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Collaborating on Capstone Projects with Students from International Institutions – Lessons Learned and Path Forward

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ABSTRACT

For the first time, our mechanical engineering program at George Mason University included students from institutions in India in our capstone design projects. We are partnering with four engineering colleges from India on a total of five projects. Each project consists of a team of six students, three from our program and three from one of the partner mechanical engineering programs in India. Each team has two faculty advisors, one from each country. The purpose of this paper is to share the lessons learned from the perspectives of faculty mentors, and students from both countries, and benefits of such a collaboration. Challenges that the students encountered include coordination of activities and combined deliverables for courses from two institutions, communication due to time zone differences and virtual nature, and fabrication of prototypes. Benefits include our students adapting how to apply engineering design to produce solutions considering global, cultural, social and economic factors by first-hand experience. Further, our students are learning how to lead and function effectively on a team made of international teams in a collaborative and inclusive environment. It should be noted that faculty members involved as advisors, also known as mentors, are aware that this collaboration must continue to meet continue ABET accreditation requirements for major engineering design experience. The paper will also share data from the surveys of students and faculty mentors from both countries and recommendations for such collaboration in the future.

Introduction

In recent years, international collaborations in engineering education have become increasingly common, as they offer opportunities for cross-cultural exchange and global problem-solving. Several studies have emphasized the significance of such collaborations, highlighting the benefits of diverse perspectives in tackling complex engineering challenges [1]. These partnerships often promote cultural competency, teamwork across borders, and a broader understanding of global

engineering practices [1]. However, they are also fraught with challenges such as communication barriers, differing academic systems, and the need to adapt teaching methods to cater to international students [1, 2]. Virtual collaboration requires the development of new strategies for effective communication, project management, and mentorship across time zones [3]. Moreover, ensuring that these international partnerships meet accreditation standards remains a significant concern for educators, especially when students come from institutions with varying levels of resources and infrastructure [4]. Previous research has also explored the importance of aligning curricula and project scopes with global engineering standards, ensuring that students from both sides of an international partnership are equipped with the skills required for success in a globalized workforce [5]. Although the setting is a "3+1" engineering technology program in residence, the challenges faced are similar to those in our present situation such as curricular alignment, candid communication, student interaction and teaching styles [6].

In the past, students in our mechanical engineering (ME) capstone program have partnered with students from other programs within our college of engineering. Also, multi-disciplinary projects have included students from outside of our college on campus. During the academic year 2024-25, our ME students have, for the first time, collaborated with students from five engineering colleges in India. The corresponding author, who is the director of the capstone program for our ME department, was initially approached by a coordinator from India about the possibility of partnering on capstone projects. After initial discussion, we decided to proceed with collaborating on select capstone projects. This collaboration promised to provide additional opportunities to enhance the design experience of our students. This was the primary motivating factor for this collaboration. For each project, instead of the usual four or five students per project team, we decided to have six students per project team. This includes three or four fourth-year students from our ME program and three or four ME students from one engineering college in India, either third- or fourth- year students. In total, 19 of our students collaborated with 16 Indian students on six capstone projects and teams. Projects are still ongoing until the end of spring semester in May 2025. One of the authors is an experienced ABET volunteer as a program evaluator and team chair, and was very proactive in ensuring the collaboration aligned with ABET Engineering Accreditation Commission's (EAC) accreditation requirements [7] for

major engineering design experience. Of the-four Indian colleges partnered, one ME program is already accredited by ABET EAC and all others are either aware of or were made aware of ABET requirements.

Formation of student teams and course deliverables

Capstone projects in our ME program have been sponsored by industry partners in the past. For the current collaboration, we decided to include projects sponsored by either our program or by Indian programs. Projects were solicited from all parties and we jointly selected the projects that were deemed to provide engineering design experience to both sides. We thought that having four students from each institution, amounting to a team of eight students, would be too large. In discussion with the faculty mentors from the Indian colleges, we decided on teams with three students from each country for a team size of six students. Each team also had two faculty advisors or mentors, one from each country. Each design team was thus organized into "two sub-teams" with three students and one faculty mentor. After initial joint discussions with the full team, each sub-team decided on roles and responsibilities, and the division of project tasks and deliverables.

It should be noted that the academic year and semester calendars for both sub-teams did not match and course deliverables were not the same. Students tried to meet outside of the academic calendar to make the best use of time. Student sub-teams were asked to share their course syllabus with their collaborators, and emphasize common course deliverables. Students were aware of their partners' deadlines and worked together to deliver the best product possible.

Virtual challenges

After the teams were formed, the first challenge faced by the teams was how and when to meet regularly. As the standard time zones are separated by 10 hours and 30 minutes, students were advised to "self-select" a 30-minute time convenient to all for a recurring weekly team meeting. Due to six students and two faculty members on each team, students initially struggled to schedule regular team meetings. After a challenging start, the teams held regular meetings and

met virtually on a recurring schedule. Online meeting tools such as Zoom or MS Teams were used for regularly scheduled recurring team meetings. In addition to e-mails, students also used other online tools such as Discord or WhatsApp to share information outside of regular team meetings.

The corresponding author, who manages the capstone program, held meetings with all students from our program to mentor and provide focused advice on how to overcome various challenges. Since students from India are versed in English, language was not an issue. However, due to different cultural settings, it took some effort to convince students to take the initiative to "lead" conversations and team organizations. Students were advised to appoint a "team lead" for each sub-team, to better coordinate tasks and scheduling. During fall semester, all students explored the project concept, finalized the project requirements and worked on planning and design. Teams were given two weeks of additional time to meet initial deadlines to compensate for slow, unexpected late starts compared to the rest of the class. As our ME students have prototyping requirement, it was another item that needed discussion. Initially we decided that one sub-team would do the prototyping and testing while the other sub-team will be "consultants" to review and provide feedback. However, ultimately all teams developed prototypes since most students wanted hands-on experience.

Consideration of accreditation requirements

As our ME program is accredited by the Engineering Accreditation Commission (EAC) of ABET, maintaining the accreditation status is critical for the program and efforts were made to ensure it. The ME program's capstone program director is an experienced ABET volunteer as a program evaluator and team chair. ABET criteria were explained to all to ensure that the collaboration will not jeopardize the accreditation status. It also provided the Indian colleges opportunity to observe how our program strives to continuously meet accreditation requirements, especially the General Criterion 5 by EAC of ABET. Criterion 5(d) states that the curriculum must include "a culminating major engineering design experience that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work." Initially two of the projects proposed by the Indian

programs appeared to be research oriented. After discussions and consideration of ABET requirements, project objectives were revised to include adequate major design experience.

ABET EAC General Criterion 3 Student Outcome 2 requires "an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors." Student Outcome 4 requires "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts." Attainment of these two outcomes were usually included and assessed as part of our ME curriculum in various courses. One advantage gained by our students working in the six collaborative capstone projects is that that they experienced these attributes first hand and are better prepared to enter the practice of engineering after graduation. Further, these students are prepared to work for multi-national or global companies where these attributes are needed to function effectively.

Expected results and continuing challenges

GMU students were required to produce written reports and oral presentations similar to other teams in the class, and worked on the final design presentation together. Although the students in international collaboration faced more challenges than other students in the class, their deliverables remained the same. The only difference is some of the teams may not prototype a full-scale model due to financial constraints. In these cases, students plan to 3D print the models at a smaller scale. Note that prototyping is required by our ME curriculum and it is not a requirement by ABET criteria. As time progressed, there were disappointments due to expectation management. Because the students and faculty mentors from both sides had not met in-person meant the sub-teams continue to be virtual partners. The fact that all team members could not meet in person together or as frequently as could otherwise has led to less-than-optimal coordination and productivity.

Overcoming challenges

The faculty mentors and the director of the capstone program met more frequently with these sub-teams than with other teams to provide additional mentoring. At the end of the first semester, a brief survey was sent to the students and faculty mentors to gauge their experience and solicit feedback. The survey results were used to develop and implement changes in the spring semester to minimize disappointments and manage expectations. The survey was conducted in December 2024-January 2025 and the results are discussed next. Preliminary data shows that although majority of students struggled and had disappointments, they recommend future collaboration with modifications to current arrangements. To overcome the virtual nature of collaboration, the director of our ME capstone program visited the partner colleges in India in early January 2025 and met with faculty mentors and students. The meetings have helped to increase motivation by the students and mentors alike, and the authors expect improved collaboration and output in the spring semester.

Survey of students and faculty mentors

A brief survey of five questions was sent to all 18 students and four faculty mentors of our program and 16 of them responded. As the current projects began in September 2024 and will continue until end of April 2025, these questions focused on students' and faculty mentors' experience in the fall 2024 semester. For the question, "Did the project progress during fall 2024 semester meet your expectations?" 81 percent of the respondents stated it as partially met. One respondent stated yes, and two respondents stated no. Main reasons cited were lack initial organization, coordination due to time zone differences and delay in receiving responses from students in partner institutions. On the question of "If you had a chance to do over, what is the one thing you would do differently?" answers ranged from "setting expectations up front, in terms of both scope and priority" to "Be more proactive in communicating and more direct in what we need to be successful."

Next question asked was "If you are asked to advise upcoming senior students for next academic year, will you encourage them to collaborate on such an international capstone project?" Many of the respondents, 68 percent stated no and others said yes or yes with reservations. For the

question “Based on your experience to date, should our engineering program proceed on collaborating with international colleges for capstone projects in the future? Again, many of the respondents, 56 percent, stated no while 44 percent stated yes with modifications. The last question was open ended about the collaboration to solicit feedback from participants. Table 1 shows the survey and response rate from both countries.

Table 1: Survey of Faculty mentors and Students

Partcipants			**Both Faculty and Students**
	faculty	Students	
GMU	5	18	23
Response	4	12	16
Response ratio	80.0	66.7	69.6
Indian Colleges	5	16	21
Response	3.0	6.0	9
Response ratio	60.0	37.5	42.9
GMU and India	10	34	44
Resonse	7	18	25
Response ration	70.0	52.9	56.8

The following are select responses from our university faculty mentors and students:

a. Excellent idea in theory. There is certainly potential somewhere for this, but it is logistically very challenging and very risky in a senior capstone project.
b. International Cooperation can be very difficult when it comes to scheduling, budgeting, and deciding where physical supplies are going to go.
c. Set clear plans and logistics with the international colleges before starting the collaboration and
d. There needs to be a true leader from either student team (preferably one on each) who is willing to take charge and overcome the communication challenges.

Whereas the survey was sent to George Mason students at the end of fall 2024 semester, survey to Indian colleges were sent in April 2025, very near to the completion of projects.

For most part, the response from Indian colleges were very positive of the experience. About 70 percent of the respondents stated it met their expectations and 80 percent of the respondents said this partnership and collaboration should continue in the future. Select responses from our Indian participants are as follows:

a. Yes, the project met my expectations because it was well-organized, the objectives were clearly defined and the execution was thorough. The team maintained excellent communication throughout, addressed challenges proactively and delivered high-quality

results within the expected timeline. Overall, the collaboration and outcome aligned perfectly with what I had envisioned

b. Some challenges included team dynamics, time management during the project, and low engagement from certain members.
c. It provided a great opportunity to apply technical knowledge, collaborate internationally, and improve project management and communication skills.
d. I am satisfied with the overall experience and would not change anything significant. I would just try to engage even more proactively from the very beginning.
e. Have a physical interaction session with GMU students coming to India or Indian students going to US, would have been good and spend 1 or 2 weeks together and implement our ideas together so that some kind of different approach could have been made.
f. If given the chance to do it over, I would focus even more on early-stage planning to identify potential risks and solutions upfront. While the project was successful, I believe an even deeper initial analysis could have made the process even smoother

Authors plan to conduct another survey, towards the end of spring semester in May, to obtain feedback from students when the projects are near completion. This second round of survey will solicit feedback from students and faculty mentors in the Indian institutions as well. Authors expect the results to be more positive as the collaboration is progressing better in the second semester. The negative perceptions tend to go away with time as the projects reach a successful conclusion.

Conclusions, recommendations and plans

For the current academic year, collaboration was started after two meetings, and it was semi-formal. In the future, it is recommended a “formal” contract detailing the roles, responsibilities and expectations should be established at the start. Also, having at least one in-person meeting would be immensely beneficial. One way this can be done is by the utilizing the existing student exchange or study abroad programs at our university. To date, this paper reflects the experience of participants in one semester. Experience based on a full academic year will be reflected in the final paper and in the conference presentation. Since this is the first year of such international partnering, the authors recommend one more year of partnering to obtain additional data to validate our recommendations and decide on recommendations for future capstone collaboration. As suggested by students in India, providing an opportunity to collaborate in a face-to- face, in-

person environment even for two weeks during our winter break would increase the level of collaboration. Authors expect that a second year of collaboration and data will enable us to advise the program on long-term options for collaboration outside of our university and especially with international institutions.

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