MARK-IT: A SOFTWARE TOOL FOR HIGH-ENROLMENT PROJECT BASED LEARNING

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ABSTRACT

In open-ended project-based learning courses, large class sizes make equitable grading a challenge. The subjectivity and diversity of Problem-Based-Learning (PBL) outputs introduces inequity when multiple graders work in parallel. On the other hand, the burden of maintaining a consistent grading precedent over a large number of sequential project demonstrations is overwhelming for a sole grader and leads to similar inequity. A software tool is developed to remedy this. It displays a sorted list of photos and grades to ensure that subsequent projects grades conform to the precedent. Photos are organized by lab section and may be sorted by grade, team name or chronology. The tool is developed to improve grading equity in a 3rd year Electrical Engineering Design Studio course with an enrolment of 136 students divided into 34 teams. Initial results demonstrate significant reductions in the deliberation time that is required to arrive at a grade, particularly later in the demonstration process when equitable grading is most challenging. It is also found to improve the confidence level that assigned grades are appropriate relative to one another. The software tool is implemented in Python (open-source).

Keywords: *Grade equity, Large class, Project based learning.*

INTRODUCTION

University enrolment in North America has grown steadily over the past 10 year. In Figure 1, undergraduate enrolment in the department of Applied Science at the University of British Columbia is shown to have increased by 65% in 10 years, from 2007 to 2017 (UBC, 2017).
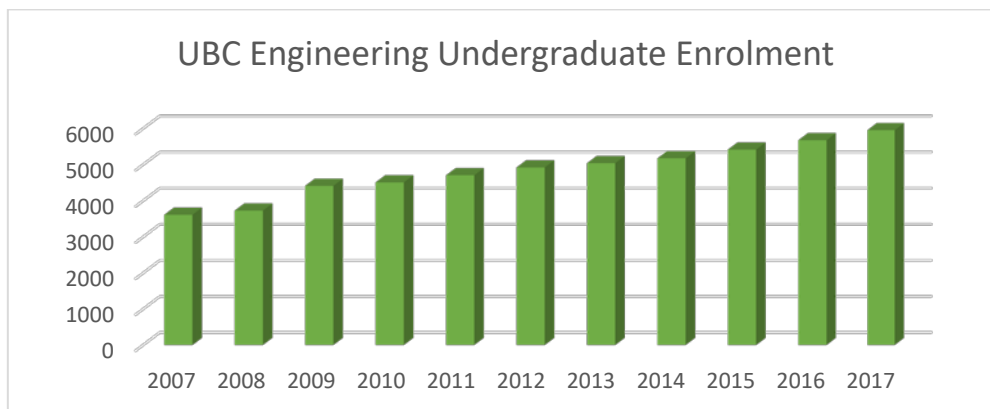

Figure 1. Undergraduate Enrolment in APSC at UBC

Mathematically, enrolment need not impact class size as long as faculty recruitment keeps pace. This is not the case with Problem-Based-Learning (PBL) due to resource demands that can make multiple parallel sections impractical, regardless of staffing. Lab spaces, technical support staff, prototyping equipment and qualified TAs are all expensive and limited resources which may prohibit parallel sections due to scheduling and time conflicts. In engineering programs, PBL courses are fast becoming the norm (Helle, Tynjala, & Olkinuora, 2006) (Macias-Guarasa, Montero, San-Segundo, Araujo, & Nieto-Taladriz, 2006) (Mills & Treagust, 2003), so class sizes at many institutions can be expected to grow along-side enrolment trends.

In lecture-based courses, grading workload is easily subdivided and equity is relatively independent of class size. A study evaluating assessment strategies (Duncan & Noonan, 2007) reports little correlation between class size and assessment practices. While this may be true for conventional examination grading, PBL grading is much more susceptible. An open-ended design project has no "right answer". It is uncertain what students will deliver so it is unclear how to prepare a grading rubric. The following features distinguish PBL grading from exam grading.
- Grading is subjective
- Graders must be qualified in all aspects of the entire project
- Student teams are diverse in their approach
- Student teams routinely deliver more than what is asked

Maximizing grade equity under these conditions imposes the following constraints.
- A common grader or grading team must assess all projects
- The grading team must be qualified in all aspects of the project
- The grading criteria must be adjusted in real-time to accommodate unanticipated outputs
- A mental inventory must be kept of all prior outputs, throughout the grading process

An inter-disciplinary capstone design project has such diverse technical content, the only person qualified to evaluate it in its entirety is usually the course professor. And since adjusting the grading criteria should also be handled by the course professor, a sole grading team is unavoidable. But assessing many projects sequentially over a span of several days while keeping an accurate mental inventory is very difficult, if not impossible, and the author is no exception. This leads to a lack of confidence in grading equity that is the primary motivation for this work.

A required course in the 3rd year Electrical Engineering program at UBC is ELEC 391 - Design Studio. This is a 13 week PBL course where students are assigned a capstone-style project which incorporates their entire 3rd year experience, or as close to it as possible. Topics include:
- Energy Systems
- System & Control
- Electro-Magnetics
- Circuits & Devices
- Real-Time Systems

The broad scope, high enrolment, and tight time constraints of this course present many challenges that have motivated a stream of pedagogical innovations that include formative assessments and time optimization (Stocco, Rosales, Galiano, Liu, & Feixo, 2016) and partial integration with a pre-requisite course (Stocco, Galiano, Paz, Rosales, & Feixo, 2017).

In the Spring 2018 term, students were asked to develop an electro-mechanical 2-DOF real-time control system that combines a laser with a robotic spherical wrist to draw a figure on a surface (see

Figure 2). Students designed and constructed mechanically commutating motors, optical encoders, digital and power circuits, and a PID controller running on a micro-controller to command the system. All system components were modeled and simulated in Matlab/Simulink so that formal design techniques could be used to develop and optimize the PID controller.
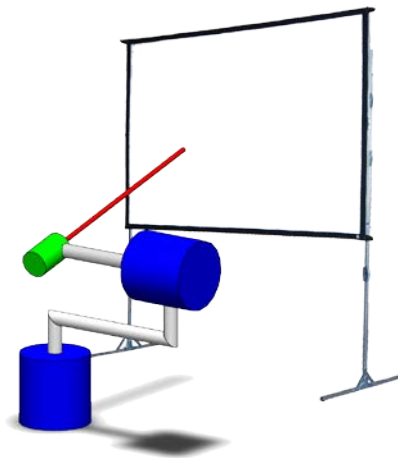

Figure 2. Schematic of ELEC 391 Design Project

A class of 136 students were divided into 34 teams of 4 students. Evaluations allowed 15 minutes for each demonstration and 5 minutes for deliberation and grading. That equates to a total of approximately 12 hours which was split over two days so it could be done sequentially.

This was the 4th year that this course had been delivered. In each of the previous 3 years, there had been a noticeable and inevitable decay in the confidence level regarding the fairness of each subsequent grade, as the memory of past projects and grade allocations faded during the deliberation process. In this paper, a software tool is developed which provides a snapshot of all past projects and their associated grades. It improves grade equity and the confidence in grade equity to more fairly reward students for their efforts while expediting the deliberation process.

SOFTWARE TOOL – MARK-IT
A software tool is developed to help maintain an established precedent when a large number of diverse outputs are being compared. It accomplishes this by meeting the following requirements:
- Simultaneously display a photo of each project
- Display the team name associated with each photo
- Display the assigned grade for each team photo
- Organize the team photos chronologically by lab section
- Sort the entries in each lab section chronologically, by team name, or by grade
- Allow grades to be modified
- Archive and retrieve data

The tool is written in Python (Python, 2017) which is a free, open source, scripting language that allows rapid development of PC applications. To run the tool, Python 3.6.5 or later is installed on the host computer. The tool is contained within a single text file which may be viewed and edited using any text editor.
- Mark-It.py   *Python script*

To use the tool:

1. Run the application (double-click the Python script)
2. <optional> Load a saved workspace
3. Load a new photo of a student project
4. Click on a photo to see an expanded view and/or change the grade
5. Repeat steps 3 & 4
6. Save workspace to an archive file

When the tool is run, a blank screen appears with three menu options and three sorting options. The associated sub-menus are displayed in Figure 2.

- Menu Options
  - Load
  - Save
  - View
- Sorting Options
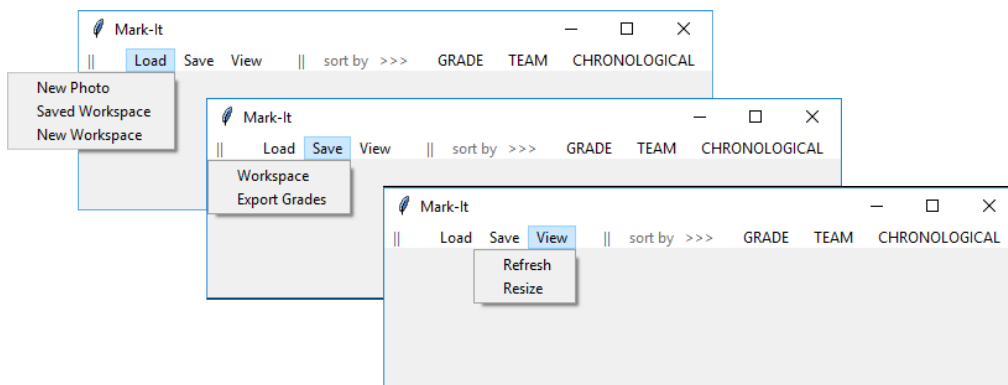 - Grade
  - Team
  - Chronological

Figure 2. Mark-It Menu & Sub-Menu Options

Each time a project is evaluated, a photo is taken and loaded onto the computer. The "Load / New Photo" menu option is used to load the photo into the workspace and assign it to a lab section. The "New Photo" screen is shown in Figure 3.
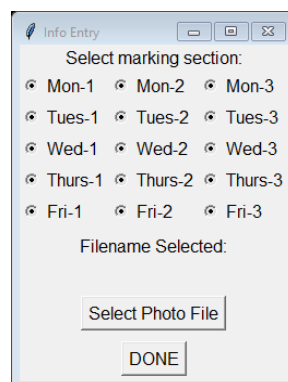
Figure 3. New Photo Pop-Up Screen

Once a photo is loaded, it appears in the workspace with the team name and assigned grade. Clicking on a photo opens a pop-up window that expands the photo and prompts for a grade change (see Figure 4). If no grade is entered, the existing grade is retained.
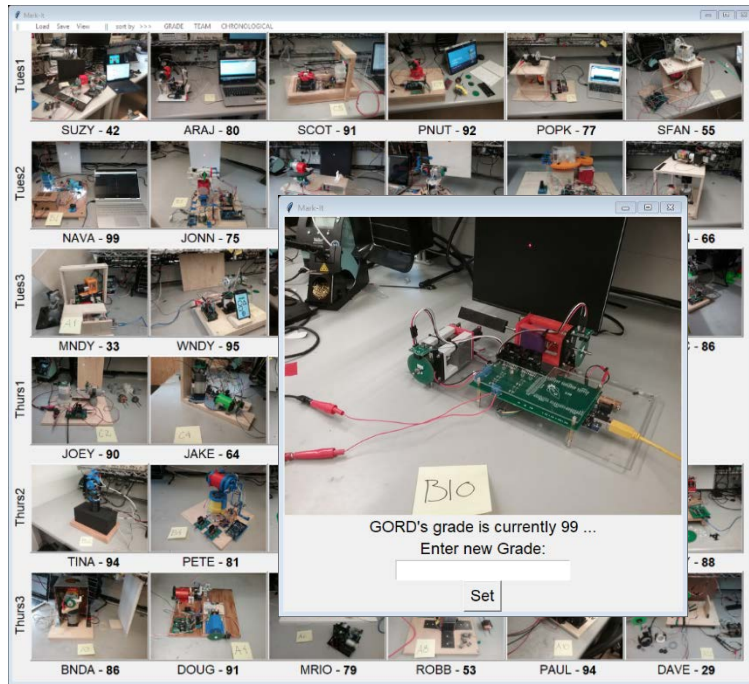
4

Figure 4. Expanding a Photo & Changing a Grade

All photos in a section are displayed on the same row in the workspace and the columns may be re-organized by clicking on the any one of the three available sorting options. For example, clicking on "GRADE", orders the photos in each lab section (each row) by grade (see Figure 5).
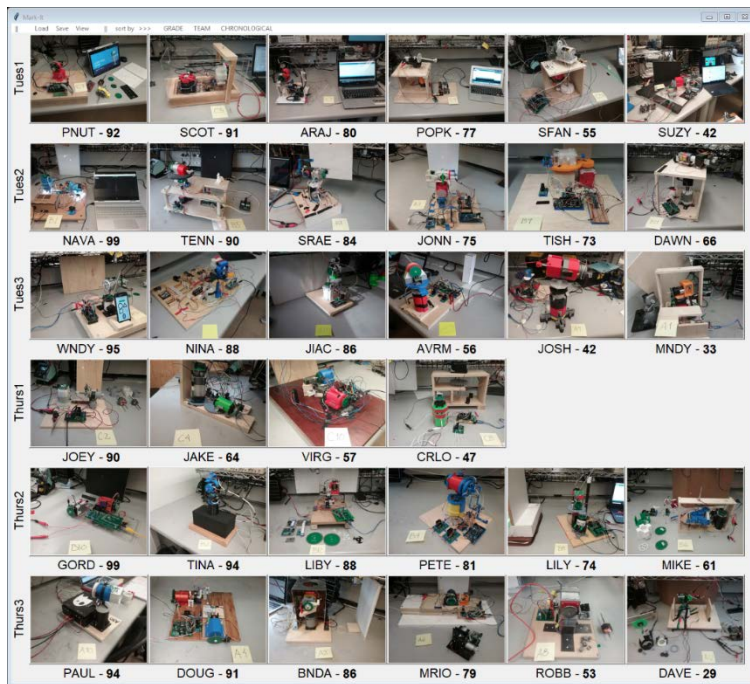

Figure 5. Workspace Sorted by Grade

The workspace may be re-sized to fit a particular computer screen by clicking the "View / Resize" menu option which opens the pop-up window shown in Figure 6.
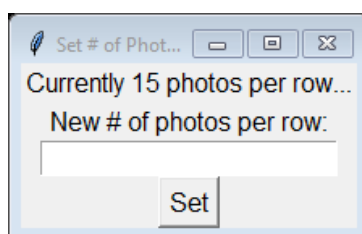
Figure 6. Resize Pop-Up Window

The "Save" menu option provides two options for archiving the workspace. Clicking the "Save / Workspace" menu option saves the workspace configuration to a text file which can be re-loaded using the "Load / Saved Workspace" menu option to resume the current session. The text file is self-explanatory and may be edited using any text editor to correct errors such as misspelled team names or to change where the photos are stored. The text file is stored in comma delimited CSV format so Excel may be used to view or edit the file by changing the filename extension to ".csv".

Clicking the "Save / Export Grades" menu option saves the team names and grades to a text file which may be imported into an Excel spreadsheet that is used to record student grades. Excerpts from the two archive files are shown in Figure 7.
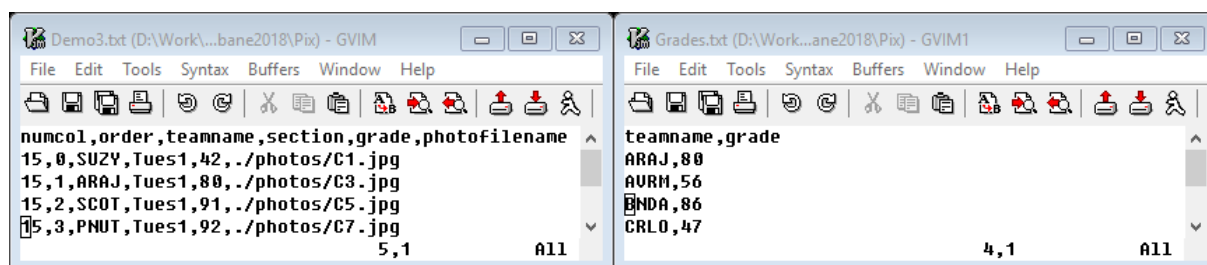

Figure 7. Archived Workspace Text Files

RESULTS

The tool was developed in Summer 2017 and was initially deployed in the Spring 2018 term. Projects were evaluated 3 separate times in 4 week intervals throughout the term. During each evaluation cycle, 34 projects were evaluated over two days with 6 projects per lab section, each spanning 2 consecutive hours, with a total of 20 minutes allocated to evaluating each project.

In prior years, each 2-hour session would go progressively over-time with each subsequent lab section. As the number of graded projects grew, 5 minutes became increasingly insufficient to identify how a particular project ranked, with respect to all others. The first 2-hour session would conclude 10 minutes late (typical), the next would conclude 20 minutes late (typical), and the final 2-hour session which would conclude close to an hour late (typical). After 12 hours of evaluations over 2 days, fatigue and confusion combined to make timely decisions impractical. Eventually, one become overwhelmed by the amount of information they struggled to remember, and the confidence level in grade equity degraded.

With the assistance of the Mark-It tool, each 2-hour block consistently concluded about 10 minutes late. This discrepancy is accounted for by unscheduled delays such as late starts, bathroom breaks, and informal feedback sessions. All evaluation sessions proceeded effectively on schedule with surprisingly little mental effort expended during the 5-minute deliberations. The level of difficulty did grow with the number of prior projects, but 5 minutes was always sufficient to arrive at a confident conclusion and record it.

With the assistance of the Mark-It tool, grading a project would proceed as follows.

- Estimate grade window – Fail / 50s / 60s / 70s / 80s / 90s
- Sort the projects by grade
- Identify subset of projects occupying the same grade window
- Compare current project to project subset
- Assign and adjust grades as necessary

For example, grading the 30th project might proceed as follows.

- Estimate
  - Requirements are met with no outstanding qualities
  - Assign to 80s (80% - 89%) grade window
- Sort & Identify
  - 4 projects already placed in 80s grade window
    - #1 – 88
    - #2 – 85
    - #3 – 84
    - #4 – 82
- Compare
  - Current project placed between projects #2 and #3
- Assign & Adjust
  - Current project assigned grade of 85
  - Project #2 grade adjusted to 86

In the above scenario, the 30th project is only compared to 4 prior projects that share its grade window. The other 25 are momentarily disregarded. Those 4 projects are organized chronologically by lab section and all 4 photos are expanded and displayed side-by-side. After a brief review of any notes that were taken, the specifics are recalled and grades are assigned and adjusted with relative ease. The grader is never faced with the formidable task of placing the current project with respect to all 29 prior projects.

SUMMARY AND CONCLUSIONS

Grading open-ended PBL course projects in a fair and equitable manners is a Catch-22 situation when enrolments are large. On one hand, the professor is the only one qualified to evaluate the multi-disciplinary projects, and must be involved to mitigate the individual biases and incomplete technical backgrounds of the teaching assistants. On the other hand, one person cannot reliably keep track of subtle differences between many projects that are demonstrated at a frantic pace over multiple days.

A software tool is developed to assist with this dilemma. It combines a photo of each project with the associated team name and its assigned grade. All photos are displayed simultaneously on the screen, organized by lab section. The photos in each lab section may be sorted chronologically, by name, or by grade. Photos may be expanded, grades may be changed, and the workspace may be archived to resume grading later, or to up-load the grades into an Excel spreadsheet. The tool provides a clear overview of all projects that have been demonstrated, and assists the grader to narrow down the relative ranking of each subsequent project by considering only the subset of projects that resemble the one being considered.

The initial deployment of the tool has virtually eliminated regularly observed time delays associated with deliberations occurring late in the grading cycle of a high-enrolment PBL course. More importantly, the confidence level in grading equity was markedly improved, indicating a stronger correlation between student output and awarded grades. Deploying the tool does impose some overhead since a photo must be taken of each project and loaded onto the computer prior to the deliberation step, but it is easily satisfied by a teaching assistant with minimal photography skills.

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