Industry-based Case Studies for an Online Graduate Certificate Wind Energy Program

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Abstract— **This project involved the addition of practical, real world, experiences for online Graduate Certificate in Wind Energy students via case study based problems developed in cooperation with wind industry partners. Overall, five case studies were developed and integrated across three courses offered in Summer 2016, Fall 2016, and Spring 2017. A qualitative study employing focus groups gathered feedback from the students in these courses. The students reported learning from and being motivated by the inclusion of the case studies. They were more inclined to be focused on the accuracy of their results because they were based in the real world. They particularly appreciated the practicality and applicability of the case studies, the opportunity to hear from a real-world industry partner, and the insight into industry jobs and how a project works from start to finish. In execution of the case studies, the biggest challenges were adapting the expectations of the students, balancing the workload along with other course assessments, and encouraging the students to pace their work to optimally interact with and engage with the industry partner.**

I. Introduction & Background

Problem-Based Learning and Project-Based Learning have been increasingly employed over the years as providing a means to overcome the shortfalls of traditional "chalk and talk" delivery of engineering content. Engineers in their profession must not only be technically excellent in the fundamentals of their discipline, but they are also in an environment which is full of uncertainty, has a series of competing demands and ethical dilemmas, necessitates excellent communication skills to work across multiple disciples and requires keeping up with continual changes to technology and the workplace. In recognition of the ways in which the traditional approaches were not preparing students for success in this environment, in 2003, Mills & Treagust [1] defined six critical issues that needed to be addressed in changing the delivery of engineering education, as follows (paraphrased):

1. Engineering curricula are too focused on engineering science and technical courses without providing sufficient integration of these topics or relating them to industrial practice. Programs are content driven.
2. Current programs do not provide sufficient design experiences to students.
3. Graduates still lack communication skills and teamwork experience (programs lack experiences).
4. Need awareness amongst students of social, environmental, economic and legal issues of modern engineering.
5. Existing faculty lack practical experience and are not able to adequately relate theory to practice or provide design experiences.
6. Teaching and learning strategies outdated and needs to become more student-centered.

Issues 1-4 and 6 are addressed by implementing either a Problem-Based or Project-Based Learning approach. Issue 5, however, is a challenge we will return to later. The distinction between the two approaches was well differentiated by a faculty member at Aalborg University in Denmark which bases approximately half of their curriculum in a blend of these styles [2]. The difference is in Problem-Based Learning the faculty member plays a role of "process-oriented supervisor" and in Project-Based Learning the faculty member plays the role of "product-oriented supervisor"[3]. In order for students to be effective when they go off and apply their knowledge in their careers, they need to have both tools for independently and swiftly doing process oriented tasks (Problem-Based) and also the big picture perspective and determination to deliver a quality end product (Project-Based)—and all of this happens as a member of a team, subject to uncertainties and ethical dilemmas, likely in a global environment.

Returning to issue number 5, this is where partnership with industry can help bring in the practical experience which is critically needed. Having experts help craft meaningful learning experiences which can provide a real world perspective on how these intangible issues are dealt with in a controlled environment. In doing so, graduates are better prepared to jump into industry ready to be put straight onto a task without months of training to develop the professional skills needed to make effective decisions in the ultimate delivery of a project. Thus, this project focuses more so on developing Project-Based Learning experiences, but there are certainly elements which would be classified more closely as process rather than product focused, so this is a subtle distinction.

The Project-Based approach has been shown to result in better attitude toward learning, problem solving ability, metacognitive skills as well as content and conceptual knowledge [3]. It can also result in better communication and teamwork skills, understanding of professional practice and how to apply learning to solve problems [3].

II. Courses, Context & Case Studies

A. Wind Energy Certificate

This project involved the addition of practical, real world, experiences for students pursing the online Graduate Certificate in wind energy at Penn State,via case study based problems. The Graduate Certificate in wind energy is a Post Baccalaureate program offered via a web-based platform to both University Park students as well as distance education students via the World Campus. Students must have received an undergraduate degree prior to beginning the certificate program, and it has a technical focus, with a recommended background in engineering, physics, or science. With many individuals looking to transition from one career to another, the focus of the graduate certificate in wind energy is geared towards providing participants with tools that can be put directly to practice as they pursue wind energy careers. Thus, it is directly beneficial for them to be tasked with assignments that they find marketable as they are seeking careers and that they can put to use on day one of a new job. This was an objective of the project. These skills are also useful for recent graduates from undergraduate degree programs who are looking to looking to enhance their resume with wind energy specific skills to find work quickly in this highly competitive field.

The Graduate Certificate in Wind Energy is composed of successful completion of the following three online courses:

- Summer 2016: AERSP 886, Engineering of Wind Project Development
- Fall 2016: AERSP 880, Wind Turbine Systems
- Spring 2017: AERSP 583, Wind Turbine Aerodynamics

In partnership with DNV GL, three case studies were created and integrated into AERSP 886 in Summer 2016 and one case study was created and integrated into AERSP 880 in Fall 2016. Additionally, in collaboration with the blade design engineering unit at Envision Energy, an additional case study was implemented in AERSP 583 in Spring 2017.

It is worth noting that these online courses are taught in a blended environment. Blended has multiple meanings here. Students participating in these courses are both resident students on campus as well as the university's online campus with students participating at locations from across the globe – so the students themselves are blended together all in an online environment. Additionally, the content is multimedia (not video-capture) incorporating text, short video, and example problems, using a Drupal platform and

occasional webinar based interactions using Adobe Connect or Zoom. In the absence of face-to-face interactions, discussion boards, through the Canvas course management system in this case, tend to be a dominant form of interaction in online environments. However, in more technical courses, weekly discussion topics are not as easy to weave into the curriculum or as popular with the student as they typically can be in non-technical courses. Therefore, providing a project-based experience in which discussions are opportunistic and thus provide value and an opportunity for engagement for the participants was an objective of the current project.

Each of the topics covered across the three course series were initially evaluated for their suitability for matching with a project-based learning activity working with an industry partner. Summer 2016: AERSP 886 Engineering of Wind Project Development was identified as a prime candidate as it dealt considerably with wind data, which could be provided from industry while masking the actual location of the data. Opportunities were also identified in Fall 2016: AERSP 880, Wind Turbine Systems and Spring 2017: AERSP 583, Wind Turbine Aerodynamics, but with more restrictive limitations as proprietary information was at play throughout many of the topics of relevance to industry in these courses. The case studies which have been integrated into these courses are described in the following sections.

B. Summer 2016: AERSP 886, Engineering of Wind Project Development

Three industry-based case studies were identified, developed, and integrated into the Engineering of Wind Project Development course for the summer offering in 2016. The course covers nine lesson topics with nine associated assignments. The three assignments that were revised all involve the analysis of wind data and the resulting project economics, which are greatly benefitted by the real world professional practice of an industry-based case study.

- Quality Control of Wind Data

Objectives: Using Windographer [4] software for wind data analysis. Understanding the role of the wind measurement campaign, measurement uncertainty, and other sources of error. Identifying and getting experience with how to appropriately flag for data errors such as icing events and equipment errors. Accounting for data from redundant anemometers due to mast wake issues.

- Annual Energy Production and Uncertainty

Objectives: Once again using Windographer [4], applying vertical extrapolation of the 10-min average wind speed and use of reference data to adjust for long-term variations. Estimation of site air density and adjustment of the turbine power curve. Estimation of gross energy yield, losses and net energy yield as well as quantification of estimation uncertainty.

- Financial Modeling

Objectives: Evaluating scenarios to reduce uncertainty and selecting the best development scenario. Running cashflow statements and understanding the meaning of P99 and minimum debt service coverage ratio.

C. Fall 2016: AERSP 880, Wind Turbine Systems

One industry-based case study was identified, developed and integrated into the Wind Turbine Systems course for the fall offering in 2016. The course covers nine lesson topics with eight overall assignments. The assignment that was revised as a part of this course involved the IEC 61400-1 [5] industry standards which are used to define the appropriate selection of a turbine for project site conditions.

- Site Suitability and Certification

Objectives: Introduce wind turbine certification and the concepts of site suitability. Complete a site suitability review.

D. Spring 2017: AERSP 583, Wind Turbine Aerodynamics

One industry-based case study was identified, developed and integrated into the Wind Turbine Aerodynamics course for the spring offering in 2017. The course covers 11 lessons with associated Quizzes and a total of 6 assignments overall. The assignment that was revised involved a blade design activity (Assignment 5) bringing together many aspects of wind turbine aerodynamics covered in the course up to that point, i.e. week 11 (out of 15) in the semester.

- Wind Turbine Blade Design

Objectives: Design a utility-scale 2.0 MW rated wind turbine blade using acquired knowledge and modeling skills in aerodynamics, structural mechanics, and airfoil characteristics under a number of industry-standard design constraints.

For this assignment, a special discussion forum was created for students to interact directly with the industry professional. In addition, an Adobe Connect meeting was held where both the faculty member and the industry professional discussed with students directly on wind turbine blade design and demonstrated some sample simulations with wind turbine design and analysis tool, XTurb [6].

III. METHODS

Due to the small sample size of enrollments in the graduate courses (around 10 students in each course), a qualitative study was developed. Rather than using surveys and quantitative statistical analyses, the focus group study allowed a deeper exploration of student perspectives on their experience completing and learning from each case study. Focus groups were conducted during the final weeks of each semester in which a case study was first implemented. The focus groups allowed exploration of a more in-depth perspective of student experience working on the implemented case studies [7].

Questions used in the focus groups are included in Table 1. These questions were developed to address the students' experiences with the industry case studies generally and specifically around motivation, workload, and expectations. Each group began with a broad question about the students' overall experience in the class and with the case studies to allow the students to authentically introduce thoughts and feedback of importance to them prior to the more directed questions:

Focus Group Questions

1. Describe your overall experience with the course
2. Describe your overall experience with the industry case studies.
3. Were the case studies motivating?
4. What did you learn from the case studies that was surprising or unexpected to you?
5. In what ways did the hour session with a real-world industry partner contribute to your experience?
6. These were fairly extensive case studies. How did the workload for the case studies influence your learning experience in the class?
7. In order to complete these case studies, you were required to use the computer and computer software. How prepared did you feel to use this software? *(Only asked in Summer 2016)*
8. What elements of the case studies would you like to see changed to improve the experience in the future and how would you improve them?
9. What other parts of the course you would like to see case studies used for?
10. Are there any other comments that you would like to make about your experience in this course and the case studies used?

The group facilitator followed up on certain student responses for more detail or to explore potential new avenues that would not be covered by the original protocol.

IV. Results

The focus groups results will be discussed with respect to the course they were associated with.

A. Summer 2016: AERSP 886, Engineering of Wind Project Development

During the Summer 2016 "AERSP 886, Engineering of Wind Project Development" course focus groups, students immediately brought up two benefits and two concerns around the case studies from class. First, students found that the case studies helped them grasp the relevant concepts from the course better and, second, the conversations with industry specialists were a large motivator to do well in the course. On the other hand, students commented on the unexpected intensity of the workload once the case studies were introduced and on the timing of the projects, specifically that they were unable to fully grasp the size and scope of the project.

More specifically, the students identified that knowing the case studies were coming from people who are experienced in industry gave the work a more authentic feel and encouraged the students to check the accuracy of their results. However, the amount of data and the resulting amount of data processing necessary was unexpected for them and they found that the increased intensity of the case study increased their course engagement but also could be distracting from learning the concepts.

Suggestions that the students gave for improvement of the case studies focused mainly on redistributing the assignments to spread out the work and adding more due dates or checks to help students stay on top of the work. They also suggested that having the software required for the projects more readily accessible would help.

B. Fall 2016: AERSP 880, Wind Turbine Systems

For the Fall 2016 "AERSP 880, Wind Turbine Systems" course, students overall found the course to be a good introduction to wind, with well-designed and well-timed assignments. Like the summer, the Fall students reported learning from and being motivated by the inclusion of the case studies. They also mirrored their summer peers in their appreciation of the practicality and applicability of the case study and the opportunity to hear from a real-world industry partner. The real-world nature of the task gave them insight into industry jobs and how a project works from start to finish.

Unlike the Summer students, however, the Fall students felt that the case study was an appropriate amount of work for the level of the course and that the case study could even have been more detailed or in-depth. They commented that most of the information needed to complete the task was included in the session, so they didn't have to delve too much.

Fall students' suggestions for improvement to the case studies and the course included a potential visit to a real-world setting such as a wind farm, the addition of optional or practice case studies for other topics within the course, increased focus on developing aspects of the field such as offshore wind turbine systems, and the inclusion of more software based projects or mini-projects.

C. Spring 2017: AERSP 583, Wind Turbine Blade Design

In the Spring 2017, students in the "AERSP 583, Wind Turbine Aerodynamics" course appreciated the active and online nature of the class and they found the overall organization and provided lecture notes helpful but commented that the notes could sometimes have confusing wording. Suggested improvements for the course included having a mentor through the whole course and the opportunity to discuss with an industry specialist on one of their own projects.

For the industry case studies, students felt that it was a beneficial experience to get to do more design and see the connection between classwork and real industry work, though they also commented that the project did not require much of their own design because of the tight boundaries that they were given to work within. The students in the focus group also commented that, though there was a change in workload from the first to second month of class, the smaller projects built up to the industry case study well both for workload and for computer program and file manipulation preparation and practice. However, students thought that the smaller projects could have had more continuity, such as beginning with running solvers on a pre-designed blade, then jumping to a larger design project where they would design parts of their own. Students also appreciated the industry speaker as he gave context to what they learned in class, but he did not seem to know much about the assignment itself.

V. Discussion

Overall, students appreciated the addition of the industry case studies and found them motivational. The conversations with the industry specialists and working with real data from industry increased their understanding of what is involved in professional practice.

The student perceptions across the two semesters begin to illustrate a balance that must be achieved around the use of case studies. Each group of students indicated that the case studies had the potential to improve their learning. In the summer, however, students felt the case studies increased their workload and that this increased workload could distract them from gaining conceptual knowledge. In the fall students had the opposite problem; they felt the studies could have been more beneficial if the students had been required to do more in depth investigation on their own. In the spring, the smaller projects scaffolded necessary skills and the workload for the larger industry case study, but lacked continuity.

The courses are being offered for a second time with the case studies in the current year, and some of the suggestions have been implemented, such as distributing the workload more evenly across the summer course: Engineering of Wind Project Development. Additionally, more instruction was provided on how to use software tools necessary to complete the case studies.

VI. Conclusions

Industry-based case studies were introduced into three courses across the Graduate Certificate in Wind Energy, an online non-degree graduate program. The case studies were developed and introduced into these courses to provide additional opportunity for engagement among course participants as well as to provide interaction with industry and provide real-world, practical experiences useful for their future careers. Feedback from student focus groups indicate that the students appreciated the real-world nature of the problems being solved during the case-study assessments, and they benefited from interacting with industry members in these assignments. It seems a balance could be achieved in executing the case studies both within each course and perhaps across the program as a whole so as to equalize the workload of the assignments and provide continuity.

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