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Indo Japanese Program on Water Rockets

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Katsuyuki Ohsawa has published over 70 papers including over 40 papers in peer reviewed journals. He received best paper awards from Society of Automotive Engineers in Japan and Japan Gas Turbine Society. He also works as a member of supporting committee in JICA for Pan-Africa University.

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She is pursuing her doctoral research in Computer Supported Collaboration Leaning (CSCL) and the Engineering Design. Prior to this, she also has over 5 years of experiences as a Production Engineer. She designed a jig, production processes and production systems for on-vehicle unit systems.

Indo Japanese Program on Water Rockets

Abstract

Engineering is a fast-growing profession and is increasingly cutting across boundaries of disciplines, countries, and cultures and engineering education has to prepare students for these scenarios. Towards that, we organized an Indo Japanese program involving two student projects. The students and projects were from different engineering and non-engineering disciplines. This paper presents one of them - a water rocket project. Both the teams worked together for about four months and had enriching experience. The project had three parts: fabrication of water rockets, design and development of sensor systems, and analysis of the launches. Both the teams worked collaboratively on the activities. Initially, the teams worked from their respective locations and towards the end of the project, the Japanese team visited India for a week to fabricate water rockets, test sensor systems, and carry out and analyze actual launches. While the participants cherished this inter-cultural experience and gave a satisfaction rating of 4.82 on the 5 point Likert scale, they felt that they should have spent more time preparing for the visit, for learning the other language and establishing better communication with their counterparts. Even though the water rocket was a novel idea and resulted in substantial technical learning, the cultural learning was more significant. It may be due to the project's shorter duration and the significant divergence between the two cultures at syntactical levels.

Introduction

Globally, engineering educators are recommending development of multi-cultural and multi-disciplinary skills based on the expectations of employers. That motivated us to design an Indo-Japanese program consisting of two multi-disciplinary projects. This paper presents one of them - a water rocket project. The project involved measuring and calculating flight trajectory of water rockets using inertial sensors. It had three parts; fabrication of water rocket, design and development of a sensor system and analysis of launches. The main contribution of this paper is in proving the efficacy of such multi-cultural and multi-disciplinary projects. The next two sections provide the background and elaboration of the experiment. The subsequent sections have feedback of all the participants and concluding remarks.

Background

ABET has identified criteria for Accrediting Engineering Programs. They consist of student outcomes such as the ability to function on multi-disciplinary teams, the ability to communicate effectively, and the broad education necessary to understand the impact of engineering solutions in a global and societal context[1]. The Royal academy of engineering also has identified attributes required of graduating engineers, which include ability to work in team and on multidisciplinary projects[2]. Male and Chapman[3] have quoted requirements of Engineers Australia Accreditation Board (EAAB) from graduating engineers. They include (a) the ability to communicate effectively, not only with other engineers but also with the community at large, (b) the ability to function effectively as individual contributors and in multi-disciplinary and multi-cultural teams with the capacity to be leaders or managers as well as effective team members, and (c) the understanding of the social, cultural, global, and environmental responsibilities of a professional engineer, and the need for sustainable development. The Indian National accreditation board (NBA) has developed its accreditation programs requiring similar attributes of the graduating engineers[4].

This unequivocal agreement between the leading policy makers is based on findings of many researchers and industry pundits. Many of them have been working on various facets of cross-disciplinary and cross-cultural learning exercises such as project-based learning (PBL) and team-based learning (TBL). In that context, they have either reinforced the utility of PBL-TBL or analyzed the technique to discover its finer aspects.

Passow[5] has studied the ABET competencies that engineering graduates find the most important at their work-places. The graduates of 11 engineering majors rated a top cluster of competencies (teamwork, communication, data analysis, and problem solving) significantly higher than the rest. Bunting[6] has argued that learning at higher cognitive levels is better addressed by active learning - often using teams. Prince and Felder [7] have found that inductive methods like project-based learning are more effective than traditional deductive methods for achieving a broad range of learning outcomes. Smith et al. [8] have analyzed various classroom-based practices and strongly suggested using active learning instructional strategies such as project-based learning . Simpson, et al. [9] believe that interdisciplinary experience is more representative of what students will find in the real world and advocate interdisciplinary capstone projects. Schaffer, et al. [10] have concluded – based on their study of 256 students from 60 teams - that Cross disciplinary Team Learning (CDTL) increases self-efficacy across all respondents. Apelian[11] believes that one of the important skills for the 21st century engineer is the ability to work with anybody anywhere. He concludes that we need to educate engineers such that they understand the societal context of their work and have an understanding of the human dimension around the globe, coupled with innovation and creativity. Michaelsen, et al.[12] have claimed that innovation and entrepreneurial competencies can be reinforced through TBL. Bell (2010)[13] has explained Project-Based Learning (PBL) as a student-driven, teacher-facilitated approach to learning and claimed that it helps students develop 21st century skills. Mills, et al. (2003)[14] argue that project-based learning is the best way to satisfy the current industry needs. Barge [15] has outlined the nine principles identifying critical considerations for implementation of the Aalborg PBL Model with regard to key dimensions of the university. Lehman (2008) [16] has found that TBL helps students in developing diverse process competencies such as problem solving, collaboration, project planning, and communication, besides technical knowledge and skills.

Erez, et al.[17] designed an on-line, 4-week virtual multicultural team project to test its effect on the development of management students' cultural intelligence, global identity, and local identity and found that cultural intelligence and global identity significantly increased over time. Jiang, et al.[18] found that educational specialty fault line negatively predicted task-relevant information sharing, and that nationality fault-line negatively predicted off-task social interactions.

Experiment

We designed an experiment to provide multi-cultural, multi-disciplinary, project experience to Japanese and Indian students with the expectation of reaping the benefits reported in the literature. We included the element of in-person interaction between the teams by including a week-long visit by Japanese students and faculty members to India. The Japanese university sought students interested in the experiment. The Japanese students studying regional sciences, medical sciences, and engineering enrolled for the program. Based on the student profiles, we chose two projects; multi-cultural portal and water-rocket. We floated the projects to Indian students from computer engineering and instrumentation and control and selected nine students for the multi-cultural portal and ten for the water rocket. This paper presents our findings on the water rocket which had four Japanese students. Out of them, three travelled to India for a week. Two of the Japanese students were from mechanical engineering and the remaining two were from electrical and electronics engineering. Nine of the ten Indian students were form instrumentation and control and one was from computer engineering. The project for Japanese student was carrying two credits and for Indian students was a co-curricular activity.

A water-rocket is launched by water and air pressure. It can reach a maximum altitude of about 50m and has a ground range of 50-100m. The project involved the design and development of the rocket and its sensor module. The sensor module is mounted on the rocket with a mounter to monitor the state of the rocket. The sensor module consists of an accelerometer, an atmospheric pressure sensor, a gyro sensor, a magnetic sensor, a GPS sensor, a micro-computer and a memory card.

During November and December of 2013, the Japanese team defined the specification of the sensor module as well as designed and fabricated it. The Indian team was unavailable in those two months due to examination and vacation and could receive the specifications only in January 2014. The Indians designed and fabricated their module in the next two months. The Japanese team procured all the parts required for fabricating water rockets and brought them along to India in the last week of February. In that week, both the teams reviewed sensor modules of each other and revised them suitably. Both the teams fabricated water rockets and had many successful launches on two days. They acquired flight data and analyzed it. The week ended with team presentations to all the stakeholders from either side. The project schedule is showed in Table 1 below;

Table 1: Project Schedule

	1st (Teams were in their home countries)				2nd (Japanese Team visited India)
	Nov	Dec	Jan	Feb	Feb
Japanese	+Defining specifications +Designing and fabricating a sensor module		+ Developing measurement software		+ Checking and revising a sensor module + Designing and making rockets + Launching + Acquiring flight data + Presentation
Indian			+ Getting specifications from Japanese +Designing and making a sensor module + Developing measurement software		

The water rocket that is ready for launch is shown in figure 1 and the launch trajectory in figure 2;

Figure 1: Water Rocket Ready for Launch

The launch trajectory graph has acceleration and height reached on Y axis and time on X axis. The acceleration is measured by the sensor and the height is computed based on that. The graph indicates that the accelerometer got saturated resulting in wrong height computations.

The Japanese faculty members evaluated and graded performance of their students. The Indian faculty members did not, since it was a co-curricular activity for their students.

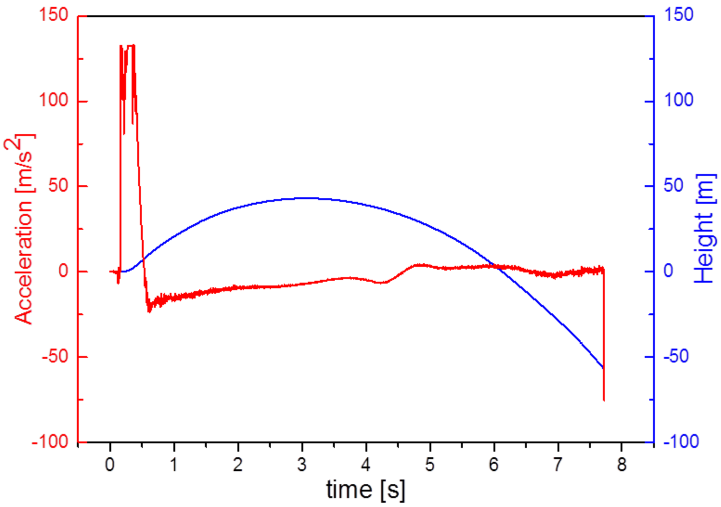

Figure 2: Launch Trajectory

Overall Experience

We asked the participants if they would recommend such an experience to their colleagues and have presented their responses in figure 3. All the Indian students and one Japanese student said that they would proactively recommend the experience. Two Japanese students chose the 'recommend' option. This resulted in the overall satisfaction rating of 4.82 on the 5 point likert scale. The faculty members also voted for the 'Proactive Recommendation' option.

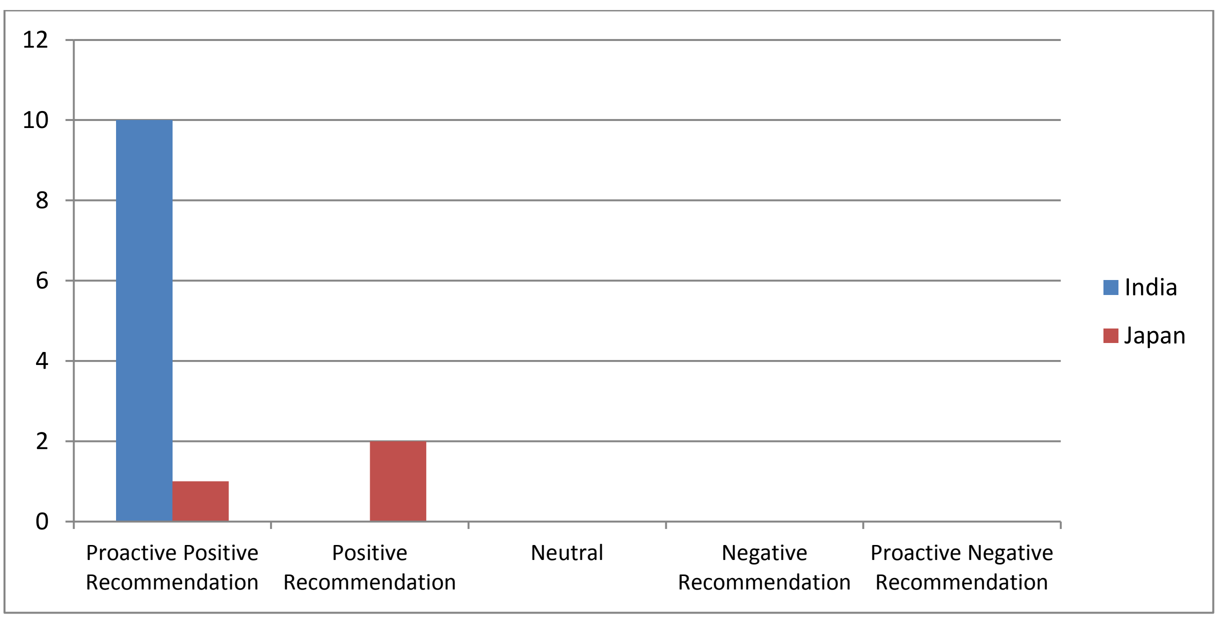

Figure 3: Overall Feedback from the Student Participants (Y axis has number of students and X axis has different responses)

We also asked the students if they would be willing to self-finance the cost of an international trip to gain similar experience and their budget. We have presented their responses in figure 4. Nine of the ten Indian students and all the three visiting Japanese students indicated their willingness. Each of them gave different budgets. We agree that the budgets would be influenced by the financial situation of individuals and wanted to just get an indication of the extent of the benefits that they have received and collect information for planning similar experiments.

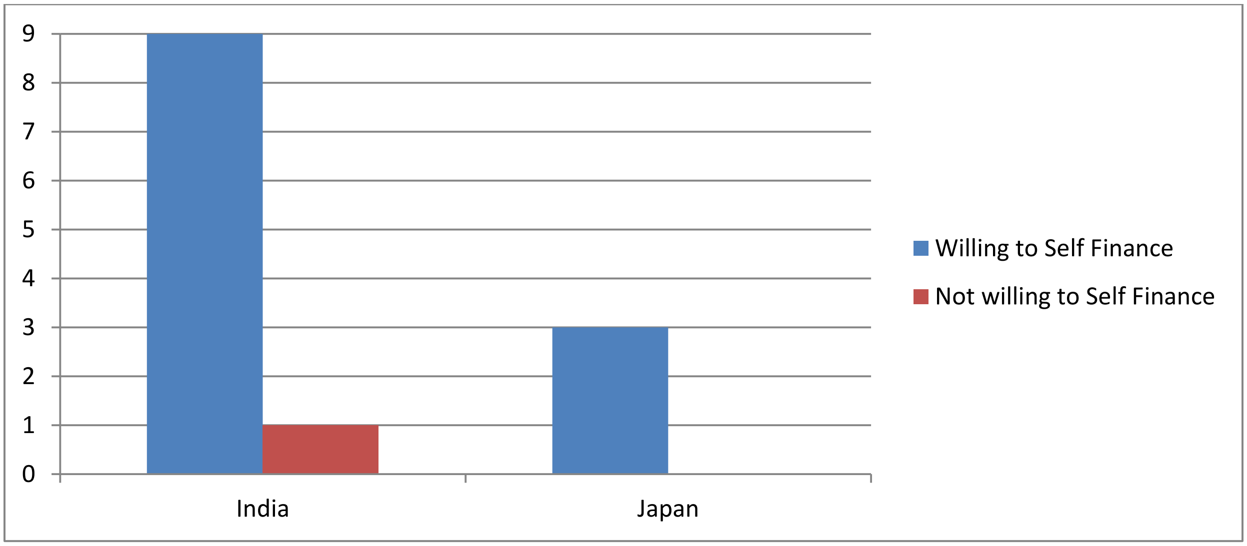

Figure 4: Students' willingness to self-finance such projects (Y axis has number of students and X axis has nationality)

We also requested the participants to comment on their top three expectations from the program and received responses as shown in figure 5 and 6. Since we had sought ordered responses, we allocated weights of 5, 4 and 3 to the responses based on their order. While the Indian team expected more learning in cultural areas, the Japanese team expected more learning in the technical area. The Indian team members had some unresolved questions on the system specifications. Some of them have indicated that as one of the expectations. Some of the students just wanted to learn new things (of any type) and Japanese students were eager to learn communication. We think they were considering English skills as a requirement for their career while Indian students were looking for Japanese skills only to know more about Japan and its culture.

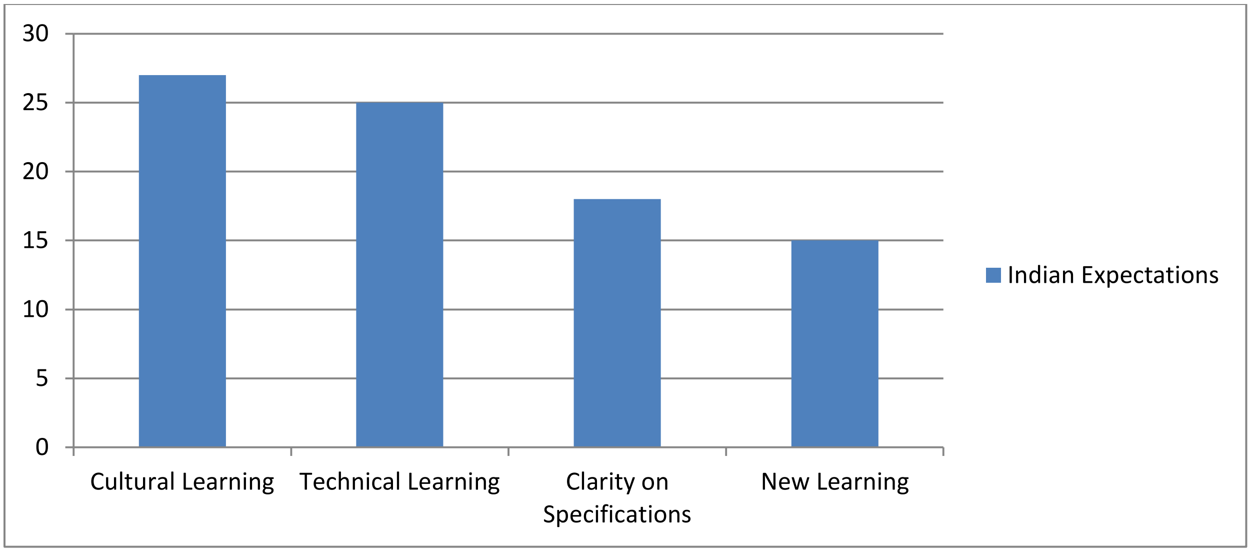

Figure 5: Expectations of Indian Students (Y axis has weighted sum of expectations and X axis has different expectations)

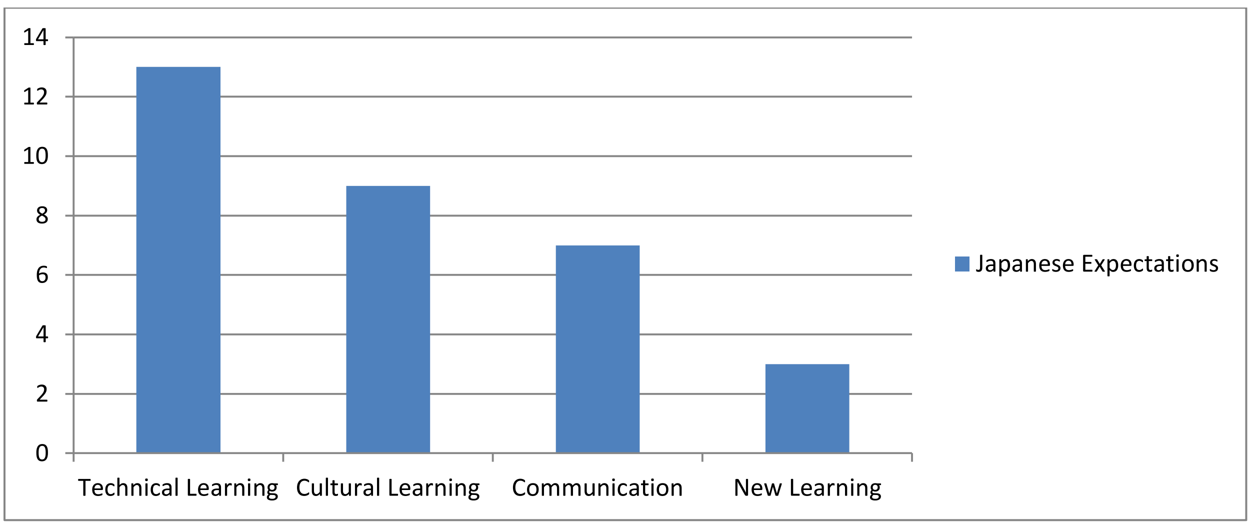

Figure 6: Expectations of Japanese Students (Y axis has weighted sum of expectations and X axis has different expectations)

We sought feedback on 'takeaways' and have shown them in figure 7 and 8. 'Learning other culture' has scored the maximum in case of both the teams. It was followed closely by 'learning about the project'. Some of the Indian students were very impressed by the hard work of the Japanese. Importance of discipline also found place in the takeaways. Some Japanese learnt about communication in an international context. Overall, it seems that cross-cultural experience was more evident than cross-disciplinary. This could be due to inadequate engagement when teams were working in their countries, shorter duration visits of the Japanese team and higher syntactical divergence (difference in food, language) and semantic convergence (similarities in values, relationships) between the two cultures. The faculty members learnt working and life styles of a different culture.

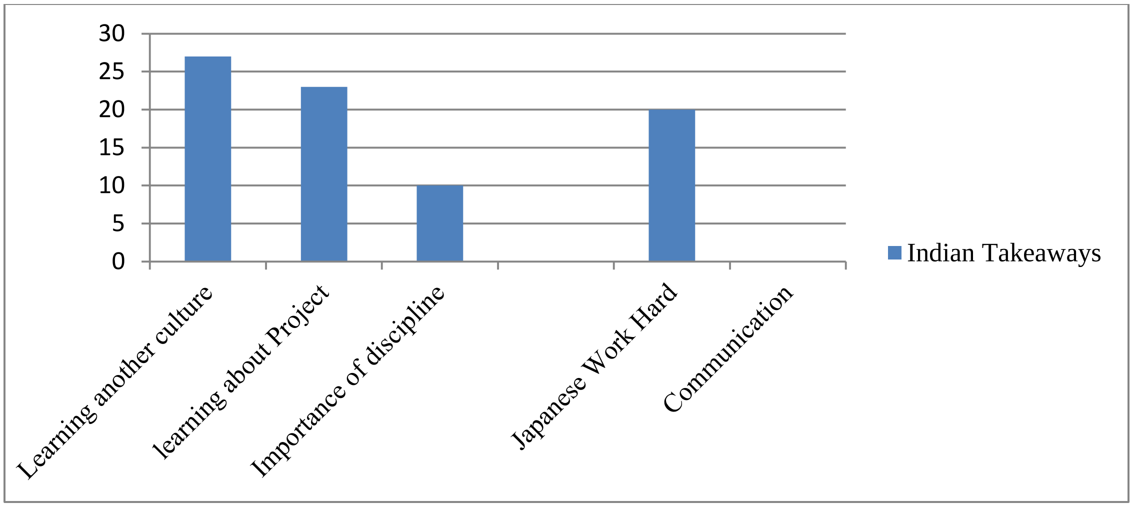

Figure 7: Takeaways of Indian Students (Y axis has weighted sum of takeaways and X axis has different takeaways)

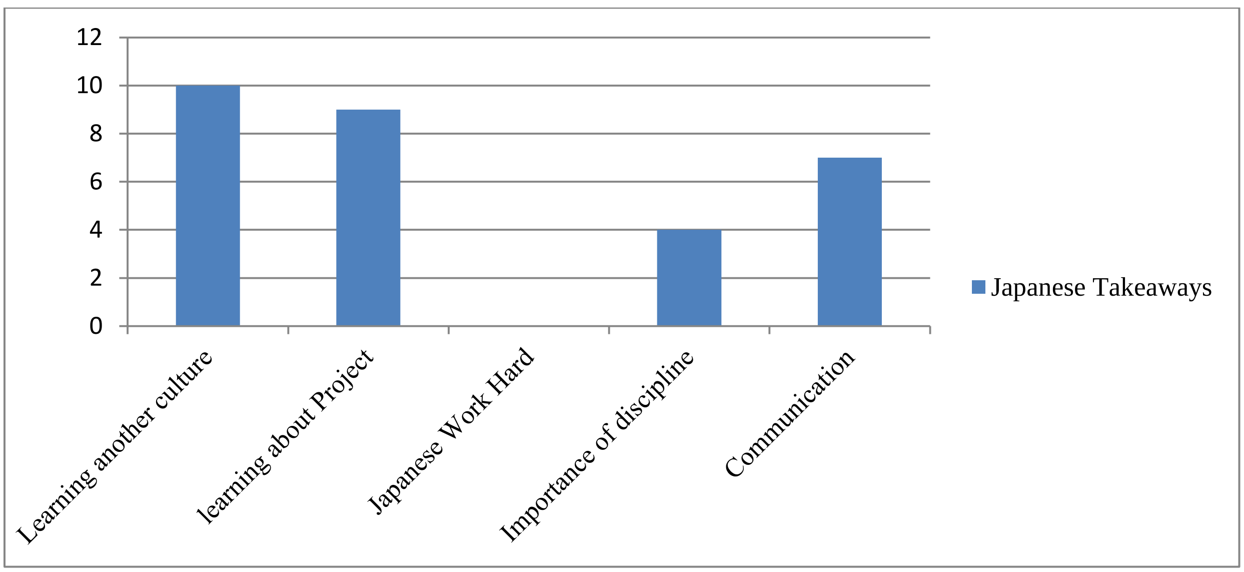

Figure 8: Takeaways of Japanese Students (Y axis has weighted sum of takeaways and X axis has different takeaways)

Suggestion for Improvements

We asked students for suggestions for improvements in the design and execution of such programs and have shown them in figure 9 and 10. Indian students wanted to overcome the language barriers and have more interaction with their Japanese counterparts. For language barriers, they suggested crash courses or use of interpreters. In order to have more interactions, they opined that there should be involvement of more people in the program and opportunities for Indian students to visit Japan. Students also suggested better planning and longer duration programs.

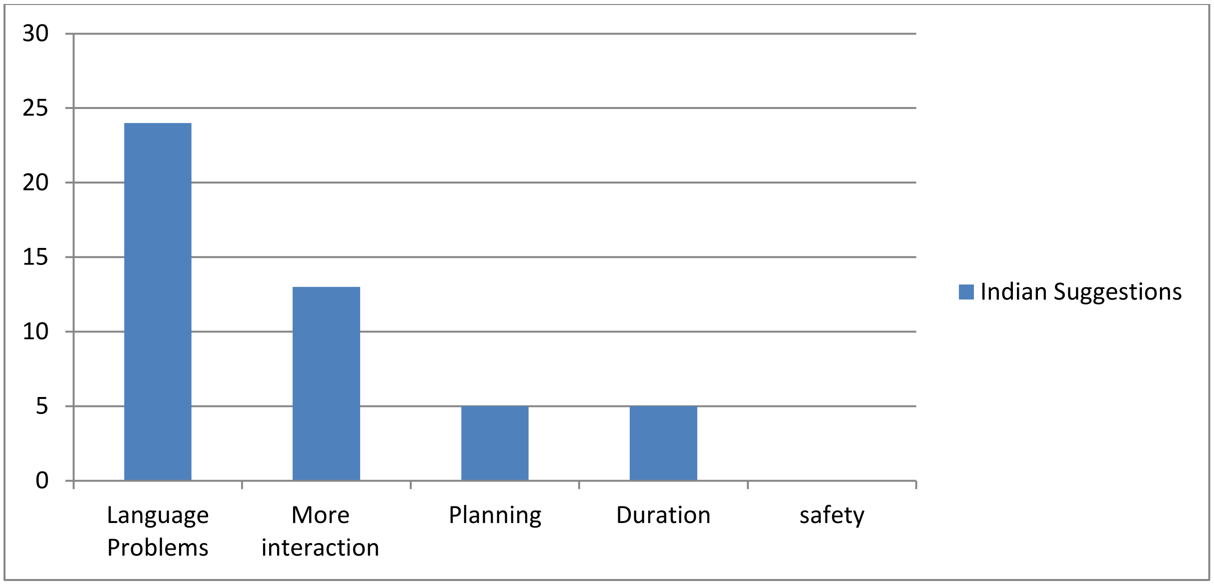

Figure 9: Suggestions of Indian Students (Y axis has weighted sum of suggestions and X axis has different suggestions)

The Japanese students were unhappy about the planning. They had suggestions to improve logistics, and have better communication. They wanted to have a detailed schedule a priori and to adhere to it. Interestingly, on the other project of the program – the multi-cultural portal – students did not have so many issues with the planning. This may be because the water rocket project was highly technical and had all engineers on the team. More interaction, longer duration and safety also figured in their suggestions. The faculty members said they would like to have better preparation and reduction in the cost to students.

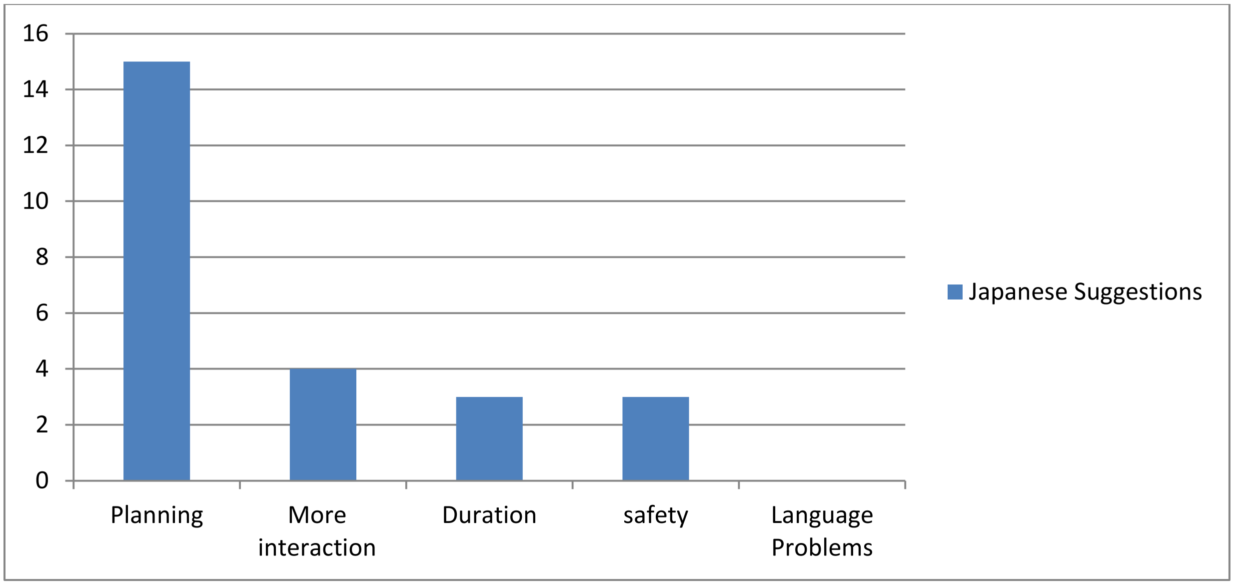

Figure 10: Suggestions of Japanese Students (Y axis has weighted sum of suggestions and X axis has different suggestions)

Concluding Remarks

Team and Project-based learning are essential in today's engineering education across the globe. Further, the teams need to draw students from diverse cultures and disciplines. Educators will have to find ways to innovate activities that can create opportunities for such learning. We presented one such experiment between Japanese and Indian institutions. The experiment was immensely successful going by the feedback received as well as from the interactions we witnessed between the two teams – especially during the visit part of the program. The participants highly valued the cross-cultural (international) experience. The Japanese participants suggested better planning while the Indians wanted to overcome the language barrier and have more interaction with their Japanese counterparts. It seems that the cross-cultural learning was a little more prominent than the subject matter learning. The main reason for that may be the higher syntactical divergence (difference in food, language) and semantic convergence (similarities in values, relationships) between two cultures.

Such a joint Indo-Japanese program for engineering projects appears to be the first of its kind. It was on a small scale. We need to sustain this initiative and do more such experiments involving more participants. The overwhelmingly positive feedback can help us enroll greater number of students and faculty, and allow us to refine our conclusions. The interaction can be longer than a semester and visits can be longer than a week. The plan could start with a visit by students from a culture, followed by project work and could end with a reciprocal visit i.e. by students from the other culture. We can track and evaluate performance of all students to enhance learning from the experiment. Experience of individuals in such cross-cultural situations depends on many factors such as, prior experience, team composition, and task complexity, and requires to be analyzed leading to maximized learning from the experiment.

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