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Work in Progress: Project-Based, Multilevel Teamwork for First-Year Engineering Program

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Abstract

The long process of educating a new generation of engineers requires more than just the progressive accumulation of classes as students move through a departmental curriculum. Engineering education goes beyond solving equations and retaining systematic procedures. It requires cultivating ethical values, honing creative skills in engineering, working collaboratively and iteratively, and solving complex problems in a multidisciplinary environment. The Accreditation Board of Engineering and Technology (ABET) formally acknowledged the importance of these notions in their most recent requirements - (students' outcome 5): "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives."

Project-based teamwork is particularly crucial in a first-year engineering design course. An experiential learning environment promotes acquiring essential skills and abilities that will be used in future projects throughout their education. In addition, multidisciplinary teams cultivate a respectful and inclusive work environment, support a deeper understanding of engineering concepts, and encourage students to apply these concepts to meaningful solutions to engineering problems while nurturing a healthy and interactive classroom environment.

This Work in Progress paper describes the design and implementation of a semester-long project as part of the first-year design class at the University of Connecticut and how it promoted teamwork on multilevel. The class had over 400 first-year engineering students (from all engineering fields except computing) divided into 16 multidisciplinary sections, all working in the First-Year Design Laboratory. Students in each section were further divided into smaller groups of 4-5 students using the guidelines on equitable teams and inclusion discussed in the lectures. The ten-week project emphasized improved collaboration and teamwork through iterative design-and-build cycles of a "Solar-powered Martian habitat" at multiple scales: small (4~5 student group) and medium (6~7 group habitat communities). The project involved students in smaller groups working collaboratively on individual components of the habitat, such as a solar-driven dwelling, a carport, a rover, a solar tree, a bridge, and machinery. Students acted as "residents" living together, designing each component to accommodate the needs of their own and other teams and contributing towards the habitat. Finally, the smaller groups integrated their components and collaborated to maximize the energy efficiency and performance of the Solar-powered Habitat.

The assessments of this project were designed for each level of teamwork: 1) Students highlighted their contributions through an Engineering Portfolio. 2) Smaller groups reflected on their design and building process by submitting weekly engineering logs and a semester-end poster. Finally, 3) Each group habitat (comprising 5~6 groups) presented its energy-efficient habitat design in the first-year design expo at the end of the semester. The ongoing data collection of this effort on project-based, multidisciplinary, multilevel teamwork proved how this project design effectively cultivated better teamwork practices across all engineering fields.

Introduction

Teamwork is listed as one of the measured outcomes for accrediting engineering programs [1]. There are a few systems in place that have been used recently for teamwork with relative success, such as the community of practice [2], the use of videos [3], virtual environments [4], learning from industry experiences [5], project-based learning approaches [6], the production of cohesive teams [7], and Input Process Outcome (IPO) process [8] which covers in its umbrella a subsequent adaptation as an IMO process. The teamwork-integrated Equity Diversity and Inclusion (EDI) system [9] can be placed under a project-based learning approach but with a strong EDI component.

Some critical theoretical frameworks on teamwork are drawn from sociology, psychology, and organizational behavior, such as: a) Engineering identity (EI) by Allison Godwin [10] is defined as how a student identifies with the role of engineer (i.e., I am an engineer vs I am doing engineering). EI comprises four components: interest in the subject, perceived recognition by others, performance/competence beliefs, and self-awareness. b) Engineering thriving (ET) by Juliana Gesun [11] is inspired by shifting the narrative on engineering students from "surviving" to "thriving." ET is formed by three components: internal thriving competencies, external thriving outcomes, and the engineering culture, systemic factors, resources, context, and situation and lastly c) Intergroup Contact Theory (ICT) by Thomas Pettigrew [12], which discusses interpersonal dynamics within teams, particularly individuals from different social groups such as racial or religious groups. ICT posits that positive and meaningful interactions between people from different groups work best under four conditions: equal status between the groups, cooperation between the groups, work toward a common goal, and support from the institution (i.e., instructors). The three frameworks selected align with the goals of the course, such that (a) we are mindful and intentional with humanizing experiences for undergraduate engineering students, (b) as an experience required of first-year students, this contributes to positive identity, belonging, and thriving.

Besides the apparent technical implementations that occur in a large classroom setting with 400+ students, the critical pedagogical decisions for the design of such a course are Learning methods (contents in the equitable teams lecture and instructions and prompts in formative assessments) and Facilitation methods (scaffolding behind the multi-level team projects, and supporting and accommodating neurodiverse students in teams). Both of these methods create activities that lead to the practice of team-building skills, which have been shown to promote equity, diversity, and inclusion [9].

Our class has a mix of national and international students with diverse cultural backgrounds and a large percentage of female representation. Implementing various learning modules in our class follows a project-based learning approach, where students learn by conducting the work themselves but with a strong focus on teamwork. We are aware that students do not necessarily possess the required skills to work efficiently and cohesively as a team, so we offer a practice assignment at the beginning of the semester where the students get to work with a foundational set of skills, like gathering and interpreting data, practice building a project in common, and giving feedback to other teams, all while offering that they attend off-hour workshops to improve their technical skills. We also practice in class the critical skill of how to communicate with each other while making sure that we guide and respond to comments from dominant groups that might send the message that under-represented and underserved students are not equally prepared or have the same abilities as those of the dominant group [9].

An essential element of our course is the multidisciplinary approach to our team formation and learning styles in the design labs of the course. We know that engineering graduates face issues requiring a multidisciplinary approach and that employers look for engineers with interdepartmental communication, teamwork, and the capacity to learn new skills [13]. Our projects introduce our students to uncharted topics. We guide them in the understanding of the scope and context, the solutions that they can provide in a collaborative environment, the constraints that they will be facing, the development of an array of prototypes during class time, testing the models, and presenting the results to the community of learners.

Description of the First-Year Engineering Course

The Foundations of Engineering (ENGR 1166) course at the University of Connecticut is a core course for all first-year engineering students during the spring semester. The student enrolment for this course is over 440 students per year, and this substantial student population consists of all engineering disciplines (Biomedical, Chemical and Biomolecular, Civil, Environmental, Electrical, Materials Science, Mechanical, Multidisciplinary, and Robotics). This course covers introductory topics related to various engineering specializations. Students choose a section aligned with their current or prospective major. Within the field, the curriculum aims to cultivate skills that can be applied across different engineering disciplines.

The University is committed to enhancing the student learning experience. We have faculty from all engineering departments (Biomedical, Chemical and Biomolecular, Civil and Environmental, Electrical, Material Science, Aerospace and Mechanical, and Department of Fine Arts) as part of a robust, multidisciplinary team. ENGR 1166 also appoints six full-time Graduate Teaching Assistants and approximately 20 Undergraduate Teaching Assistants from the departments to help with the course and the project-based lessons.

ENGR 1166 is an ABET-accredited course that carefully follows the ABET learning outcomes. The learning outcomes of the course are to 1) demonstrate an understanding of concepts and solve fundamental problems in the primary area of study; 2) iteratively design, build, and improve a device or a process to meet a specified need within given constraints; 3) work effectively in multidisciplinary teams; 4) communicate effectively by presenting work in a structured, clear, and engaging way to a range of audiences; 5) apply the ethical responsibilities of their profession to the design process. Students strive towards these course objectives through active learning methods and multiple hands-on projects throughout the semester.

This course has three segments: 1) Large Lectures, 2) Major Specific Components, and 3) Design Lab, which occur concurrently throughout the semester. The Large Lectures consist of presentations on a wide range of relevant foundational topics in engineering. The lectures meet in the Active Learning Classroom at the University (a state-of-the-art classroom with a layout of clusters of tables) that allows students to work in teams and collaborate on small-scale projects during lectures. Students learn about 1) Engineering topics such as "Creative Thinking and Prototype Design," "Equitable Team" "Estimate," "Ethics," and "Effective Communications"; 2) Essential software such as "Excel," "CAD Designs," and "SolidWorks"; and 3) Tools such as

“Microcontrollers” and “Circuit Python.” Students team-up into smaller groups in the large classroom to build hands-on, in-class projects. These activities foster the development of problem-solving abilities, teamwork, technical communication, ethical considerations, and documenting their work. Lecture topics are aligned with lab topics, aiding students in their project tasks. Within the Major-Specific Component, students asynchronously learn engineering concepts and challenges relevant to their fields. Feedback on their solutions is provided by instructors specializing in their respective majors.

The third segment of the course is the Design Lab, where students apply the knowledge and technical skills learned from the Lecture and Major-Specific components to design, iterate, and build a prototype with given constraints. It is in this segment that the aforementioned theoretical framework of teamwork is put into practice. The projects created for the Design Labs required students to highlight teamwork in multidisciplinary teams. Students were strategically placed in teams of 4-5 for long-term projects based on their technical skills, engineering majors, backgrounds, and identities and encouraged to form a thriving team [11].

During the lab times, students practice some of the information presented in the lecture in smaller settings. Some skill-building lectures and workshops cover handling responsibilities in a team project and balancing and differentiating tasks given as a set of parameters. Other skills, such as handling power dynamics and decision-making in team formation or giving and receiving feedback in team environments, are mostly covered during lab times. These activities are exclusively framed under the scope of work for two projects in the semester and are chosen for their proven value in a project-based learning environment [14]. We do that while stressing to the students the importance of becoming aware of globally important issues, like energy sources and consumption, or using engineering solutions to help the underprivileged, with a strong focus on prototype construction and testing.

The First-Year Design Laboratory is a dedicated maker space classroom for all ENGR 1166 students. It is equipped with 3D and resin printers, laser cutters, other machinery, and various other tools. Students enrolled in this course are divided into 16 Design Labs, with approximately 28 students in each section.

During the earlier portion of the semester, students completed a short-term (2-3 weeks) service-learning project and then dedicated the rest to a long-term project. Projects included designing, building, iterating, and testing (offered on a rotating basis), such as a wind turbine, spacesuit helmet, and hot air balloon. Each project had set goals, several stretch goals, and discussion goals, which students accomplished over the semester. Previously, students in teams of 4-5 would choose to work on one of these semester-long projects. Students focused on interacting only with their teammates over the semester. However, the implementation of the new Solar Village project for life on Mars (the highlighted project in this paper) was intended to increase the interaction of the students not only with their teammates (4-5 students) but with the rest of the students in their design lab (28 students).

Implementation of the Multilevel and Multidisciplinary Project

Climate change is a global phenomenon with widespread impact. The critical aspects of global climate change are rising temperatures and extreme weather conditions, resulting in further risk to social and economic systems, water resources, infrastructure, and livelihoods. Therefore, contemporary engineers face critical challenges in addressing global climate change and transitioning to sustainable energy sources. To create awareness about renewable energy sources (e.g., solar panels and wind turbines), the University College of Engineering and the School of Fine Arts have collaborated to design and build a Sciences, Technology, Engineering, Art, and Mathematics (STEAM) Tree. This Tree symbolizes and acts as a portable renewable energy source for the campus. This Tree is aesthetically pleasing with artistic renditions and is a functioning clean energy-harvesting power source.

Inspired by this initiative and to create awareness among first-year students about renewable energy, engineering, and design, ENGR 1166 implemented a ten-week project for all its students in the spring of 2024. Students worked on designing, building, and testing a “Solar-powered Martian habitat” that featured multidisciplinary and multilevel teamwork. This project aimed to provide a positive roadmap to learning about complex social challenges (such as climate change) and using resources on a new planet to build a sustainable habitat through collaborative work. As such, the goal of this ten-week project was twofold: 1) develop social interaction and 2) achieve an engineering goal.

Being one of the most extensive engineering courses in the University, first-year students often feel overwhelmed when establishing a connection with their peers. The project encouraged students to get acquainted with peers from different fields and develop a healthy and professional working environment to enhance social interaction. Cohorts of students from multidisciplinary fields collaborated, communicated, and contributed towards designing and building a functional habitat or village (just as residents in a neighborhood would help in a community). The teamwork occurred at multiple scales: small (4~5 student groups) and medium (7 group habitat communities). Small student groups contributed towards the safety, connectivity, and transportation elements in the Mars habitat by designing, prototyping, testing, and iteratively building seven separate projects (dwelling, bridge, rover, carport, a piece of machinery, a STEAM tree, and a secondary source of renewable energy such as a wind turbine). Students designed each project to accommodate the needs of their own and other teams. Finally, the smaller groups integrated their projects into a full-scale Martian habitat. Therefore, this project promoted interaction between students as all of them worked towards a common goal of designing their own thriving Martian Habitat.

To achieve the engineering aspect, the challenge of the project was to generate a sustainable, energy-efficient village on Mars through solar technology. The goal for all the teams was to maximize the power output of individual projects while meeting the constraints of the design (e.g., size of the project, powering LED lights, using microcontrollers) and varying parameters (e.g., number of solar panels, connectivity of the solar panels, distance and angle of the solar panels from the light source). The project required a unique solar tree specifically designed to harness solar energy. This STEAM tree offered versatility in design and tailored to the energy demands of the Martian habitat, making it a flexible and scalable solution. Once the students optimized their projects, all teams of the Design Lab (seven teams) united to form a “Solar-powered Martian habitat.” In this process, students deepened their grasp of the learning outcomes of the course mentioned earlier.

One of the primary learning objectives for the course was the exploration of the iterative design process. For this to work optimally, the students needed a concrete, quantitative evaluation of how well their design performed in a given iteration to assess the need for potential changes. By focusing on a performance metric (such as maximum power output), they made engineering design decisions at each iteration based on quantitative measurements of their system. This was not to say that they ignored the needs of the residents - the decisions the students made in regard to habitat layout and power priority were essential and were expressed in their team presentations as part of the overall "story" of their design. Figure 1 shows the prototype of the Solar-powered Martian habitat, and Table 1 provides the project considerations.

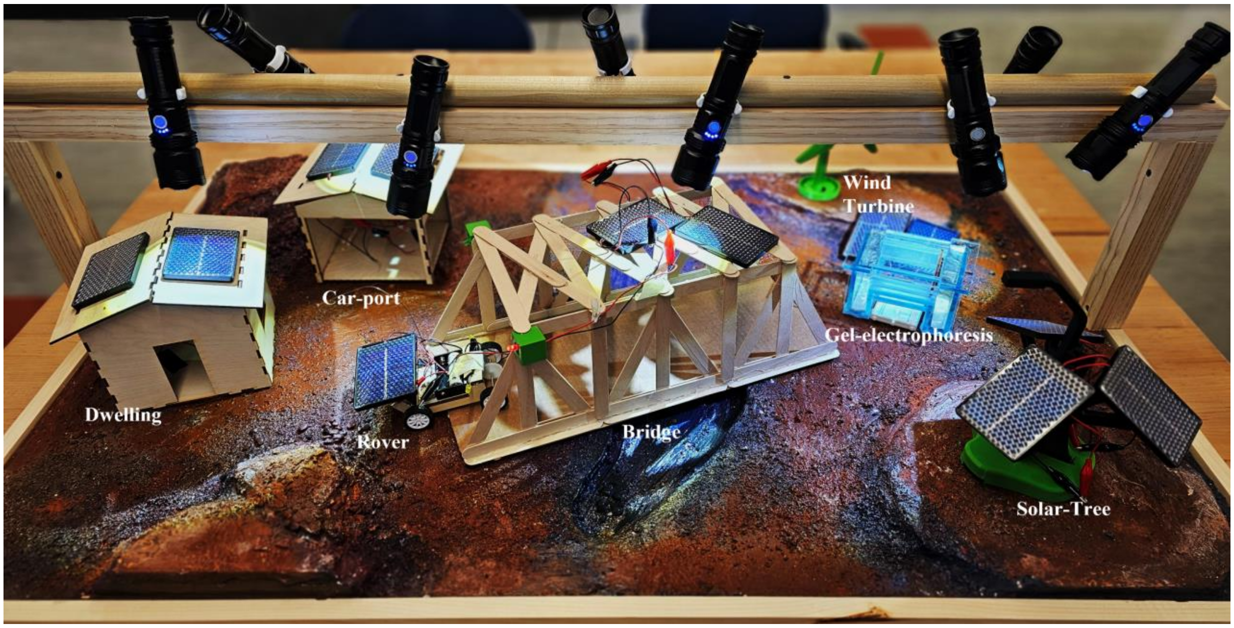

Figure 1: "Solar-powered Martian habitat" –a prototype of the Martian Diorama. Seven individual projects include: 1. Dwelling 2. Car-port 3. Rover 4. Bridge across the crater 5. Solar Tree 6. Gel Electrophoresis 7. Wind Turbine. All projects were powered by solar panels exposed to flashlights simulating the sunlight.

Students were provided with a brief introduction (written and video) of the project description, outlining the requirements, constraints, and stretch goals. It also highlighted the areas where collaborating with other teams was crucial when designing their projects. Additionally, documents and videos explaining prototype design and how to measure the power output with varying numbers of solar panels, with distance and angle as variables, were provided during the project to help students' understanding. Topics in the large lectures introduced students to technical knowledge. The raw materials for the project, including the solar panels, microcontroller, and LED lights, were available in the lab. Students built the project in stages: prototype design and parameter testing, followed by iteration of the prototype to improve the design. Following these scaffolded guidelines eliminated uncertainty regarding preliminary measuring and assembly steps and helped students focus on their design and optimization methods.

Table 1. Overview of the project deliverables, considerations, and collaborations.

Project	Deliverable	Considerations/ Restrictions
Dwelling	A structure with solar-powered lights that can turn on and off.	It should accommodate the rover in case the carport fails. Must fit in the diorama with sufficient exposure to power an LED during one time of day (morning, noon, or dusk).
Rover	A car that moves with solar-powered headlights that can turn on and off.	Must fit in the carport and travel across the bridge.
Carport	A structure that accommodates the solar rover and lights that turn on and off with the door.	It must accommodate the rover and fit in the diorama with sufficient exposure to a light source to power an LED during one time of day (morning, noon, or dusk).
Bridge	A bridge that is capable of supporting loads that has a traffic control lighting system.	It must fit across the crater of the diorama. Minimum required length and width of 15 inches and 8 inches, respectively. It must accommodate the load and shape of the rover. It must have a red, green, and yellow LED that can be turned on/off by users.
Gel Electrophoresis	A functional agarose gel electrophoresis instrument with solar-powered lights that can turn on and off.	Experimental run time, migration rate, and quality of color separation. Must fit in the diorama with sufficient exposure to a light source to power an LED during one time of day (morning, noon, or dusk).
Solar Tree	A structure of solar panel arrays. Attach an LED of choice to act as a "street light" to illuminate the area.	Orient and position to maximize exposure to a light source to power an LED during one time of day (morning, noon, or dusk).
Wind Turbine	A turbine that produces power when wind spins the blades.	Up to 8in tall.

Formative and Summative Assessments of the Multilevel-Teamwork

The assessments for the Solar-powered Martian habitat highlighted the work of the individual students and highlighted their efforts at multiple levels of teamwork. At the individual level, students iteratively developed and submitted a feedback-based Engineering Portfolio at the end of the course to demonstrate their mastery of the course's learning outcomes through the project described here. In this assignment, students highlighted how they evolved through this project and what they learned about teamwork. At the intra-team level, smaller (~5 students) groups reflected on their design and building process by submitting 1) weekly engineering logs and 2) a semester-end poster. In the logs, teams discussed and explained their design thinking, prototype development, iterative processes, and testing methods. Additionally, they built and demonstrated their ability to work in interdisciplinary teams by documenting their project management through

Gantt charts and timelines. Finally, at the inter-team level, habitat groups (7 teams) collaborated to present their designs in the first-year design expo at the end of the semester.

We conducted a pre-project survey for this Mars Habitat project. Students were asked to complete a short online survey of multiple-choice questions (during the lab sections) to assess their perspectives on teamwork. 325 students participated in the survey. Quantitative survey responses demonstrated that 34.5% of the students worked with others on either homework or projects at least once a week. 40% of the students responded that they team up with students from their engineering disciplines and/or other engineering fields, and 17% of the students work with students outside the engineering disciplines. 35% of the students stated that they worked with a maximum of four teammates in a given team. Qualitative survey responses revealed that students learned various aspects of a large project better through teamwork. They emphasized working with each other's strengths was helpful in teamwork and in meeting project deadlines and common goals. 49.8% of the students were confident in contributing towards teamwork, and 49.2% of the students revealed that group work was effective in learning new materials.

To assess the impact of multi-level teamwork, we also conducted a post-project survey through short online questions. 220 students participated in the survey and 39.5% of these students collaborated on homework and projects with others at least once a week. Students mostly worked with other engineering students. 35% of the students mentioned working with four teammates in a given team, but 68% of them also revealed that they worked with design constraints of other teams. The post-project survey showed that students felt more confident contributing to teamwork (60%) and better at communicating with teammates (54%). Additionally, almost all students (98-99%) mentioned that the project was effective in meeting the design iteration, multidisciplinary teamwork, and effective communication objectives of the course, where 67% of the students applied their fundamental knowledge from their specific engineering fields, and 62% of students applied ethics to the project deliverables. Therefore, from these short surveys, the Solar-powered Martian Habitat was effective in promoting teamwork at a larger scale.

As part of this work-in-progress paper, we will continue to enhance the students' experience in multidisciplinary teamwork throughout the project. Our goal is to increase all metrics as we implement this project next year. This process will be ongoing to collect data on teamwork and how this level of teamwork has enhanced their learning experiences.

Conclusions

The ongoing data collection of this work-in-progress paper on project-based, multidisciplinary, multilevel teamwork showed how this project effectively cultivates better teamwork practices across all engineering fields. Institutions across the nation may adopt the project's different aspects to promote teamwork on either a small-scale project or a large scale, particularly for their more extensive engineering courses. Additionally, this project is unique and inclusive, where students from non-engineering fields may contribute to the design and testing aspects. This emphasizes the importance of the creative side of the engineering mind and may encourage non-engineering students to weave into the engineering curriculum and eventually pursue an engineering degree.

References

[1] D. T. Avila, W. Van Petegem, and A. Libotton, "ASEST framework: a proposal for improving teamwork by making cohesive software engineering student teams," European Journal of Engineering Education, vol. 46, no. 5, pp. 750–764, 2020. Available: https://doi.org/10.1080/03043797.2020.1863339

[2] A. Gates, E. Villa, and S. Salamah, "Developing Communities of Practice to Prepare Software Engineers With Effective Team Skills," in Proceedings of the IEEE, 2017, pp. 1–12. doi:10.4018/978-1-5225-3923-0.ch073

[3] M. Arvold et al., "Teaching Teamwork: A Training Video Designed for Engineering Students," in ASEE Annual Conference & Exposition, Seattle, Washington, 2015.

[4] P. Sancho, J. Torrente, E. J. Marchiori, and B. Fernández-manjón, "Enhancing Moodle to Support Problem Based Learning the Nucleo Experience," in IEEE Global Engineering Education Conference, EDUCON, Amman, 2011, pp. 1177–1182. doi:10.1109/EDUCON.2011.5773296.

[5] D. M. Bowen, M. Alvaro, D. Mejia, and M. Saffi, "Industry Practices for Providing Engineers with Team Skills," in ASEE Annual Conference and Exposition, Portland, Oregon, 2005, pp. 7999–8006.

[6] J. Membrillo-Hernández et al., "Challenge Based Learning: The Importance of World-Leading Companies as Training Partners," International Journal on Interactive Design and Manufacturing, vol. 13, no. 3, pp. 1103–1113, 2019. doi:10.1007/s12008-019-00569-4.

[7] L. Silvestre, S. F. Ochoa, and M. Marques, "Understanding the Design of Software Development Teams for Academic Scenarios," in 34th International Conference of the Chilean Computer Science Society (SCCC), 2016. doi:10.1109/SCCC.2015.7416570.

[8] D. R. Ilgen et al., "Teams in Organizations: From Input Process-Output Models to IMOI Models," Annual Review of Psychology, vol. 56, no. 1, pp. 517–543, 2005. doi:10.1146/annurev.psych. 56.091103.070250.

[9] R. R. Chromik et al., "Teamwork Training As A Means Of Mastering More Equitable, Diverse, And Inclusive Practices In Engineering Curricula," in Proceedings of the CEEA Conference, 2020. doi:10.24908/pceea.vi0.14194

[10] A. Godwin, "The Development of a Measure of Engineering Identity," in ASEE Annual Conference & Exposition Proceedings, 2016. Available: 10.18260/p.26122

[11] J. Gesun and E. Berger, "Thriving for Engineering Students and Institutions: Definition, Potential Impact, and Proposed Conceptual Framework," in ASEE Annual Conference & Exposition Proceedings, 2018. Available: 10.18260/1-2--31141

[12] T. F. Pettigrew, "Intergroup Contact Theory," Annual Review of Psychology, vol. 49, no. 1, pp. 65–85, 1998.

[13] B. Say, Z. Erden, and C. Turhan, "A team-oriented course development experience in distance education for multidisciplinary engineering design," Computer Applications in Engineering Education, vol. 30, no. 6, pp. 1617–1640, 2022. [Online]. Available: https://doi.org/10.1002/cae.22546

[14] K. Y. Lin, Y. T. Wu, Y. T. Hsu, and P. J. Williams, "Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers 'engineering design thinking," International Journal of STEM Education, vol. 8, no. 1, 2021. [Online]. Available: https://doi.org/10.1186/s40594-020-00258-9