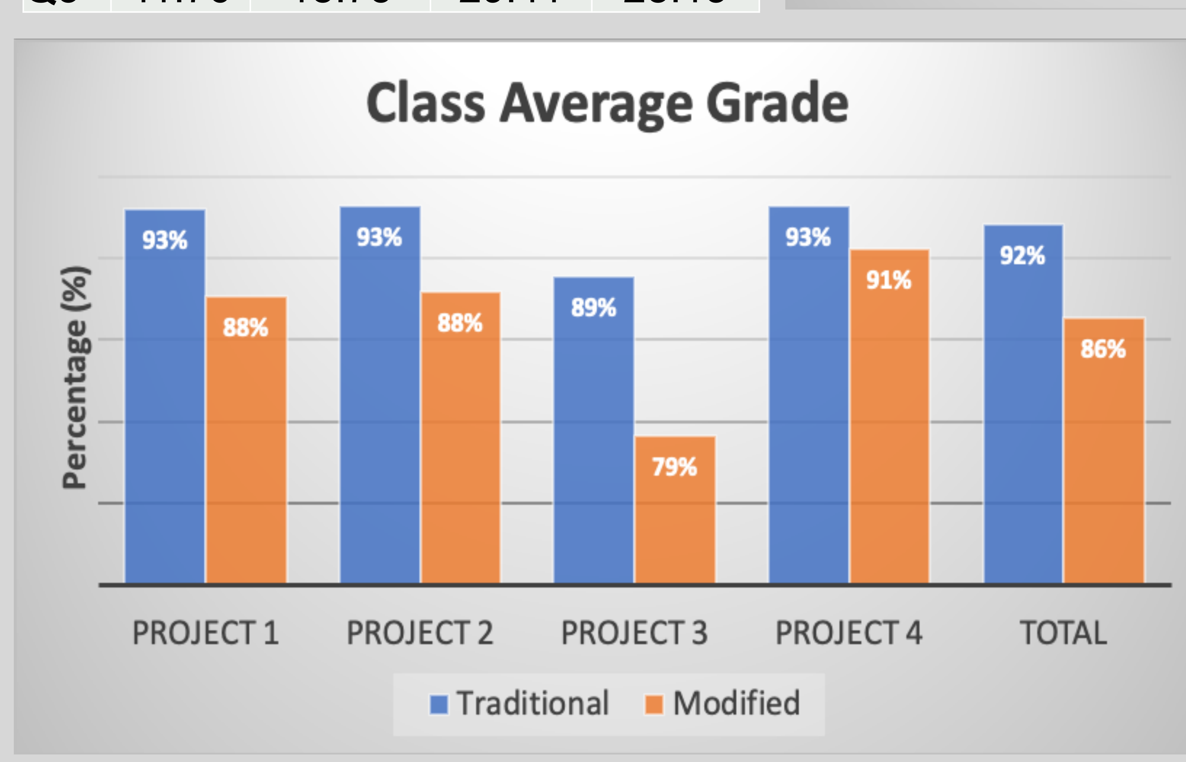
The results below were collected from the PHYS2060 laboratory in the Summer I Session of 2020. The size of the class was 17 students.

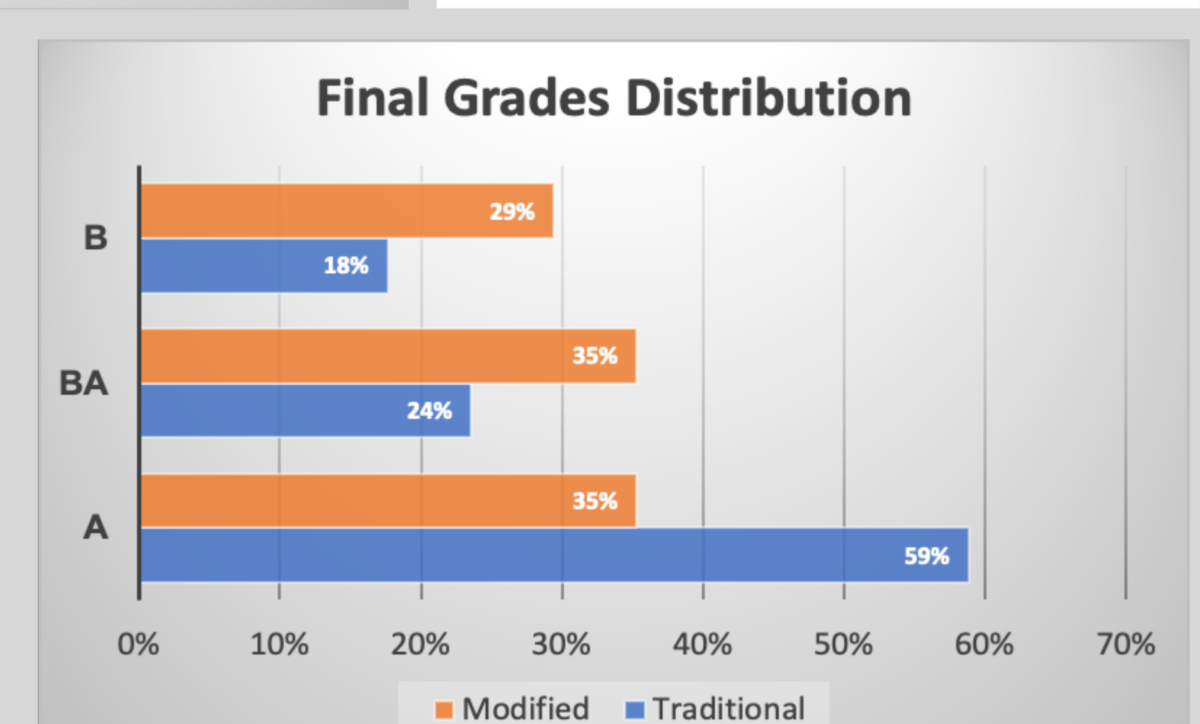
Percentage of students with correct answers in each post lab

	Lab 1	Lab 2	Lab 3	Lab 4
Q1	82.35	47.06	58.82	65.63
Q2	23.53	5.88	52.94	43.75
Q3	11.76	18.75	29.41	28.13









ANALYSIS

First looking at the **Post Lab** results, we note the following:

- On average, 37% of students cannot recall facts, definitions or procedures seen in the lab. This result is unsettling because it is difficult to explain, except we resolve to bad student behavior.
- On average, 68% of students cannot repeat calculations done in the project. Considering that such calculations were done correctly in almost all the team reports, a possible explanation is that only a few students do these calculations for their team. This reveals to us a serious problem, that many students do not learn how to do these calculations.
- On average, 78% of students cannot apply the concepts in a new but similar problem. Based on conversations with students, it seems like one of the reasons for this is that the parallel PHYS2050 class lags the PHYS2060 lab in terms of introducing the physics principles required for the lab.

Then we can examine the **Average & Final Grades** and note that:

- The traditional assessment method shows an average of 92% grade for the team projects. This a very misleading picture of the performance of the class in contradiction of the individual post lab data. Our modified method, which only used a 9:1 mixed assessment ratio, showed a lower average of 86%. This is still not a true representative of the class performance, but it is much closer than the traditional method.
- Even after including the individual lab ethics penalties, the final grades distribution of the traditional method is still off from the true performance of the class. For example, the traditional assessment method produced 24% more A students than our modified method. That means in the traditional method 4 more students out of 17 would have received an A that does not reflect their performance in the lab. This is a huge margin of error.

Another way to see the problem with the traditional method is to consider a typical lab with 24 students. If students are grouped in teams of threes, then with only one hard-working student per team then every student in class would get an A. However, the true class performance is supposed to yield 8/24 (33%) of students with an A grade. This is not just a hypothetical scenario, but an outcome that is consistent with our data. Our modified method yielded 35% of A students in the same class whereas the traditional method showed a class average of 92%. This calls for review of assessment method.

CONCLUSION

The STEM Instructional Training Program advocates for assessment to be designed to measure how well learning objectives are met. By this standard, the traditional team based only assessment does not show the true class performance. We propose a mixed assessment method, that will reveal to the instructor which students need more help with the lab. We believe this will help solve the first two issues raised in the introduction concerning learning objectives and "spectator" students. The third issue is still an open problem. These results are not conclusive, but they call for further study and examination of how science labs are taught and assessed.

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