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A Pedagogical Framework for Understanding the Alignment Between Classroom Project Evaluations and Real-World Industry Requirements

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Abstract

Recently, there has been an explosion in incorporating (typically, group-level) projects as an important component of individual course-level curricula in many engineering departments. A motivation that is often cited for using projects to evaluate students in groups is ensuring that students are well equipped to collaborate on, and negotiate, real-world projects. Unfortunately, it is not always evident that the actual design and evaluation of such projects by instructors is guided by real-world concerns. We suspect this may be due to a lack of agreement on best practices, or due to *misalignment* between university curricula and actual (i.e., in practice) job requirements. This work-in-progress paper briefly contextualizes the alignment problem, and argues for a framework that treats the project components of courses as first-class citizens. We present five example categories, with three item-prompts each, from the framework, which could potentially be instantiated for independent project-based engineering courses. We also present the outlines of an experimental plan for evaluating the framework.

Introduction

There has been a growing recognition in engineering pedagogy of the importance of class-based projects for the development of students' real-world skills [1]. In their ideal state, projects allow students to embark on an ambitious agenda, not otherwise achievable in a semester's work by the prototypical individual student, through coordinated groupwork. Projects allow students to flex their communication and team-work abilities in a relatively safe and pro-discovery environment. At an even higher level of aspiration, projects can also be designed to be amplifiers of behavioral engagement [2], including serving as community builders within the classroom by facilitating organic friendships and exchange of ideas, especially in smaller colleges and programs where students may find themselves as repeat colleagues in classes. Beyond engineering, in an effort to actualize such a phenomenon, many MBA programs require students to form their groups for the entire first year during the orientation (or early) weeks of the program[1].

Idealism aside, from an evidence-based standpoint, the pedagogical merit and utility of class-based projects has still not been fully established. One issue that can arise, as with so many

[1] An example is the MBA program for Professionals and Managers offered by the University of Southern California Marshall School of Business, which requires this for its class within the first week of orientation.

other educational interventions, is the impracticality of running controlled experiments, and the many confounds that cannot be controlled for in any sensible manner. This is not to say that evaluating groups is infeasible; indeed, there is a wide body of literature showing when groups work, or do not work, indirectly hinting at when group projects tend to be more (or less) effective, or of varying quality, depending on the nature of the group. An example of an accessible treatment of the subject, relying on data collected within Google, is the reporting by Duhigg [3].

In profit-driven enterprises, especially those relying on engineering and technology for their proverbial bread and butter, projects are often benchmarked against inexpensive resource-light alternatives (so-called 'baselines', especially in Artificial Intelligence applications) and there is a stronger degree of accountability, enforced through both formal mechanisms, such as software version control, code quality evaluations, and managerial evaluations, and informal social mechanisms, such as peer pressure. Some of these mechanisms have been explored in a wide body of literature on group accountability [4].

Because group-based work and collaboration are so important in organizational and professional life, and have witnessed strong adoption in education as well as 'needs-oriented' pedagogy [5], we argue that the time is ripe to make a deeper study of what we refer to as the *alignment problem*. Stated intuitively, the alignment problem asks whether the pedagogical design, evaluation and products of group-based projects in engineering *classrooms* are aligned with the needs-oriented goals of *industry*. Is there a strong degree of peer accountability, for instance, or are there opportunities for students to 'free ride'? Is there strong emphasis on communication? While such questions (and the answers to them) might be complex, one cannot ignore them in a world where people increasingly expect, and demand, value for their tuition dollars [6].

We recognize that the alignment problem is a controversial one, both in terms of formal defining and agreeing *what* should be aligned, but also in terms of whether alignment is fundamentally misguided i.e., it should not be a pedagogical goal to begin with. Certainly, a case could be made that the version of alignment we proposed (industry alignment) is misguided if we were considering a general education curriculum, such as a four-year liberal arts degree, or even an undergraduate engineering degree, since the aim therein might be to prepare students for a range of possible careers, and not just in profit-driven industry. However, if we consider students (many foreign and self-funded) in engineering master's programs, especially in fields like computer science and industrial engineering, the goal very often is industry. Hence, while we leave a full argument on the merits of the alignment problem for a future paper and other authors, we maintain that the motivation to formulate, evaluate and present partial solutions to, the alignment problem (if found to be acute) is a worthwhile pedagogical task. It also has practical goals, allowing engineering programs in universities to justify their value in a world where a traditional college education path has come under attack as elitist [7].

The broader goal of this paper is to design, propose, and rigorously argue in favor of a framework that can be *instantiated* for specific classes and project settings in engineering schools and departments. Properly done, the instantiation would serve as a benchmarking standard, allowing courses to be compared to each other specifically in terms of alignment. In the next section, we briefly discuss the key categories and features of the framework, with three item prompts per category. We conclude the paper with a proposed experimental plan for using the framework to assess project components in engineering courses using only the course syllabus (or other

publicly available material).

1 Framework

Table 1: Item prompts for the *Peer accountability* category of the proposed framework.

Category: Peer accountability				
Item prompt (intra-group accountability): What mechanisms, if any, does the course use to ensure that members on groups cannot 'free ride' i.e., rely on the other members of the group to do all the work?				
Course relies on the honor system and leaves it up to the group members to self-regulate	*No formal mechanism, but instructor encourages students to reach out privately if free riding takes place*	*Each group member has to **compulsorily** independently review other group members at the end of the course (i.e., the review has grading consequences, both if a member does not submit or if free riding is clearly detected in scores)*	*Each group member is asked to optionally review other group members at the end of the course*	*Other (please indicate, using as much space as you need)*
Item prompt (inter-group accountability): What opportunities are there for groups to evaluate each other?				
Each group must necessarily review other groups using a specified rubric or formal submission format. The quality of the review is taken into account when grading the members of the group submitting the review	*No formal mechanism, but individuals in class are encouraged to comment on other groups' presentation*	*Group reviews are taken into account when grading the group for which the review is submitted*	*Each group must necessarily review other groups using a specified rubric or formal submission format. The review is not graded for quality, and may/may not be communicated by the instructor to the group for whom the review is intended*	*Other (please indicate, using as much space as you need)*
Item prompt (work product reviewing): What products are peers given the opportunity to review?				
Peer review compulsorily applies to some, but not all, project outputs (e.g., to a presentation, but not to a written report)	*Peer review compulsorily applies to all project outputs*	*Peer review applies to no project outputs; nor are there optional opportunities for reviewing*	*Peer review is optional (and may even involve extra credit) but not required*	*Other (please indicate, using as much space as you need)*

The current version of the framework has five categories with three item prompts each, illustrated in Tables 1-5. Each prompt has five options, one of which is an 'other' option that always gives the person filling it out, the ability to comment if the appropriate response is not covered among the other four provided responses.

Since the framework is options-driven, it could be administered as a survey, although we would strongly recommend incorporating *a priori* expertise in survey design and administration. For example, rather than present the options for the *intra-group accountability* item prompt under the peer accountability category, a survey expert may decide that it is best to solicit ratings on a scale of 1-5 (from strongly agree to strongly disagree) per option. We note that the options should not be thought of as mutually exclusive, since multiple (or no) options might apply. Another mechanism might be to design the survey in such a way that answers to some questions inform what the next question would be.[2] However, such mechanisms should likely be considered only after the framework has been applied and tested in a pilot study. It may be that, even presented

[2]For instance, again considering the *intra-group accountability* item prompt, if an annotator selects the third cell,

Table 2: Item prompts for the *Multi-modal communication* category of the proposed framework.

Category: Multi-modal communication				
Item prompt (communication types): What kinds of *graded* communication and presentation does the project component of your course rely on?				
Written report	*Live Presentation*	*Video*	*Live demonstration of system or method*	*Other (please indicate, using as much space as you need)*
Item prompt (guidelines): What are the guidelines and constraints for presentation, report and other products?				
Students are given clear 'syntactic' (such as word length / time length) requirements and penalty is imposed for not fulfilling these requirements	*Students are given some syntactic guidelines, but they are not held to be formal. Students have considerable leeway in how to organize written or presented material*	*Students are given content-based, but not syntactic, guidelines that must be followed. For example, the written report and presentation (or other components) must have certain content, but how it is organized, written up or presented are up to the students.*	*Students are given strict content-based and syntactic guidelines. While there is some leeway, students are expected to faithfully adhere to the guidelines for the best possible grade.*	*Other (please indicate, using as much space as you need)*
Item prompt (Creative work products): Are students expected to produce work products that are not traditionally considered in an engineering course?				
Students have to make a creative video product, such as a 'trailer' for their project	*Students have to do a creative written product, such as a mock press release for their project*	*The class includes interactive exercises where the students' product may be subjected to unexpected (or hypothetically unexpected) stresses, such as 'red team reviewing' by other groups*	*Students are asked to create separate work products for business, engineering and/or other disciplines such as marketing.*	*Other (please indicate, using as much space as you need)*

linearly using a simple 1-5 scale per option, the questionnaire provides an opportunity for pedagogical self-reflection to the instructor on designing, grading or structuring their course.

Since this is the first version of the framework, we expect that it will undergo revisions and course-specific, or even department-specific, modifications over time. In some cases, collating responses to 'other' options may reveal a common response that should be included as an actual choice in a revised edition. We also hope to expand the framework with at least two more categories, with 3-5 items per category. We also hope to expand some categories with more item prompts.

To avoid bias, the framework is *not* intended to be filled out by the instructor of a course, although it could still be used by them as a design or self-reflection exercise. As discussed in the next section, our true intent is for independent educators to instantiate the framework using a formal (and typically, binding) description of the course, such as the course syllabus, and other materials (such as grading rubrics) that could be made available on request even if they are not included in

they may be asked whether such a review only requires scores, or also a description of each member's contributions; in some cases, the score-assignment is also designed to be zero-sum i.e., students are told to 'divide' up a total of 100 points between all group members, meaning that giving more points to one individual will necessitate removing points from another.

Table 3: Item prompts for the *Systematic, robust grading* category of the proposed framework.

Category: Systematic, robust grading				
Item prompt (rubrics): To what extent do you rely on pre-formed rubrics for grading?				
I rely on rubrics for all elements of the project	*I rely on rubrics for some, but not all, elements of the project*	*I rely on guidelines/criteria that are written down in advance and shared with students, but not rubrics i.e., I do not give scores along various dimensions, followed by aggregation*	*Where applicable, rubrics are always shared with students after grading so students know the justification for their overall project grade*	*Other (please indicate, using as much space as you need)*
Item prompt (external judges): Do you have judges besides yourself for presentations or other work products?				
External judges who are not part of the course are invited to evaluate the visual/presentation component of the project	*Judges, who are part of the course, such as my teaching assistant, are invited to also grade students on the project, which are then combined with my own scores*	*With or without judges other than myself, my own scores always count when I am calculating the project score (i.e., I always serve as one of the judges)*	*I do not rely on external judges; instead, all the scores are based on a clear system of peer review alone, with the instructors serving as a quality check on the reviews.*	*Other (please indicate, using as much space as you need)*
Item prompt (weighting of project components): How would you best describe the weighting scheme you adopt for grading the different work products (written report, presentation etc.)?				
All turned-in components are graded roughly equally	*Presentation is compulsory, but is only used for providing feedback (or a small part of the total grade). Written report counts for much of the grade*	*All graded components are 'front facing' (e.g., presentation, video, live demonstration). Written components, if any, are only meant to solicit feedback and don't factor significantly into the overall grade*	*We do not have an explicit weighting scheme for the various components. The project is given an overall grade holistically*	*Other (please indicate, using as much space as you need)*

the main body of the syllabus.

Last but not least, the options are currently not *normatively* ordered from cells 1-5 per item prompt i.e., we do not make value judgments on whether one option is 'better' than another. Indeed, we believe that the options should be randomly ordered per item prompt to avoid any kind of bias.

Experimental Plan

We briefly discuss the outlines of an experimental plan that we designed, but have not yet implemented, to critique and evaluate the merits of the framework (possibly after some expansion) using actual course descriptions. We propose first to analyze syllabi from a sample of analytics[3] courses in terms of the presented framework. Since applying the framework requires rating a course or syllabus along multiple dimensions, we advocate (resources permitting) for multiple annotators to prevent blind-spots and biases. Annotator disagreement will likely be an important source for improving the framework, and the wording of items within it.

Which universities or schools should be used in the sample? In our study, we are especially

[3]We propose analytics courses in this experimental plan because the author is an expert in that area, and periodically teaches analytics graduate-level courses himself. However, there is no requirement for others to select that area. For obvious reasons, we recommend choosing an area in which the evaluator has some expertise.

Table 4: Item prompts for the *Expected complexity* category of the proposed framework.

Category: Expected complexity				
Item prompt (complexity of written component): If your project has a written component, what is expected to be included within it?				
The project does not have a written component	*The written component is primarily a free-form description of the project, with some quantitative elements*	*The written component is designed almost like a grant proposal with executive summary, background, findings, technical description of approach and other such sections*	*The written component is designed like a technical article or paper, with sections such as Related Work, Approach, Materials and Methods etc.*	*Other (please indicate, using as much space as you need)*
Item prompt (complexity of visual/presented component): If your project has a presentation (or otherwise visual, such as video) component, what is expected to be included within it?				
The presentation is short and expected to convey the key points only	*The presentation is technical, but not long: students convey background, motivation, and key results*	*The presentation is more like a demonstration; informal, but expected to showcase a substantive element of work*	*My project does not have a visual or presentation component*	*Other (please indicate, using as much space as you need)*
Item prompt (complexity of reviews): If your project has peer review, or any components that require them to critique other submissions, what is expected to be included within it?				
The review looks like a paper review, and students have to actively comment on strengths and weaknesses	*My project does not have such a component*	*I provide a clear rubric and students have to give numerical scores on various dimensions of the rubric, with short explanations*	*Peer review is free-form without rubric or section headings. Students may be subject to a minimum word or page limit, but can otherwise structure it as a free-form essay.*	*Other (please indicate, using as much space as you need)*

interested in comparing the top universities in various geographies of the US[4], and our sample will intentionally reflect that.[5] We expect to finish finalizing this sample by late summer in 2022.

Once the data has been collected, refined, tested for biases, and the framework has been applied, a process we expect will occupy much of the fall semester of 2022, it needs to be properly analyzed. We suggest both item-wise comparisons across the sample, as well as less granular comparisons at the level of categories, such as peer accountability, or even at the level of the overall framework. A systemic trend, such as low scores in some category across the sample, may very well emerge from such a study. This is not necessarily an indicator of low quality or a cause for concern. It may be that the sample is not well chosen. To take a hypothetical example, there may be a possibly inadvertent emphasis on courses that have explicitly stated that their goal is to prepare students for careers in policy or law.

Ultimately, if done correctly, a judicious mix of statistical computation and qualitative analysis can help lead to insights that may spur changes, whether incremental or significant, in the project components of curricula that lead to better alignment with industry. One must also always be open to the possibility that the syllabus itself may not be reflecting the actual quality of the

[4]For example, tech-heavy West Coast cities versus the Mid-west and the South.

[5]In other cases, researchers may want to understand the extent of the alignment problem in small versus big colleges, or even consider non-engineering schools as a control e.g., business schools. Eventually, if the framework is found to provide value, longitudinal and cross-department studies could also be considered.

Table 5: Item prompts for the *Diversity of skillset* category of the proposed framework.

Category: Diversity of skillset				
Item prompt (communicating to diverse audiences): Are students asked to consider non-engineering audiences when presenting or describing their project?				
Students have to assume a non-engineering audience	*Students are asked to assume an engineering audience, but have to present the relevant background*	*Students are told to assume a non-engineering, but technically adept, audience and must be careful about use of jargon and terminology*	*Students are told to present their project from a completely non-engineering (e.g., business) perspective*	*Other (please indicate, using as much space as you need)*
Item prompt (diversity of communication modalities): In order to achieve a top grade, how proficient must a group be in different 'modalities' of communication such as spoken vs. written?				
Written, spoken and visual components all carry significant weight in the final project grade	*Written component carries the most weight, with the presentation serving mainly as a feedback mechanism. Hence, to achieve a top grade, the written component must be high quality*	*I provide feedback to students on writing and presentation, such as grammar or visual design of slides (including use of visual aids). I take points off for egregious errors, but otherwise do not include good communication (whether spoken or verbal) as part of the rubric*	*The presentation or demonstration carries almost all of the weight in the project grade*	*Other (please indicate, using as much space as you need)*
Item prompt (communication versus technical proficiency): In order to achieve a top grade, how proficient must a group be in both communication and technical aspects of the project?				
Communication and technical proficiency are both important. If a group communicates well, but is technically shallow, they will not have a top, or even above average, grade	*Communication matters and can result in an A-/A transition (or the equivalent) but the grade is primarily determined by the technical aspects*	*Since this is an engineering course, I look almost exclusively at the technical aspects than the communicative aspects of the project.*	*Communication matters much more for the presentation, but for written aspects, I look much closer at the technical aspects, since students are not expected to be good at grant/academic paper-style writing just yet in their careers*	*Other (please indicate, using as much space as you need)*

alignment. Hence, we also recommend that the framework be applied 'locally' i.e., in the context of the evaluator's educational or organizational setting, to better understand the relation between what is stated in the syllabus and what actually happens in the course. In the local context, one will likely be able to use data, at least in aggregate, such as students' course and instructor evaluations for such understanding.

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