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Effect of Multinational Projects on Engineering Students through a Summer Exposure Research Program

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***Abstract*—This paper studies and quantifies the impact of active learning experienced through multinational projects. The hypothesis was engineering education delivered through Active Learning in multicultural environment improves student competencies. The investigation captures the impact of international exposure program in developing global competencies of the modern engineer. The paper shows positive trends in the development of domain and life skills of engineering students. Post-survey after six months of completion of the program revealed that the program was valuable to students and their motivation increased.**

***Index Terms*—active learning, global competencies, engineering education, multinational projects**

I. Introduction

Globalisation has caused world economies to become interdependent and integrated. It has enveloped governments, companies and finally the people. It has resulted in the amalgamation of local and world economy. The growth accelerates due to advances in Information and Communication Technology (ICT) and transportation. The International Monetary Fund (IMF) has suggested fundamental aspects of globalisation, trade and transaction, capital and investment movements, migration and movements of people, and the dissemination of knowledge. In response to these opportunities, it is necessary to train engineers for the global market. Their technical and life skills have to evolve following a multinational collaborative environment. Modern engineers need exposure to the multicultural world, using active learning pedagogies [1], [2]. They need such experiences while working on a project spanning countries or as a part of multicultural teams within a country [3], [4]. The requirements of the collaborative environment also requires engineers with multiple competencies [5], [6] in globalization [7].

The critical competencies include:

- hands-on skills
- domain knowledge
- cross-cultural communication
- leading an ethnically diverse team
- effectively dealing with cultural differences while developing solutions.

The four primary objectives for students in short term study abroad program is:

- intellectual advances for nurturing problem-solving and language.
- intercultural sensitivity for empathy, language and global interest.
- personal goal for self-awareness, flexibility and creativity.
- professional benefit.

There are many educational experiences driven by Governments that also helps to develop global competencies and promote active learning. For example, The Erasmus+ is an EU program that provides opportunities for students [8], National Student Exchange [9], or Idea League [10]. The need-aware Universities expose their students through International Exposure Programs (IEPs) to develop modern engineers [5]. Such programs introduce engineers to professional skills required from the international workforce. The active learning will train engineers by simulating realistic situations. It helps students to develop skills required for the execution of the international project and provides motivation and confidence. The effectiveness of IEP is impacted by; intrinsic motivation, language, culture, education, government, economics, geography, and time zone.

The authors in [11] discuss international collaboration in computer science between US University and Iraq University. The work presents an informal timeline and outlines potential projects. It uses cluster configuration for network security and presents the planning and design phase of the project. The [12] cover issues of creating and implementing an innovative program among several Universities in European countries. The interdisciplinary program uses ICT, and it focuses on transnational and intercultural context. It uses blended mobility, team and project-based learning for the field of education, training, youth and sports. The open education approaches across ten universities from the South Mediterranean represents an example of intercultural and multilingual experiences [13]. The paper discusses the opportunities and challenges when adopting an open approach for intercultural learning. The [14] discuss team complexities specific to project team composition and project dynamics. It is exciting to study dealing with the team's ability to compensate for non-contributor member in the distributed environment. The project dynamism develops with the ability of the team to deal with changes in customer requirements. The paper identifies various sub-factors for these complexities and establishes a correlation among them for the final product. The international exposure is also available through the capstone project [15]. The paper shows and encourages attempts to broaden their student to life skills which solving engineering problem.

International Mobility Programs impacts the employment likelihood [16], [17] three years after graduation. The students from disadvantaged background reap the most benefit. The country-specific instances of summer programs are gaining student's interest [20], [21]. The summer school is an excellent mechanism to attract USA students to Germany and the paper reports one of the case studies. The exchange between 11 universities from the European Union and nine universities from the Middle East is in [22]. The paper reviews experiences, academic obstacles in teaching and learning with different educational systems.

More data is required to form the conclusion about the short term exposure program satisfying four objectives [17]. It also seems that none of the objectives can stand apart as they are intertwined. The success of such programs dramatically depends on the quality of the program and the individual student [19]. The international mobility program has unique requirements, and the program must be set up accordingly [21]. The program must aim at increasing outbound mobility by encouraging students. The different stakeholder in internationalization must work to reduce the barrier against mobility and the paper [23] overviews the participation structure and evaluation results over the nine sessions for four years.

The present work aims to study the impact of summer exposure program on the students of Pandit Deendayal Petroleum University (PDPU), India. It aims to study the impact on five competencies: hands-on skills, domain knowledge, critical thinking, intrinsic motivation and teamwork. It is a work in progress as this study will help to shape the future summer programs. The current results are from students surveys during the summer exposure program and six months later. The rest of the paper is as follows: Section II details the summer program including types of prototypes developed. Section III does the outcome analysis based on student feedback during the summer program and six months post the program. Section IV concludes and discuss the changes in the future versions of the program.

II. The summer programme

The summer program followed the iterative design cycle; conception, design, implementation, assessment, and conclusion [25]. The project with a multinational team participated during the summer program at Sacred Heart University(SHU), Connecticut, USA. The summer program orginated with continuous interaction between faculty groups at PDPU and SHU. The emphasis is to deliver the project through active learning with a focus on global competencies. The Internet of Things (IoT) emerged as a domain for project execution after several rounds of discussions between faculty teams. The interaction commenced six months before the actual dates of the program. Eight students with major in computer engineering from PDPU at Gandhinagar, India participated in the program. The students varied from Freshmen to Juniors.

The design and implementation phase follows the conceptualization. The program was announced to PDPU students by their advisor, and the application and selection process was carried out by PDPU. Their program director selected students at SHU and recruited in advance to the program for preparation. Internet of Things (IoT) was the main topic for the projects. The Engineering students from PDPU were a part of the larger group, which also had 36 students from liberal studies.

The program was conducted with the following participant groups:

- Faculty mentors: One faculty each from SHU and PDPU were present at campus of SHU during the program. These were the two faculty members who worked closely to develop the program details. Their role were mostly advisory. The faculty from SHU planned the logistics at the site and recruited students at SHU. The faculty from PDPU promoted and recruited students at PDPU. Additionally, the lab manager at SHU were involved in planning the projects and logistics. Lab manager also was present during the program to mentor projects.
- Student staff at SHU: 3 undergraduate computer engineering students were hired to work in this program over the summer. These students were paid to attend with the understanding that they could assist with student projects. These students were trained one week before the program to make sure they can be helpful to PDPU projects. They actively participated in the projects as a helper and worker.
- Students from PDPU: 8 students committed to travel with their professor to attend this program. Students worked on projects and received help from SHU student staff. The cost of the program was covered by PDPU (except the flight) that included the accommodation, field trips, project parts, and the staff at SHU. English was the working language. Students from PDPU needed to present their results in multiple avenues in front of wide audience and interact with faculty from SHU to show their progress. Several workshops were offered to broaden their skill set in both technical and professional skills.

The summer program had a modular flow, and it developed across the four weeks with; (1) dependent, (2) interdependent, and (3) independent phase based on interaction styles between teams and their mentors. The hypothesis of the current work is Engineering education delivered through Active Learning in multicultural environment improves their competencies. Each student team had multinational team members, and they developed the project for over four weeks. Intermittently the teams pitched their projects during presentation conducted by liberal studies sessions.

A. Project Timeline

TABLE I: Project Timeline.

Week	Task
1	**Dependent Phase**: Introduction to Maker-space, team formation, Microcontroller boards, programming environment, guided intervention about project selection, brainstorming about project ideas, identification of deliverables.
2	**Interdependent Phase**: Reiterating over ideas, ordering components, Proof of concept programming, design initiation, Presentation about the ideas to business students.
3	**Interdependent Phase**: Mentoring from Industry experts, prototype development, working with hardware and software tools, development of the early prototype, pitching to the business audience.
4	**Independent Phase**: Preparing final prototype, making presentations, Preparing for final day demonstration, availability of the manager of the maker space for Just in Time help.

PDPU students proposed the projects after SHU University team delivered a structured workshop program in the first week about IoT (Internet of Things). Explicitly, ESP 32 microcontroller boards introduction and programming aspects using programmable LED strips (WS2812B LEDs). During the week, PDPU students brainstormed project ideas with the SHU team members as they planned their projects. SHU students were part of these discussions as they were aware of the capabilities of the engineering laboratory. The project proposals of four PDPU student teams supported by four SHU student and staff members delivers at the end of the first week with deliverables identified.

The second week of the program covers design prototypes and order components that would be needed. PDPU students experienced shopping at local construction stores to find parts for their projects as well as communication with SHU faculty members. The second week also utilizes to work on the proof-of-concept programming for the designs. PDPU students gave presentations in front of the other summer program participants from liberal arts and business programs.

Furthermore, guest speakers from local industry also participated in the program as mentors and speakers. Weeks 3 and 4 were focused mainly on finishing the prototypes for the final day demo. During this timeframe, PDPU students worked closely with SHU students. A full-time lab staff was available for any questions as well as engineering students from SHU. Final demo projects included: (1) smart clock (Fig. 1a), (2) smart farming sensing (Fig. 1b), (3) smart safe (Fig. 1c), and (4) moods lighting (Fig. 1d). Each project was functional at the end of the program, with most of the deliverables met.

B. Project Prototypes

Smart clock project (Fig. 1a) included a digital display that is controlled by the ESP 32 controller along with close to 100 programmable LEDs. Two lines of LEDs represent the hour and minutes. Wood forms the frame, and a plexiglass piece keeps the clock transparent while protecting the LEDs. Students used hand-operated drills to make the holes. Fig. 1b displays the smart farming bucket, which was a modified version of the first idea (scarecrow) due to the team realizing the limitations of the project. Smart farming included a soil pH sensing capability with Wi-Fi signal transmission capabilities. This project included complicated wiring with LEDs and sensors. A bucket repurposes for this project where drilling and painting were involved. The idea for the third project was to create safe for students who stay in dorms (Fig. 1c). It was the only project that consisted of mechanical movements where students had to deal with motors and face the issues of drivers. A keypad outside the custom-made wooden box provides access and LEDs were again used to indicate user inputs, i.e. password verification. Fig. 1d shows the last project with name as mood lights. Students had the idea of changing the colour of the LED lights as the day progresses to indicate morning, day-time, and evening. This project was heavily involved with coding as students needed to deal with real-time clock.

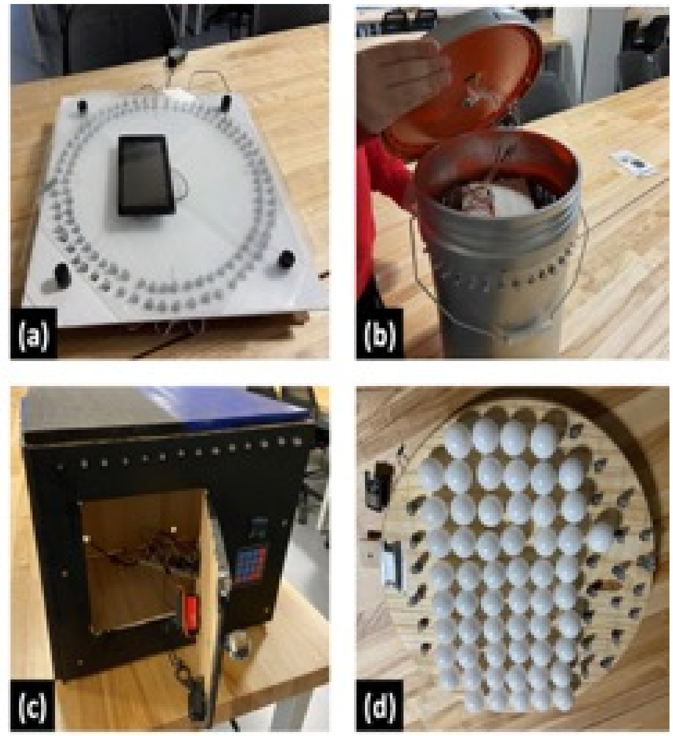

Fig. 1: Photos of the final prototypes at the end of the program: (a) smart clock, (b) smart farming sensing, (c) smart safe, (d) moods lighting.

III. Outcome Analysis

The summer program needs to improve on the competencies of the students. The program targeted following competencies in the participants:

- Hands-on Skills (HS)
- Domain Knowledge (DK)

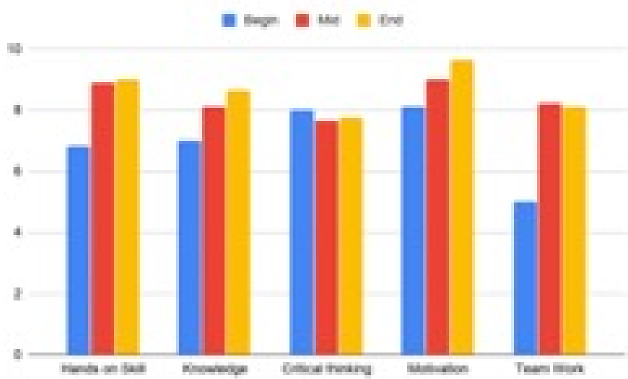

Fig. 2: The satisfaction survey of the participants during begin-mid-end of the summer program.

- Critical Thinking (CT)
- ntrinsic Motivation (IM)
- Team Work (TW)

The student satisfaction survey collects and analyzes the outcome of the program. The three-stage (begin, mid and end-term) survey covers competencies, and it reports the mean opinion scores (MOS). Table II depicts the mean and standard deviation for the competencies.

TABLE II: Mean and Standard Deviation for the three-stage survey. Comp.: Competency; STM: Start Term Mean; STD: Start Term Deviation;MTM: Mid Term Mean; MTD: Mid Term Deviation; ETM: End Term Mean; ETD: End Term Deviation.

Comp.	STM	STS	MTM	MTS	ETM	ETS
HS	6.83	0.75	8.88	1.05	8.50	1.00
DK	7.00	0.89	8.11	1.61	8.50	0.96
CT	8.00	0.89	7.66	1.73	7.75	0.96
IM	8.16	0.75	9.00	0.92	9.62	0.56
TW	5.00	0.90	8.20	1.85	8.50	1.12

Fig. 2 depicts the participant's satisfaction survey for the summer program at SHU. The participants reported a significant increase in hands-on skills, domain knowledge, and motivation. Also, teamwork improved significantly in the initial stage and dropped very marginally at the end. The critical thinking deteriorated marginally due to the diverse team which had juniors and sophomores with different proficiency levels. The p-value between the beginning and mid review is 0.03, begin, and end review is 0.02, and between mid-review and end is 0.06. The low p-values indicate that the data did not occur by chance.

It is crucial to identify statistically significant relationships and measure strength in sample-based estimation. The Cohen's *d* is one such metric in which effect size measures the strength of the relationship. It is a difference between two means divided by a standard deviation for the data. The effect size is quantifiable as small, medium or large, and its range depends on the context. Table III finds Cohen's d between Initial & mid, mid & end, and initial & end term MOS for five competencies.

TABLE III: Cohens d scores for competencies. I-M: Initial - End; M-E: Mid - End; I-E: Initial - End

Comp.	I-M	M-E	I-E
HS	2.24	0.37	1.88
DK	0.85	0.45	1.62
CT	0.24	0.06	0.27
IM	1.0	0.82	2.21
TW	2.19	0.19	3.43

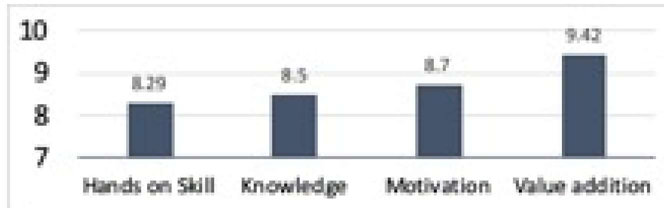

Fig. 3: The satisfaction survey of the participants after six months of the summer program.

The Cohen's d with a value less than 0.2 is small size effect. The statistical relationship, in this case, is weak, and it can be observed only through careful study. Cohen's d with a value higher than 0.5 signifies large effect size. It represents the substantial relationship between the entities, and which is big enough and consistent. All competencies show a large effect size during various phases of the summer project, which means that participants competencies are growing.

Fig. 3 depicts the satisfaction survey of the participants six months after the summer program. It shows the mean opinion scores on four parameters: hands-on skill (8.29), knowledge (8.5), motivation (8.7) and summer program's value addition (9.42). It is interesting to observe the positive impact of the summer program on the participants. They overwhelmingly felt that the summer program had done a significant value addition to their technical and life skills. The participants could extend hardware and software development skills learnt during the summer program to their academic practices. Five of these students also participated in Hackathon [24] organized by the Government of Gujarat in November 2019. It showcases their intrinsic motivation to excel in competitive environments as well.

The written comments by participants revealed some interesting insights into the summer program. All participants appreciated the delicate balance of hardware and software development stages in the project. They had good exposure to software development at their home University but working with a hardware component of the IoT problem was very appealing to them. The coding of the microcontroller is also fascinating for participants, especially for first-year students and sophomores. The participants enjoyed the guided intervention by the team of teaching associates and faculty mentor. The participants appreciated the availability of the maker space with its facility. The project scope gradually grew over the weeks, and so the hands-on skill and knowledge.

The week-wise presentation to experts and non-technical audience improved their presentation skills. It was revealing experience for many as they dealt successfully with the stage fear. They observed that many of their colleagues are also equally vulnerable, and it is fine to fail at some time. Some of them even felt an improvement in their listening skills. The healthy competition within teams to complete the project, the inputs from various experts and visits to places impacted the life skills of the participants. They appreciated the idea of international exposure and its impact on their competencies.

IV. Conclusion and future

The impact of international exposure had a positive impact on the participants. They showcased overall improvement in the competencies both in the short term and long term. The sophomores and juniors participated in a 24 hour Hackathon after returning from IEP and also in Hackathon conducted in November 2019. Each participant formed a team with a new student, and many made to final rounds of the hackathons. The above results are encouragingly pointing to the Hypothesis that Engineering education delivered through Active Learning in multicultural environment improves their competencies. The rigorous testing of the hypothesis will need more runs of the program and data analysis. It led to another experiment where the faculty team from SHU and PDPU initiated project collaboration during regular courses in the semester. The experiments cover the Sophomores in Semester III course on Digital Logic Design. The results of the experiments are under evaluation. The aim is to understand the student skills, mindsets, motivation levels, and soft skills. It will help both Universities to tune future programs and making them more impactful.

Participants of the summer programs had much exciting suggestion for the improvements in the future runs. Some of these suggestions are as follows: a) The program should have a longer duration with more exposure to the maker space. b) More technical visits correlated to project can be part of the itinerary. c) Improvise on the scope and definitions of the project. d) The project definitions to be finalized well before the commencement of the summer program.

Motivated by the impact, the future immersive summer program will include tracks of AI and Cybersecurity. It will provide more opportunities for explorations. The definitions will have an open-ended nature for explorations, and it will have a more independent phase in the project development. They will also attend intensive workshops to improve soft skills. The students will also interact with Industry leaders and experience technical and cultural aspects of the Engineering.

V. Acknowledgement

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