WIP: From Passive to Passionate: Using Genuine Projects to Motivate Students

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***Abstract*—This innovative practice WIP paper presents our work to increase student motivation and engagement using real-world projects. Specifically, we assigned final projects to students that came from a genuine need from our research program on campus. The team projects were assigned in a networking course offered to undergraduate and graduate students. Anecdotally, the students seemed more motivated to complete the projects because they knew the requested designs were novel and provided local utility. Student performance toward project completion was, anecdotally, exceptional compared to traditional projects.**

We surveyed students to assess their perceptions of their motivation and subsequent engagement. The survey results suggest that the students perceived what we also perceived: students had more motivation from these types of projects than the typical contrived recycled projects typically assigned.

In this paper, we provide the details behind these projects, how we managed the students to complete them, how we attempted to make the process mirror a commercial environment, and analyze the results of the student survey data. We also outline our experimental design to be executed in future course offerings to better understand how student motivation and engagement is affected by these types of projects in comparison with typical contrived recycled projects. Lastly, we outline how we intend to scale up across campuses and to create an experiential learning environment outside of formal course work.

***Index Terms*—experiential learning, team projects**

I. Introduction

To gain some insight into effective teaching practices we can look at the more than 2000-year-old quote from Confucious: *"I hear and I forget, I see and I remember, I do and I understand"*. Many faculty still use lecture style teaching to engage students, this style has limited success because we are merely broadcasting concepts to students: **I hear and I forget**. In some instances, faculty create active classrooms employing in-class demonstrations and in-class discussions, these strategies have limited impact: **I see and I remember**. Additionally, faculty will flip classrooms and spend a significant amount of time solving problems in-class, these strategies are indeed quite effective: **I do and I understand**. Various out of class activities (e.g., homework assignments, projects) are also used to follow the **I do and I understand** approach.

However, we now turn to recent educational psychology research to see that these isolated out of class activities do not inspire robust student motivation. The educational psychology research literature identifies a variety of influences on student motivation [1], [2]: (i) self-efficacy and related constructs [3], (ii) interest [4], [5], and (iii) intrinsic motivation [6]. Self-efficacy is the self-perception of an individual's ability to accomplish something. The higher an individual's self-efficacy for a particular accomplishment the more motivation they have to pursue the accomplishment [3]. Individual interest is a preference an individual has for a certain subject that is derived from positive feelings and/or attribution of significance of a certain subject [4]. The more interest an individual has in a certain subject the more motivation they have to pursue accomplishments related to it. Intrinsic motivation is an innate motivation in all humans to seek challenges and enhance abilities through learning [6]. The magnitude of this innate motivation is increased when certain psychological needs are met [2], [6]: the feeling of competence, a sense of autonomy, and a sense of connectedness.

Learning communities [7], [8] seek to increase intrinsic student motivation by fostering a sense of connectedness. Learning communities come in four general forms [7]: (i) curricular learning communities, (ii) classroom learning communities, (iii) residential learning communities, and (iv) student-type learning communities. Curricular learning communities consist of student groups such that group members are enrolled in two or more common courses. Classroom learning communities are those formed in classrooms for cooperative and peer learning activities. Residential learning communities consist of student groups taking common courses living in common on-campus housing. Student-type learning communities group students by common interest and/or common background (e.g., historically underrepresented groups, honors students, students with disabilities).

We seek to further increase student engagement by assigning students in networking courses a unique real-world project that has local utility in network research efforts. Specifically, we want to harness student interest and intrinsic motivation. Further, we have students work in teams to create a classroom learning community effect that should also increase intrinsic motivation.

A. Contribution

The real-world projects we assigned to motivate the students can be classified as experiential learning. Although experiential learning has been studied for some time, there are still significant gaps in the literature. An early access survey, to be published in 2024 [9], covering experiential learning studies over the previous 25 years indicates that nearly all studies focus on first-year students. Our study includes a mixture of undergraduate and graduate students on the same teams. Our assigned projects originated from a genuine research need on campus: development of networking experimental platforms and development of network data processing tools. As far as we know, this is the first paper on experiential learning originating from on-campus development needs. By sourcing projects from on-campus needs we can alleviate the need for outside support that can be very limited for some campuses, especially those in regions with very limited commercial engineering activity.

B. Outline

In Section II we describe the real-world projects and how we managed teams to complete them. In Section III we discuss the results of the attitudinal survey we administered. In Section IV we discuss lessons learned from the experience across two semesters. Finally, in Section V we summarize our key findings and outline paths for future improvement.

II. Real-world Projects and Our Process

The real-world projects assigned to students were related to communication networks research activities on our campuses. There were two major research efforts we wanted to support:

1) Experimentation using a software-defined networking testbed and a network emulator called Mininet [10]
2) Network traffic classification

To support research discoveries on our campuses, we conduct experiments with real networks, emulated networks, and simulated networks. For our real network experiments we wanted to setup a software-defined networking (SDN) [11] testbed in our lab. For that purpose, we designed two student projects to help with that effort: (i) create a bash or python script to easily configure Linux computers using Open vSwitch [12] to act as OpenFlow packet switches, and (ii) control those OpenFlow packet switches with network controller applications running on a network operating system, such as ONOS [13] or RYU [14]. Figure 1 shows the specialized *network appliance* computers the students used with the Open vSwitch software to create a very low-cost OpenFlow packet switch.

For our emulated network experiments we use Mininet [10] that uses light virtualization techniques like process groups and network namespaces to create a network of hosts and switches running on a single computer system. Although the hardware is emulated with light virtualization, all of the software is real. We created a single student project to help us be more productive using Mininet: create a software GUI application that allows the user to create new topologies using a canvas whereby we place various network components (e.g., host, switches, access points), link those components with transmission channels, and then instantiate the Mininet network automatically from that entered topology. Operations of this GUI include but are not limited to: adding/deleting nodes, adding/deleting links between nodes, loading/storing topologies from/to a file. There are existing tools that provide some of these features but the versions the students are creating have additional valuable features; such as supporting the Mininet-WiFi added node types. Figure 4 shows a screenshot of the topology generator the students have created.

One of the research thrusts in our group is investigating novel strategies to perform network traffic classification whereby we label network traffic flows with the application that generated the flow (e.g., email or video streaming). We created a single student project to assist us with the experimental platform to conduct experiments in this area. This project has the students develop Python software using data processing and machine learning libraries to pre-process data, and train/evaluate the performance of various classifiers.

Fig. 1. Network appliance computers student teams used with Open vSwitch to create very low-cost OpenFlow switches.

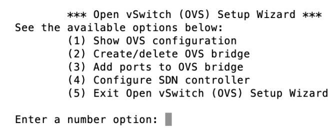

Fig. 2. Open vSwitch runs on those network appliance computers to create low-cost OpenFlow switches. Student teams have created a user friendly application to configure those computers as OpenFlow switches. The user does not need to know how to use Open vSwitch.

Fig. 3. Student teams used a variety of software tools for software-defined networking and machine learning to complete their projects.

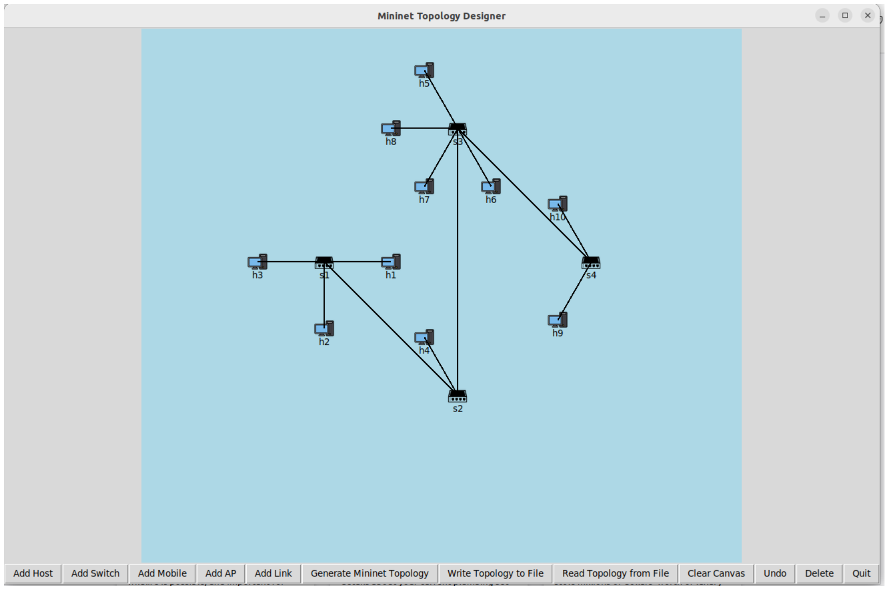

Fig. 4. Mininet topology generator a student project team created.

A. *Managing the projects*

We managed the projects employing the following steps. We created specifications for each of the project options that determined what the expected accomplishments would be. The first set of accomplishments were related to learning the necessary background material and tools to complete the project. This was then followed by specific design accomplishments. Project teams were given freedom to determine how to partition the work amongst team members and when/how to meet to coordinate their efforts. However, once a week during the six-week project each team was required to meet with the instructor to share progress, present challenges, and receive advice on next steps.

For assessment, we used three points of assessment. First, after completion of the tasks associated with the project learning curve the students prepared a seminar for the class that illustrated their knowledge of the required background material and relevant development tools. Second, midway through the development phase whereby their progress toward meeting objectives was assessed. Last, at the end of the semester during finals week their final progress toward meeting objectives was assessed.

A coarse-grained rubric consisting of three performance categories was utilized in the assessments: *Exceed expectations*, *Meet expectations*, and *Did not meet expectations*. This coarse-grained rubric is commonly used in professional settings and therefore was key to our strategy to mirror a commercial development environment. It is worth noting that we also provided two outlier categories to cover the full range of performance possibilities; so we also have a positive outlier and a negative outlier. The three main assessment categories correlate to the letter grades A, B, and C respectively; the positive outlier would correlate to a perfect score and the negative outlier would correlate to a D or F.

III. Student Attitudes

We administered a 5-point Likert-scale attitudinal survey to two cohorts of students that participated in these real-world team projects. The survey results are shown in Table I. In this table we can see the statements on the survey and the mean and standard deviation of the responses for the two separate cohorts of students whom participated in the projects. Lower scores mean the students were more agreeable to the statements. There were significant logistical differences between the two cohorts that we now outline.

Cohort 1 was a small class of 10 students offered twice a week in the afternoon; 6 students responded to the survey. Cohort 2 was a larger class of 20 students offered once a week in the evening; 18 students responded to the survey. The team sizes were three and four for Cohort 1 and were four, five, or six for Cohort 2.

A. *Results*

Both cohorts of students agreed that the real-word projects made them more engaged and motivated to complete them; Cohort 1 agreed more. Survey statements were included to see if there were any perceived differences in engagement and motivation provided by real-world team projects in relation to contrived team projects. There were slight differences for Cohort 1 but for Cohort 2 they reported nearly the same agreement for both measures.

We also included statements comparing real-world team projects to real-world individual projects. Cohort 1 was more agreeable to team projects than Cohort 2. These differences also translated to students being agreeable to the statement that they enjoy working in teams. We believe this difference was due to there being two large teams in Cohort 2 and those students commented to the faculty that they were having difficulty working as a cohesive team.

TABLE I
SURVEY RESULTS FOR STUDENT ATTITUDES REGARDING REAL-WORLD PROJECTS AND TEAM WORK FOR TWO STUDENT COHORTS (LIKERT-TYPE SCALE FROM 1- STRONGLY AGREE TO 5-STRONGLY DISAGREE).

	Cohort 1 (N=6)		**Cohort 2 (N=18)**	
	Mean	Std. Dev.	Mean	Std. Dev.
Working on a unique and useful real-world project made me more engaged and motivated to complete it.	1.333	0.4714	2.0	0.7454
The real-world team project was more engaging than a contrived team project would have been.	1.5	0.5	2.055	0.8480
The real-world team project was more motivating than a contrived team project would have been.	1.833	0.3727	2.0	0.8165
The real-world team project was more engaging than a real-world individual project would have been.	1.5	0.5	2.277	0.9313
The real-world team project was more motivating than a real-world individual project would have been.	1.333	0.4714	2.388	1.008
The real-world project motivated me to take another networking course.	1.166	0.3727	2.294	0.8921
I enjoy working in teams.	1.666	0.7454	2.222	1.1331

After managing two cohorts of students on these types of projects we believe team sizes should be ideally three but occasionally four, but no larger. The larger groups struggled to divide the work and the faculty offered advice on the topic of work partitioning but the teams still struggled. We speculate that certain teammates assumed they could rely on the work of their peers to get by. However, we were very detailed in our assessments and were able to effectively assess individual student performance.

IV. DISCUSSION

Here we outline some issues that still need to be resolved. From student written comments on the surveys and anecdotal evidence we obtained during our interactions with student teams, there are a few issues that we have determined exist:

1) Team sizes above four seem to result in one or two teammates struggling to be a productive member of the team.
2) The coarse-grained categorical rubric concerned some students because they felt their efforts were not precisely correlated to a numeric score.
3) Contingency plans or alternative objectives should be well prepared at the project start to avoid students feeling as if the objectives are not clear when some of those objectives prove to be out of reach.

First, we want to restrict team sizes as mentioned before to mostly teams of three but occasionally teams of four, but no larger. We will try this with the next cohort and see if results improve. Second, we will brainstorm to produce project-specific rubrics that allow students to accumulate points as they complete objectives. In this way, students will see a clear path to a particular numeric score. Last, we will refine our project specifications process to include formal contingency plans with several alternative paths students can take if certain objectives become too difficult to achieve in the allocated time. Our initial approach was to handle changing the objectives on-the-fly as we determined, in consultation with the student teams, that objectives were not feasible to achieve in the allocated time.

A. *Future experimentation*

These first two cohorts were pilot runs of this process. In the next few cohorts we plan to conduct experiments whereby we can study the motivation and engagement of the students between these real-world projects and traditional contrived recycled projects. We also want to study the effect team sizes and team management styles have on motivation and engagement. Lastly, we would also like to observe student performance on the project, in the course as a whole, as well as in the degree program as a whole and uncover relationships between project attributes and those measures. We plan to collaborate with an education researcher to assist with those studies.

B. *Expansion plans*

In addition to refining our process we will seek to expand these real-world projects beyond networking courses on a single campus. We plan to expand to additional campuses and to additional topic areas (i.e., outside networking). We have some genuine project needs in the area of embedded systems to support research platforms on our campuses that we could harness; this could be another avenue for expansion. We also would like to offer these projects to students as a co-curricular activity in the form of a learning community; yet another avenue for expansion.

V. CONCLUSION

In conclusion, initial evidence suggests students are more motivated to complete these real-world unique projects than they would have been to complete contrived recycled projects. A few students reported being excited about having a real project that they worked on that could provide valuable experience to report on their resumes. We are encouraged by the indications of success we are seeing in the student survey data. However, there are a few issues to resolve to improve the process. First, we received concerns from students about the logistics of working in teams larger than three students. Second, we received concerns from students regarding the coarse nature of the rubric used to evaluate them. In future iterations of these real-world projects we will restrict team sizes to be no larger than four students, but keep most teams at no more than three students. We will also brainstorm ways to create a more fine-grained rubric that provides a clear path to a numeric score.

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