IPRO -- InterProfessional Project

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***Abstract**: At IIT, we believe that the ability to work with different professions in a project-oriented setting is critical to today's engineering education. InterProfession (IPRO) projects (a three-credit course) are integrated into our curriculum. Through these industry-sponsored projects, students will deal with the real world engineering problems. This allows our student to learn "the way we will work".*

This paper addresses the principle and practice of the IPRO through: (1). the basic structure of IPRO program (2). a comparison with other similar programs, (3). our experience with the IPRO project.

From the experience with IPRO project, we can proposed the followings: the 3Cs model for teamwork, teamwork cultivation, stress and confident management for project members, and leadership development.

Keywords: teamwork, multi-disciplinary program, InterProfessional *(IPRO*) project, and leadership.

1. Introduction

At IIT, we believe that the ability to work with different professions in a project-oriented setting is critical in today's engineering education. InterProfession (*IPRO*) projects (a three-credit course) are integrated into our curriculum. As both an industry-sponsored research project and an educational program, the *IPRO* project provides opportunity for students to practice teamwork with students from different disciplines, to develop leadership skills, and to learn "the way we will work", among others.

The *IPRO* program at IIT was developed in 1996. Its main objective is to provide opportunities for students to practice teamwork with students from other disciplines. By participating in *IPRO*, student would develop leadership skills, communication skills, problem-solving skills, and managing skills that would be very attractive to perspective employers.

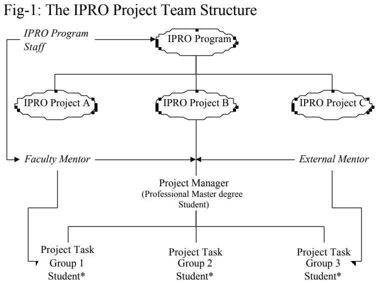
Unlike other multi-disciplinary program from other universities, *IPRO* utilizes single faculty with the assistance from graduate students to provide knowledge based for the project. *IPRO* also employs two type of academic integration: "vertical" (bridging academic levels as a "must") and "horizontal" (bridging professional programs as a "should"). This integration closely follows product's development life cycle in the industry. *IPRO* program is also compulsory to all students and runs on a continuous basis.

In spring 1997, the authors led one project, which involved nine students from four different majors. This project entitled "Integrated Digital Design and Testing (*IDDT*)", funded by National Science Foundation, was practiced as an *IPRO* project and the team won both First Place Award in *IPRO* projects and Overall Excellence Award from the university. The *IDDT* project can simple be broken down into five different stages: preparation, planning, development, prototype and documentation. Each stage lasted 3 to 4 weeks. This paper documented major phases, processes and activities of the *IDDT* project from both faculty and student perspectives. Throughout the project, the students' psychographic development was also recorded on a weekly basis. This psychograph can be used to understand the interaction among students and to improve and refine pedagogues of *IPRO* projects.

From the *IDDT* experience, many conclusions can be drawn. First, the teamwork model based on *IDDT* project can be proposed. The 3C's model is based on three important concepts: cooperation, coordination, and communication. Second, we also realize that teamwork must be cultivated but not trained, through appropriate communication, planning and management. Third, from the psychograph, we realized the importance of pressure and confidence management. It is very crucial for the *IPRO* mentors to have strong management skills on these factors. Fourth, faculty plays a very important role in developing leadership skill. Mutual understanding and trust are the keys in building leadership skill.

The remainder of this paper is organized as follows: section 2 introduce the *IPRO* project at IIT. Section 3, compares *IPRO* program to the programs from other universities. Section 4 expands on the authors' experience with the award winning *IDDT* project. Section 5 emphasizes on the findings from *IDDT* experience. The last section concludes this paper.

Fig-1: The IPRO Project Team Structure



*Student: 1) Sophomore through Graduate from at least two different disciplines of all IIT programs. 2) May join a team, depending on the needs of the project and their own interests. 3) Each undergraduate student is required to take 2-3 IPRO projects.

Table 1: Comparisons of IPRO-related programs

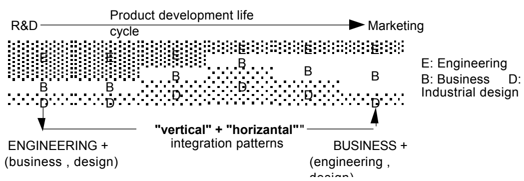
University	Auburn	Lehigh	IIT
Course title	Team-Based Design (TBD)	Integrated Product Deve-lopment (IPD)	Inter-Professional Projects (IPRO)
Program nature	project-based	project-based	project-based
CourseP roperty	elective,cas e-based	elective,cas e-based	compulsory, continuous
Focused skills	teamwork,lead ership,commu nication	teamwork, leadership,com munication	teamwork, leadership.com munication
Facultystr ucture	Multiple,multi-disciplinary	Multiple,multi-disciplinary	single
Knowledgefl ow, source	top-down	top-down, outsource	top-down, outsource
Leadership	students by turns	professors	graduate students
Student structure	mainly sophomores and seniors	from pre-college, under- to graduates	from sophomore to graduates
Student sources	engineering,bus iness,industrial design	engineering,bus iness,industrial design	at least two disciplines
Disciplinaryi ntegration	"horizontal" (by project)	"horizontal"(by courses) & "vertical" (by project)	"vertical"+ "horizontal "(by project)

2. *IPRO* project at IIT

The *IPRO* program was first implemented in 1996[1]. Its main purpose is to provide opportunities for students to practice teamwork with students from different disciplines, to develop leadership skills, and to learn the way we will work, among others. The basic structure of *IPRO* team (Fig. 1) consists of 6 – 15 students from all academic levels and disciplines with a graduate student acts as a project manager. The faculty and sponsor also serve as the team mentors. *IPRO* also utilizes the integration of both "vertical" (bridging academic levels) and "horizontal" (bridging professional programs) dimensions to stimulate students to be active in both their specialized and non-specialized disciplines. A critical aspect of the *IPRO* Program is the continuous involvement of sponsors throughout the semester long project. The external mentor, as the primary stakeholder in the project, provides advice and insight to the students in an informal setting. Mentors also host team visits to broaden student exposure to an organization and the practical issues that affect project strategy and goals. Students, by working on a challenging topic for a sponsor, can also gain many valuable skills such as, leadership, communication, problem solving, and project managing. These skills can hardly be obtained by simply attending regular school setting; only in a dynamic and real world situation, students can develop these skills.

Besides providing benefits to the students, *IPRO* also provides many benefits to the faculties, the university, and the sponsored organizations. *IPRO* program offers an attractive opportunity for many organizations to sponsor a team project: helping to mentor the students, obtaining fresh ideas and an information baseline in an important topic, and identifying interns or future employment prospects. The concept of an InterProfessional student team effort, enriched by regular interaction with a sponsor, clearly benefits the organization and the students. It also provides faculty with opportunity to practice cross-functional teamwork and leadership, and with windows to broaden their research domains, which greatly help to enhance their research capability and academic development. As for the university, it creates a sustainable channel to raise industry sponsorships and research funds, attracts larger number of students with strong academic standing as well as faculties. It also establishes a strong curriculum that enhances educational quality and stimulates growth of the university.

Fig-2: Illustration of disciplinary distribution in a product development life cycle



3. Related Programs

The *IPRO* program is one of educational programs through multi-disciplinary, cross-functional teaming or the like. The Team-Based Design (*TBD*) program of Auburn university, Alabama[2], and the Integrated Product Development (*IPD*) program of Lehigh University, Pennsylvania[3], both winners of "1996 *ASME* Curriculum Innovation Awards," are chosen for comparison analysis (Table 1). They share commonalties in many aspects:

- They are project-based and run on industry-sponsored projects.
- They provide elective courses and students could choose whatever projects and teams they would like to work on and with.
- They focus on training the concepts and skills desired by industry but not or less taught under existing educational systems, such as teamwork, leadership and cross-disciplinary communication.
- They require multi-disciplinary teams of both faculty and students, and students learn via or from multiple knowledge flows or sources.
- They attempt to integrate students horizontally (various disciplines) and vertically (multiple levels).

Despite the commonalties, *IPRO* possesses some unique characteristics. The most distinctive ones are:

- property: compulsory and continuous

At *IPRO*'s full implementation, every undergraduate is required to take two to three *IPRO* courses in order to get their degrees. The *IPRO* course becomes compulsory and most *IPRO* projects are expected to be run on a continuous basis.

- Disciplinary integration: "vertical" + "horizontal"

Since each of *IPRO* projects tends to focus on a specific discipline, the major emphasis would be on "vertical" integration. However, since product development life cycle requires more than a single discipline (i.e., business aspect, product presentation aspect), a "horizontal" integration is also applied so that the students from different disciplines are also required to take on works that are not directly related to their discipline (Fig.2).

- Faculty structure: single

IPRO can utilize single faculty with the additional assistance from graduate students and senior level undergraduates. This set up proves to be more than sufficient for both knowledge sources and spiritual and emotional guidance. Since the main goal was to provide "vertical" + "horizontal" disciplinary integration, the knowledge of a faculty with the assistance of graduate and senior level students was sufficient to provide "vertical" integration. The interaction among group member's diversity would provide the "horizontal" integration.

- Leadership: graduates

In an *IPRO* project, the role of a faculty is defined as a consultant or mentor, and that of a graduate student as a project manager. As a rule, an *IPRO* team consists 5-15 students. Of these students, one is very possibly a graduate student working as research assistant for the project, and at least one is a senior student from the faculty's discipline, who possibly can take over the team in the next run.

4. Project *IDDT* Experience

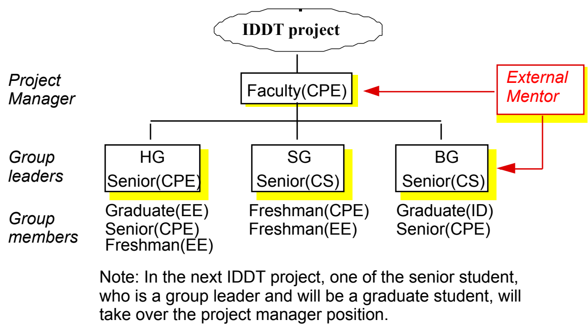
Product design is a convenient vehicle for introducing students from different disciplines to teaming methods. The "Integrated Digital Design and Testing (*IDDT*)" project[4] was chosen for this purpose. *IDDT* is a two-year project funded by National Science Foundation, of which goal is to develop a system product -- Virtual Automated Test Equipment (*VATE*) -- that is able to simulate a real multi-million-dollar ATE used in industry and that can be affordable and used in university settings to correct prevalent misconception in professional education and to bridge the gap from design to testing.

The project team consisted nine students and the project was divided into five phases -- Preparation, Planning, Development, Prototyping, and Documentation -- each spanned 3-4 weeks. Because this project was run in the second year of the *IPRO* program, some expediencies and adjustments were necessary. Key arrangements are illustrated in the following sub-sections.

4.1 Preparation phase

Because *IDDT* project was in its initial stage, preparation and planning works became vital. Major preparation works are as follows:

Fig-3: The IDDT project team organization



· · *Team forming*

The *IDDT* team (Fig. 3) consisted of 1 faculty and 9 students. Out of these nine students, two were graduate students that the faculty invited into the group to take on the responsibilities of developing the hardware and software of the *VATE* system. Beside the two graduate students, the *IDDT* team also comprised of two freshmen, and five seniors, among them three from Electrical Engineering, three from Computer Engineering, two from Computer Science, and one from Industrial Design. The students were divided into three groups—Hardware Group (*HG*), Software Group (*SG*), and Business/Planning Group (*BG*). The students chose their groups according to personal interests. Fortunately, the numbers of students in each group were evenly distributed: 4(*HG*), 3(*BG*), and 3(*SG*) (one was willing to work in both *HG* and *BG*). Two senior level students were elected and assigned as group leaders of *HG* and *SG*. Each group appointed one additional student as group coordinator whose main responsibility was to participate in all group meetings, and report major concerns and decisions to his own group.

· *Course Structure*

· The faculty gave a project overview, introduced the *VATE* system to be developed, and defined project goals for the semester. To avoid information overload and to simulate research inquiry process, some details were intentionally hidden by the faculty for students to discover. Students were asked to help make evaluations and decisions on purchasing the equipment to be used in the project. Vendors (including competitors) were invited as important knowledge sources. Three vendor presentations were arranged, one by the faculty and two by the students. Before each, students were asked to prepare question lists to learn as much as they could from the vendor and there performances were evaluated by the faculty, and so did the follow-up questions.

· · *Task assignment*

Through group discussions, the task outlines of each group were proposed by the students, and adjusted and approve by the faculty. In addition, each student wrote up a list of one's core competence and what one can contribute to the project. This list would be used at the end of the semester to compared with what student actually did, for measuring attainment rate. The purpose is for students to better understand themselves, not for final grading.

4.2 Planning phase

Because none of the students in *BG*, or even of the team, has business background, they had to learn by themselves from every possible knowledge source. Before planning for the team, each group drafted a list of resource needs and a tentative schedule in which major milestones were identified. *HG* and *SG* were asked to write their inter-dependencies to/from each other. The 2nd Annual Undergraduate Research and Presentation Conference hosted by IIT (http://www.iit.edu/~iitugr/iitugr.html), was set as the project deadline and as an evaluation tool for the faculty to assess the students' teamwork and for the university to evaluate the *IPRO* program.

According to the above information and the competence and task lists from each student, *BG* developed a *PERT*[5] chart that made clear the whole picture of the project and the role each one should play, and, importantly, the inter-responsibilities among groups. The chart was fully discussed and adjusted (it took longer time though) until both individual and group goals were included. This chart made transparent not only the project itself but also the workload of each group and even of each one. The latter was more important in that it gave a sense of fairness to each student and effectively reduced potential conflicts among groups and team members. With this chart, consensus could be reached with less effort, and teammates would actively assist each other when needed.

Besides the management works (time, project, and workload) done through the *PERT* chart, additional three major management works -- risk, communication, and resource -- were also exhaustively planned and executed. For risk management, various methods were studied by *BG*. Finally, Delphi method[6] was chosen. All kinds of possible risks that might affect or endanger the project were brainstormed and analyzed, and a risk management plan was made accordingly. The *IDDT* also realized the importance of communication management, and the following communication methods were adopted:

1) Weekly team meetings were set by the faculty as regular checkpoints, and the coordinators took part in every weekly group meeting for exchanging ideas and information. Meeting

minutes were required and should be sent to everyone as soon as possible.

2) E-mail was chosen as the main tool for communication outside of meetings. Every e-mail must be received by everyone. There were more than 250 e-mails during the semester.
3) A website <http://**Error! Bookmark not defined.**> was designed and maintained by *BG* so that every project-related information, such as project plan, progress, history, meeting minutes, relevant research papers and labs, frequently asked questions (FAQs), and even vendor information, could be easily accessed by everyone, including teammates and people from outside.

The team also realized the importance of resource management. In *IDDT* project, a certain amount of effort was devoted to filing and tracking, for keeping everyone inform of the resource they would need. It looks simple but require a lot of practice to be skillful at it.

4.3 Development phase

As in the initial stage of *IDDT* project, vendor information was critical to the students' learning, such as domain study and problem space exploration. Because the faculty told the vendors that the students would help making the decision on purchasing the equipment, students got full technical support and respect from the vendors. At one point, students experienced difficulty with the HP equipment and a teleconference call was made to the equipment designer himself. This event clearly demonstrates the valuable real world experience that cannot be found from regular courses.

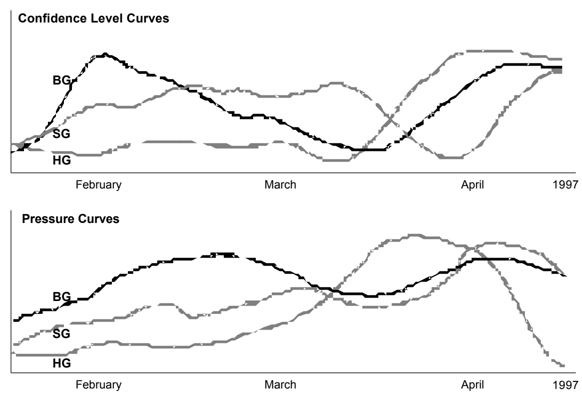
Specifying prototype's functionality was an important task in the development phase. The specification should be a product that combines viewpoints of both technology and marketing. For engineering students, the latter required extra attention. It is expected that the prototype or final product will be adopted by other universities as well, therefore, *BG* proposed a questionnaire for market analysis. Through iterative discussions, a final version was set. However, with limited time in a semester, the test and statistics of the questionnaire will be left for future team members to carry out. Key students in next development stage (such as students with questionnaire testing experience) can be defined and recruited by the faculty in advance.

4.4 Prototyping phase

Although ideas of how to improve the *VATE* system kept generating, due to the conference deadline and with limited time in a semester, tradeoffs in prototyping had to be made. Decisions pertaining to which functionalities were critical in current stage that had to be prototyped to convince the sponsor of its feasibility were made. Compared with the ultimate, ideal system, prototype made at this stage was definitely far less than complete. Some functions might be less effective or efficient, and some remain to be developed. Presentation technique, thus, became a supplemental and essential part of the prototype.

Presentation is a type of public, cross-disciplinary communication that is seldom emphasized and practiced in most engineering schools. However, it is important in industry. Students in *IDDT* project practiced to express their ideas in a concise, easily understandable way within limited time frame, and different versions of content for audience with various backgrounds were also prepared during rehearsals. Questions possibly asked by audience and conference judges were prepared and embedded into the presentation brief. That presentation can be a major component of prototyping was a new concept that students learned from the *IPRO* course.

Fig-4: Curves of Presure and Confidence level



BP: Business Planning Group **SG**: Software Group **HG**: Hardware Group **Project:** Integrated Digital Design & Testing

4.5 Documentation phase

Documentation is important in every phase, yet its significance appears in latter stages. A documentation plan was made right after the function groups were formed. *BG* was assigned to document every event and activity for future reference, including meeting minutes and photos, e-mails (over 300 during the semester), FAQs (for internal and external communications), computer files, bill of documents, crisis occurrences, presentation slides, etc. These records help to make the project status clear to students participating in next *IDDT* project, and to avoid redundancy and repetition in preliminary research works.

The students' psychographic development (Fig.4) was retrospectively recorded for educational purpose, improving and refining pedagogues of *IPRO* projects. According to self experience and observation in the *IDDT* project, each student drew curves of oneself along a timeline that could best describe one's confidence and pressure fluctuations developed during the semester. The curves were averaged and illustrated in function groups.

The students can learn something from the psychographics. They knew more about themselves and became more understanding to their teammates, for they could “see” the pressure imposed upon other groups or team members undertaking different tasks with which they do not familiar.

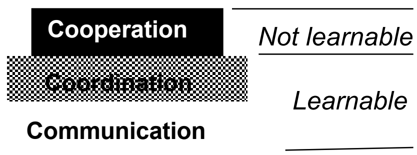


Fig-5: 3Cs model of a teamwork

5. Observations

Through *IDDT* project, the inter-, multi-disciplinary teamwork experience and technical know-how can be summarized as follows:

5.1 Modeling teamwork (3Cs model)

The utmost goals of *IPRO*-related programs are for students to experience and practice important skills required by industries but not taught in their disciplines. From *IDDT* experience, a 3Cs model for teamwork (Fig. 5) is proposed: To facilitate teamwork (i.e., cooperation within and between disciplines), two fundamental works must be thoroughly planned and implemented --communication and coordination. Communication is the basis of coordination and cooperation. Only students know how to correctly communicate to each other can an effective coordination interact; only with effective coordination can maximal cooperation be possible.

In *IDDT* project, various communication tools (Fig. 6), represented in two-dimensional matrices, were carefully planned and managed for facilitating internal/external and long-term/short-term communications. Alternative coordinates were also considered, such as direct/indirect and personal/team, to serve different functions and purposes. Valuable coordination tools (Fig. 7) were prudently selected and practiced for maximizing coordination effectiveness and enhancing quality of cooperation output. A suggested use of the teamwork tool matrices is to devise useful management plans or communication channels to either fill up or, at least, fit in all four quadrants of a teamwork tool matrix so that any situation can be handled.

Fig-6: Example of a communication tool matrix

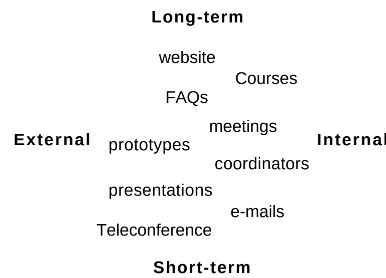
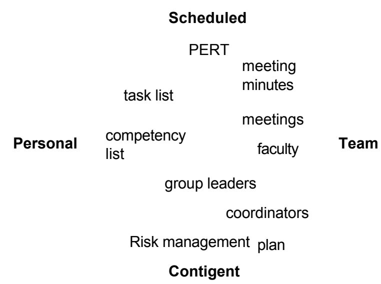


Fig-7: Example of a coordination tool matrix



In an *IPRO* course, the relationships between a faculty and students are different from that in a regular course. Students work for and with faculty in a research project, not taught and tested by a faculty. On the other hand, the faculty co-learns and co-works with students. Therefore, faculty should adjust their attitudes and teaching approaches accordingly; learn how to communicate, on an equal standing, with students; and learn how to coordinate with, not command, students during the project process.

5.2 Cultivating Teamwork

From the *IDDT* experience and the 3Cs model, it is found that teamwork can only be cultivated, not trained, through appropriate communication, planning and management. Although communication and coordination skills can be taught and learned, cooperation is spontaneous and has to come from one’s willingness, therefore, it is not learnable.

Whether cooperation skills are learnable is also reflected in the faculty/student relationships (Fig. 8). In a regular course, there exists a one-way mentorship between the faculty and the students, meaning that everything taught in the class is teachable/learnable; while in an *IPRO* course, a two-way mentorship and fellowship co-exist, meaning that interactions become a basis for mutual teaching/learning. The faculty/student relationship is so different from that in a regular course. The main responsibility of a faculty in an *IPRO* project is to build and nurture the required environment to facilitate faculty/student teamwork, i.e., to strengthen the "mentorship + fellowship" relationship. As a rule, given enough teamwork conditions or infrastructure (for example, skills and channels of communication and of coordination, and clearly defined and divided works toward common goals, etc.), students working in such environment or culture will naturally do teamwork.

5.3 Analyzing Psychograph

The students' psychographic development (Fig. 4) was recorded for educational purpose. The students were asked to plot a graph of their confident level. Then, each group average was calculated. The purpose of this graph is for the students to better understand their reaction to pressure and the emotional roller coaster that they experienced throughout the development life cycle. They also became more understanding toward their teammates because they could relate to the pressure imposed upon other groups or team members undertaking different tasks.

Let's take a look at a real situation that occurred during the project. Because of excellent vendor presentations, the Software Group (*SG*) students initially thought that their tasks would be easy to accomplish and possessed with high confidence. When they began to design the software, problems occurred and their confidence level declined; the lowest level appeared as the deadline rapidly approach and a few major software faults remain undetected. Once the major faults were detected and solved, the confidence level rose up to the peak. Examined by its pressure curve, *SG* could not build the system prototype without the critical decoding information from Hardware Group (*HG*). We can clearly see the dependency between both groups. The *HG* felt the pressure of deliverying the design, while the *SG* felt the pressure of meeting the deadline. Since *SG* would be responsible for assuring system performance at the conference, their pressure declined somewhat but remained high. Compared with that of *HG*, their mission was almost complete after delivering decoding information to *SG*, *HG*'s pressure curve dropped immediately after.

Pressure and confidence management is an essential lesson all *IPRO* mentors must learn, yet, to the best of the authors' knowledge, no paper focuses on that. The documentation method suggested here might be an easy way for faculty to study students' psychographics and to improve management/mentoring skills.

5.4 Building leadership

We also find that leadership should be built on mutual understanding and trust. Providing students with appropriate institution or tools that can help to facilitate mutual understanding and trust among students can help leadership building. The competence list, for example, is an ideal tool for students to understand each other. It also provides a team leader with a list of expert consultants for making better decisions. The strength of leadership is heavily related to the involvement and commitment of the faculty. Students won't take the project seriously if the faculty does not make a total commitment. Since *IDDT* is a real world project, it has real world pressure (time, budget, quality of deliverables, etc.). The faculty must be responsible for, be involved in, and commit to, the project in order to maintain and strengthen the leadership needed by the student. With fully empowered leadership, decisions can be made efficiently and effectively.

6. Conclusion

The *IPRO* program provides the opportunities for student to work in an industrial like environment. Each participant must work with colleagues from diverse background and learn to communicate, coordinate, and cooperate with them (3Cs model). Since we concluded earlier that teamwork can be cultivated not trained, it is also important that communication, planning, and management must be very solid for teamwork to be utilized. The faculty must also give a total commitment to the project. The faculty's abilities to manage student's stress and confidence level as well as develop student's leadership skills greatly depend on faculty's commitment.

7. Acknowledgements

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