Toward an Improvement of Engineering Teaming Skills Through an In-House Professionalism Course

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***Abstract*—*Contribution:* A modular three-credit undergraduate course that enables students to sharpen their teaming skills is introduced. The course addresses the professional skill gap between recent undergraduate students and what the work environment expects.**

***Background:* The trend of teaming in the industrial world continues to grow as the demand for team-based projects and problem-solving skills is becoming the norm in any workflow with recruiters now listing teaming as a fundamental requirement for most positions. This drives the educational system to adapt and integrate a new skillset into its various curricula with a view to equipping students with these sought-after skills.**

***Intended Outcomes:* Adoption of a new three-credit nontraditional undergraduate course targeting team-building education and teaming skills acquisition.**

***Application Design:* The design of the course includes project-based learning as well as student-centered learning where team members work on a variety of nontechnical controversial projects, and frequently undergo team/self-assessment on multidisciplinary criteria.**

***Findings:* Based on F1-scores of multiple conceptual and situational examination questions, the assessment survey demonstrates a stark change in students' understanding of professional skills before and after taking the course, confirming this course's ability in developing and enhancing the students teaming skills.**

***Index Terms*—Collaborative learning, professional skills, project-based learning, team building, team performance.**

I. Introduction

THE DEMAND for teaming in engineering jobs is shaping the engineering recruitment landscape. As a matter of fact, engineers are no longer perceived as autonomous individuals that perform technical tasks behind closed doors. Nowadays, engineers are expected to possess a robust professional skillset that complements their technical prowess [1], [2]. In other words, they need to have the ability not only to communicate their ideas but also to incorporate other ideas from different facets and disciplines of engineering into their daily tasks. As such companies recognize that individual work is no longer sufficient to boost productivity. This is particularly true since the borders between disciplines are getting more and more blurred with every technological/scientific advancement, reinforcing thus the need for having multidisciplinary teams that can collaboratively and effectively contribute to solving some of the worldwide pressing, challenging, and interdisciplinary problems [3], [4].

In the same spirit, large companies are investing a lot of time and money to come up with optimal team formations, as evidenced by an increase in public and private investments in large-scale team science initiatives over the past two decades [5]. Siller *et al.* [6] also reaffirmed that the gap between the industry and academic competencies is an issue that is expected to grow since academics lack the proper channel to integrate the professional skills that are necessary for the workplace into the curriculum

In addition, research on the existing engineering curricula identifies teamwork as an inseparable aspect of any technical project and is regarded as the most crucial competence from the student's perspective [7]. This fact is reiterated in ABET's program accreditation requirements, namely, in the student outcome (SO) number 5 that is phrased as follows "(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" [8]. This encourages programs to deviate from the standard technical recipe toward a more elaborate program that concurrently satisfies the students, industry, and ABET expectations while keeping the academic programs current and trendy.

This article discusses a three-credit course aiming at teaching undergraduate students some key professional skills, namely, communication, teamwork, understanding ethics and professionalism, engineering within a global and societal context, lifelong learning, and knowledge of contemporary issues touching in the process on the main objectives, as well as various delivery mechanisms associated with the course. This in-house course was introduced to the Electrical and Engineering (ECE) Department at the Lebanese American University (LAU) in 2010 and got continuously refined over the years, expanding on various personality matrices to allow for the development of the students' professional skills. Unlike traditional courses that relegate professional skills to a lower level, this course aims at placing professional skills at the forefront of its mission, while vouching for a multitude of

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supporting delivery mechanisms. The course is also poised to be taught and given to students in the semester prior to their internship, so as to effectively instruct and fine-tune their professional skills, prior to their first industry exposure through their internship.

This article delves into a literature review in Section II, then presents the course design in Section III, while highlighting our course implementation at LAU in Section IV, before introducing the course assessment survey's design and results in Section V, and finally introduces some concluding remarks in Section VI.

II. Literature Review

To consolidate the link interconnecting industry and academia, there has been an ongoing effort to integrate professional skills into the curriculum. The literature has already verified that we can teach ABET competencies [9], but has not provided a structured path on how to achieve that objective.

Moreover, Shuman *et al.* [9] paved the way to new research revolving around the proposal of proper delivery mechanisms targeting these professional skills. The project-based learning would produce the 21st century engineer [10], this is further substantiated by the findings of [11] that the engineering profession and academics are more familiar with the concepts of projects in their professional practice than with the concepts of problem-based learning. Note that problem-based learning is seen as an open-ended educational endeavor where numerous solutions to the problem are shared without an identified set of goals, whereas project-based learning has a predefined set of goals [12]. While the work in [13] argued that the implementation of cooperative teams would form the basis of teaching professional skills and development of students. Team-based projects were found to be the most effective strategy toward that end in [14]. The interdisciplinary project orchestrated by Irvins [15] provided students with an array of nontechnical/professional skills, such as improved interpersonal skills and a collaborative attitude, enabling them to create real-world marketable project submissions. Furthermore, it was found that embedding teaming throughout the curriculum would enhance an engineer's professional skills through practice [16]. Knight and Novoselich [17] found that entrusting professional skills, such as leadership, development to co-curriculum is inefficient for undergraduate engineers. This reinforces the status of teaming as the main vehicle for searing the different professional skills into the students' "genetic makeup" and curriculum-based solutions are the most efficient avenue.

Some academicians turned to existing courses, such as capstone design projects, which are widely adopted throughout higher education institutions and embedded teaming and other professional skills into the courses' structure. For example, assessment methods for the development of professional skills and team-based interactions are proposed in [18]. Keller *et al.* [19] demonstrated how generic skills translate better in capstone projects as opposed to sanitized classroom settings. Furthermore, the work in [20] presents a preliminary comparison between multidisciplinary capstone projects and monodisciplinary capstone projects and the positive effect they have on professional skills.

Another approach is to develop new courses or program-wide changes to address the skill gap. Mohan *et al.* [21] developed and implemented a graduate course to teach teaming and other professional skills through seminars and cooperative learning demonstrating favorable results. Moreover, undergraduate research courses were also found to have a role in enhancing a student's communication skills through the nontraditional setting of the course and the "vis-à-vis" with their advisor/supervisor [22]. Gider *et al.* [23] created a standalone postgraduate course at their institute, with the aim to teach multidisciplinary professional skills to ease the transition of graduates from academia to industry, but concluded that an undergraduate course is also needed, as their survey unveiled.

It is undeniable that project-based learning is way forward to ensure the proper development of professional skills, as discussed above. However, we still struggle to incorporate it into the curriculum either due to the rigid nature of the established status-quo and program structure or the lack of interest or maybe of professors experienced in teaching these skills, as emphasized in [16] and [24].

Enhancing the criteria for capstone projects to include professional skills would solve the issue of recreating the program and would allow the professors to see students' abilities on display. However, McKenzie *et al.* [25] suggested that there is uncertainty on the part of many faculty members concerning sound assessment practices, including writing objectives, using appropriate assessment strategies, sampling material appropriately, and controlling inappropriate measurement of student achievements. Furthermore, capstone projects are almost always given during the final year; as such, squeezing the professional skills and accumulation of technical skills into a single course is no small feat for professors and students alike, which is echoed in the findings of [25] as well. Finally, the team composition is always an issue when it comes to capstone design project groups, largely for the difference in objective and goals each member has. Specifically, one student might be after an "A" grade, another might be after a passing grade with minimal efforts, while another might want the best possible project. Such differences go against the spirit of a unified team that comes with common goals.

Finally, the development of standalone courses would be ideal; however, Schwartz [26] expressed the burden faced by professors when dealing with undergraduate research as it is, as such trying to incorporate mass-student education would not be viable or feasible.

So, in summary, this article proposes a course specifically designed to address the previously discussed issues. The proposed course holds the promise of developing undergraduate student's teaming in an environment independent of their technical background while keeping the six professional skills on its radar. In addition, the course is modular in the sense that it could be placed anywhere within the curriculum, without having a ripple effect on the other courses and with no need for prerequisites. Importantly, the course follows a project-based learning approach to further develop students' professional skills through the means of teamwork and team assessments.

III. Course Design

Bruce Tuckman's team development model [27] discusses four stages of teaming, particularly, forming, storming, norming, and performing, with each detailing the overarching behavior of small teams. In this context, "forming" is the phase in which a team is formed and introductions occur, "storming" is the conflict phase where they become irritated with each other, "norming" is the phase where they get accustomed to each other's abilities and behavior, and finally "performing" is the phase where they become productive. To ensure that the students could pass through these stages and be exposed to each stage's effects, we had to devise a way to accelerate these phases in a controlled manner, to nurture the student's abilities without compromising the integrity of the courses or allow them to spiral in a destructive manner.

We arrived at the conclusion that the course should be structured around four independent projects to be tackled in quasi-randomized team compositions utilizing Robert's rules of order and personality indices as interaction guidelines and iterative learning as the courses teaching and assessment methodology.

The initial condition for this process is that the projects to be tackled by the students must be enticing and engaging enough for the students to feel the need to argue, debate, and defend their positions and point of views. Nonetheless, detecting the passion of students can be a daunting task for professors, as such, the first three projects serve as a testing phase where the professor could experiment with topics and gauge the students' reactions to and how well they received the assigned topics. These initial three projects also expose a student to the dynamics of teaming, while allowing him/her to discover, assess, and fine-tune his/her weaknesses, consolidating in the process his/her strengths. On the other hand, the final fourth project serves as a platform for the students to demonstrate their understanding of professional skills and the efforts invested toward sharpening these skills. As a matter of fact, the final project groups the entire class into a single team, allowing thus for a full application of Robert's rules of order since the team is now larger and requires a more robust set of rules to govern its operation. During this project, the students will break down the topic into separate parts and form *ad hoc* committees to address these individual parts which further reinforces the concept of cooperation between teams, before conveying again with the larger committee and collaborating between *ad hoc* committees to create a presentable conclusion to their findings, thus reinforcing the extensive experience they acquired through the first three projects. For this reason, the composition of the teams involved in the first three projects is vital for the integrity and results of this entire process. Therefore, at the beginning of each project, the team is selected randomly to ensure fairness, prevent clustering based on preference or prejudice, and to simulate an industrial setting where teammates are selected by corporate management to perform targeted tasks. The structure of each team must emulate that of industry teams, whereby a team member works cross-culturally with others from different backgrounds to accomplish a common goal/objective. In doing this, we would ensure diversity in terms of gender, discipline, seniority, and background. To adequately develop the teaming skills of the students, the process of forming teams was devised such that each resulting small team gains a sense of collaboration and cooperation, as per the guidelines put forth by Smith *et al.* in [28]. The difference between "cooperation" and "collaboration" can be explained as follows. Fundamentally, cooperation entails dividing a given task into smaller, manageable subtasks and having each member of the team handle one of the resulting subtasks. Conversely, collaboration consolidates teaming by having different team members build on each other's contributions/ideas to serve the common purpose of producing the desired outcome. The need to reinforce collaboration translated into smaller team sizes as true collaboration can only be achieved in the context of small teams as highlighted by Smith *et al.* [28]. As a matter of fact, Nissen *et al.* [29] argued that both collaboration as well as cooperation are instrumental in securing knowledge sharing in the context of heterogeneous teams. As such we aim to utilize both in our course design, we would require the students to use cooperation in the first phase of the project where the general task is divided into smaller tasks and objectives, with each team member going on their own tangent gathering information regarding the topic, bringing it back to the team who in turn together collaborate to amalgamate each other's findings.

On the other hand, we cannot realistically expect the students to be able to coordinate amongst each other whether for meeting times or meditation when conflict arises among members especially when debates become heated. As such, we enacted interaction guidelines to help the teams better understand each other and function coherently. Robert's rule of order [30] provided a guide for conducting meets and making decisions as a large group. This makes it a suitable tool for the final large project of the course. Yet, we needed to consider that this is the students' first full-fledged experience with teaming and we thus did not want to overwhelm them with lots of rules and procedures in the preliminary three small-sized projects of the course. Moreover, we needed to ensure that they do not avoid experiencing the different stages of Tuckman's model by prematurely applying Robert's rules of order. In light of these observations, Robert's rule of order would only be introduced in a lecture between the third and fourth projects to ensure that students' progress through the different stages of Tuckman's model in the first three projects before resorting to Robert's rules of order in the last project. In particular, three officer positions were created to ensure proper handling of the dynamics emanating from smaller group sizes, while abiding to the extent possible by the "Roberts rules of order." The officer positions are the chair, secretary, and presenter positions. Students making up a team nominate themselves and are elected by their teammates to each position and are assigned accordingly a modicum of responsibilities. However, the most paramount of these responsibilities are the ones allocated for the chair, and which include, among others, shielding of debates from tension and arbitrating conflicts, thus making the chair the backbone of the team. More specifically, each officer oversees the criteria showcased in Table I.

TABLE I
OFFICER RESPONSIBILITES

Chair/Team Leader	Encourage and maintain open communication. Help the team focus on the task. Empower team members to participate. Aim for consensus. Serve as a neutral person in directing discussions. Ensure an efficient use of time.
Secretary	Keep a written record of team meetings or take minutes of each meeting. Maintain a record of individual contributions and team goals. Maintain a record of team assignments and mutual team assessments
Presenter	Organize the ideas into a deliverable presentation, under the supervision of the chair. Speak on behalf of the team to present their project and ideas

Students making up a team nominate themselves and are elected, by their peers within the same group, to each position and are assigned accordingly a modicum of responsibilities. Due to the great importance of these positions and their responsibilities, which have a catapulting effect on students' professional skill acquisition, proper nomination eligibility rules are required to ensure fair exposure of students to the responsibilities of these positions. For instance, in the context of our course, a student was eligible to stand for election for a given position if he/she did not assume this position in a previous project group. Given the conditions under which we ran our course, this rule allowed a student to take on an officer position at least once over the lifetime of the four projects. So that no individual could hold the same position more than once during the initial three projects (i.e., no one can serve as a secretary more than once in the three preliminary projects), the primary objective of this rule is to prevent students from becoming complacent and remaining in positions they are comfortable with. This is to counter a phenomenon where individuals would place themselves in stereotypical boxes and not branch out to different roles. A similar occurrence is observed by Fowler's recent work [31], where women will lean toward feeling isolated and self-select into particular roles that they feel their teammates and society want them to fall into.

Furthermore, officers and team members would not know how to deal with the conflict if they are not properly informed on how to mitigate and understand each other's differences. This is where our second guideline comes into effect, the personality indices, these indices allow the students to become more accepting of different personality types and learn how to effectively interact with each other. We introduce the Myer–Briggs-type indicator (MBTI) [32] as a lecture in the class, an index widely used and adopted by the industry that allows students to understand that a wide spectrum of personality types exist. Students are shown how a single individual could have a combination of different, sometimes conflicting, traits. This is done in an informative manner only without having the students complete an MBTI questionnaire or deriving a score for the indicator per student. The guideline exists to help them understand the different types of behavior and that everyone, if interacted with effectively, can prove to be an asset to the team. It is also important to help students combat a general misconception that certain behavioral types are inferior to others.

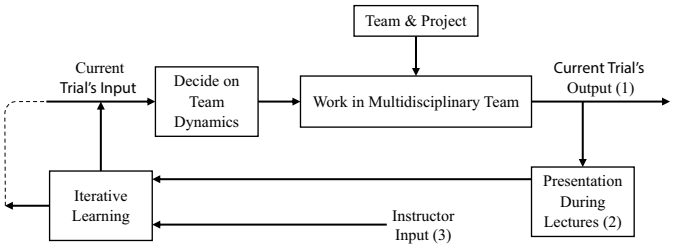

Fig. 1. Iterative learning methodology. (1) Recognize value of broad skill set resulting from teaming. (2) Identify problems occurred vis-à-vis whether it was poor communication, bad management or lack of understanding as seen by each group member. (3) Identify problems in team dynamics.

TABLE II
ASSESSMENT CRITERIA

Dedication Aptitude	Routinely Present at team meetings or work sessions. Contributes a fair share to the project workload. Is prepared for the group meeting with clearly formulated ideas.
Collaboration Aptitude	Shares credit for success with others and accountability for team results. Shares information and aids others. Demonstrates the ability to assume a designated role in the group.
Behavior Skills	Values alternative perspectives and encourages participating among all team members. Remains non-judgmental when disagreeing with others/seeks conflict. Is courteous group member.
Multidisciplinary participation and proficiency	Exhibit respect for team members in different disciplines and the diverse perspectives they bring to the group. Accept and incorporate, where appropriate, ideas from people in different disciplines. Explain pertinent engineering principles and applications in varying levels of technical detail, depending on the audience. Has knowledge of technical skills, issues and approaches relevant to disciplines outside of discipline.

Finally, the cornerstone of this course and the methodology that supports its endeavor is the iterative learning methodology, ILM, where the entire class and coursework are considered a single feedback loop with the student's professional skills as the input and output, as highlighted in Fig. 1.

Fig. 1 presents an illustration of how our iterative learning methodology is modeled. The students will go through multiple iterations spread across two levels. The first and the most fundamental iteration revolves around the in-class discussion between the professor and team members—whereby the team members present their current progress on the project and the issues they are currently facing. In turn, the professors recommend corrective measures to fine-tune the teaming, this is repeated multiple times within the span of a single project. Once the project ends, we enter the second larger iteration that occurs three times in the course, namely, at the end of each of the minor projects, where students present their findings and peer assessment. This presentation is done in front of the class and the professor. In addition to the criteria shown in Table II, team members are asked to provide comments on each of their peers, highlighting areas of improvement, with the hope after each iteration the previous area of improvement is addressed by the student or the progress has been made toward addressing it.

A simulation of the above is as follows: Team A contains students: MA, DK, AH, SR, and FT. While discussing their progress on the project during class with the professor, the chair FT noted that conflict keeps arising between members of the team. Upon the recommendations of the professor on ways to mitigate these conflicts, the team reconvenes to resolve them. In the second in-class discussion, FT noted that the conflict seems to has been subdued. In the following session, Team A presented their findings and during the student assessment, MA was found to be dominating discussions and regularly interrupting other team members. Recommendations from his peers and professor are provided to tackle these issues. When Team A is disbanded, and a new Team B is formed with MA as a member of it, now equipped with the MBTI lecture and knowledge of their previous experience in Team A, Team B goes through a process similar to the previously delineated one. Then, during the team's presentation, MA would be questioned regarding the steps he/she took toward addressing the issues mentioned in Team A—if MA is found to still struggle from the same issues, recommendations from the professor as well as his peers to address them are given once more. This process is repeated for the third time, where again MA's behavior is scrutinized one more time, in hope that the previously raised issues have been properly addressed since the last iteration.

A different criteria set is applied to the chair as his/her is the team leader and therefore is expected to behave differently than his/her teammates. The criteria account for how frequently the chair adheres to or deviates from his role of encouraging and maintaining open communication, helping the team focus on the task, empowering team members to participate, aiming for consensus, dealing constructively with conflict, serving as an unbiased side in directing discussions, and working for good use of time. Finally, the team assesses itself as a unit. For instance, the team members provide examples of what was good and bad about the team and identify the effective outcomes of the team that could not have been reached individually. This process allows the professor to track improvements in the student's professional skills and provide corrective measures when necessary. Following the discussion of the course design, it becomes necessary to shed light next on all the aspects underlying the course implementation at the LAU.

IV. Course Implementation at LAU

In this section, we will demonstrate how we implemented at LAU the main guidelines defined in the previous course design section, highlighting some of the main university-related constraints controlling the implementation process. This course was first implemented in 2010 as a required course at LAU for the electrical and computer engineering majors. It underwent several iterations with a rigorous assessment to improve and fine-tune its associated delivery methods. Following these iterations, the course became more grounded with the local culture and students' interests.

The topics utilized in the course aimed at enticing students to become productive members of the team. First, several technical topics were assigned to teams. For instance, students were required, at one point, to select and rank the top-three technological breakthroughs per technical topic, while elaborating on and justifying their selections and rankings. In this context, the task was divided among students requiring each team member to select first several preferred breakthroughs, and then each team to compile a list of top-three breakthroughs based on the students' initial selection. However, during the stage of putting together the final top three list, very few students cared enough to sufficiently defend their own initial selection and push for its inclusion in the final top-three list. We believe that this is due to the following reason. It takes a student a relatively long time to develop an attachment to a topic that he/she is not familiar with. So, the lack of the sentiment of association with or ownership of the assigned topic led students toward a passive attitude when their topics and ideas were turned down. Students would convincingly claim that a few weeks were not enough to create a bond and/or attachment to the ideas they presented. Consequently, a quick fix was needed for this problem. This fix came in the form of assigning more culturally controversial topics that would tug on the students' identity. This helped boost students' engagement in topic presentations. This is particularly true since the implementation of the course proved that lively and heated discussions could only be realized when the controversial topic under consideration is not of technical nature and touches on a more relatable societal theme that has been deeply debated over the years in the various media outlets. As expected, this helped boost students' interest and involvement in the course. This also fostered heated debates and the officer roles had the opportunity to shine as mediators and scaffolding to prevent group fallout and team failure. These topics ranged from "same-sex marriage," "religion and politics," and others close to home crises that the students felt strongly about, more details on projects and deliverables are shown in Appendix A. Allowing these topics in the first three projects provided a safe platform for students to discuss controversial topics in a controlled manner and accelerate their professional skills acquisition.

When it comes to sizes of the teams involved with the first three projects, it is important to highlight the following important point, especially that team size plays a major role in a students' exposure to professional skills as shown by [33]. A typical team size of 5–6 members was adopted. This was driven mainly by logistical constraints relating to the operation of the course. More specifically, each classroom section for this three-credit course had about 30 students. Given that the duration allocated for each weekly group presentation was set to 30 min, the 3-h long weekly classes had to be divided equally among six groups, giving thus rise to teams of 5–6 students.

The learning objectives of this course are to give each student a realistic perspective of professional skills in teams and team building.

Active learning involves the interaction of students with their peers during meetings and interaction of students with an instructor during briefs, project presentation, and assessment.

Project 1:

1) *Context:* Mainstream topic addressing contemporary issues within a global and societal context.

2) *Lectures in Parallel to Project 1:* Going over assessment rubrics, introducing officer roles, and elaborating on the fundamentals of meeting conduct.

Project 2:

1) *Context:* Controversial topic emphasizing code of cooperation and communications in teams.
2) *Lectures in Parallel to Project 2:* Familiarizing students with MBTI, introducing the essentials of teamwork and team leader (chair) responsibilities.

Project 3:

1) *Context:* Culturally divisive topic while learning to recognize and capitalize on differences.
2) *Lectures in Parallel to Project 3:* Elaborating on team building and conflict resolution.

Project 4:

1) *Context:* All-encompassing topic utilizing Robert's rules of order and engineering code of ethics.
2) *Lectures in Parallel to Project 4:* Introducing Robert's rule of order, going over the engineering code of ethics, and presenting common techniques in debate moderation.

After the completion of the projects, students are subjected to a faculty/student panel interview, with three faculty members conducting the interview. The objective of this interview is to identify whether the student was able to acquire the skills and meet the course objectives. Questions revolve mainly around the professional skills knowledge the students acquired from the teaming experience they had in the course. Understanding how to deal with different personality archetypes and the value of professional skills and teaming as opposed to individual work are key to measuring the growth and change in a student's personality. However, this is not a core structure of our course proposition as it is new and further exploration of this technique is required.

V. Survey Design and Results

To verify and quantify the impact of our course on an undergraduate engineer's professional skillset, a survey that is not part of the course was designed for this article. It is worthwhile noting that the students conducting the survey did not see their results and that they did the survey only once. The survey targets students who have yet to take or took the course in the past two years. In our survey design, we view professional skills and teaming as an ability that requires a cognitive base in order to be taught, as attested to in practical medical teaching by [34], therefore, the questions were designed as situational examinations whose aim was to test the student's ability to react common workplace situations in accordance with their cognitive base, professional skillset, teamwork, professionalism, and command of situational analysis. Furthermore, the survey has ten situational questions, augmented with three conceptual questions, based on course lectures with multiple potential answers listed for each question. It is important to note that the correct answers for the survey questions were devised by a group of seven highly experienced faculty members consistently with the culture of the participants. Some of the questions included in the survey required students to identify the least likely and most likely action to take in a well-defined situation. The reason behind this decision was to avoid a common drawback of surveys, whereby the respondent could identify the culturally accepted answer. Moreover, this has the inherent merit of requiring a student to have both a good grasp of professional skills as well as some situational awareness, to be able to identify the worst case scenario pertaining to a given hypothetical situation. Every question gauged multiple professional skills as listed in [8], [9], and [35]–[37]. The survey questions, their associated answers, and the professional skills they target are all given in Appendix B. Note in this regard that there are two types of correct answers, namely, the most-likely and least-likely ones. The most-likely answers are highlighted in bold, while the least-likely ones are italicized. Correct answers and behavior are used as a shorthand for professional behavior as defined by the aforementioned literature and our own course design.

We had to devise a way to grade each survey in a way that would accurately capture a student's understanding of professional skills. Moreover, the grading system had to achieve the purpose of discouraging lucky guessing of answers. Therefore, we envisaged awarding points to students for correct answers and penalizing them for incorrect ones. In light of this observation, the "precision and recall" metrics that enjoy a widespread deployment in the context of machine learning applications seemed a good choice. As such and inspired by some machine learning papers, such as [38], we decided to adopt the F1 scoring system, which is built upon two main tenets, namely, the so-called precision and recall parameters. The latter set of parameters is defined by Vinodhini and Chandrasekran [39] as follows: "precision is the fraction of retrieved instances that are relevant, while recall is the fraction of relevant instances that are retrieved." The true benefit emanating from the F1 system lies in its ability to measure the accuracy level of answer selection by students. The latter can be inferred from the F1 score assigned to a question, where a high F1 score suggests a positive trend in terms of sound decision making by the student whereas a low score indicates a negative trend toward this end. A formal formulation of the F1 scoring system is presented next. Let us denote by:

1) C_T the total number of correct answers per question;
2) C_S the number of correct answers supplied by the student. Note that $C_T = C_S$ if the student manages to select all the correct answers pertaining to a given question. Furthermore, $C_S = 0$, either if the student opts for not answering the question or when all of his provided answers are found to be incorrect;
3) A_S the number of answers (all the answers, including both incorrect and correct ones) provided by the student.

As such, the precision and recall parameters, denoted by p and r, respectively, can be formally defined as follows:

$$\text{Precision} = p = \frac{C_S}{A_S}$$

$$\text{Recall} = r = \frac{C_S}{C_T}$$

TABLE III
SURVEY MODEL RESULTS

	NOT TAKEN	TAKEN	Δ
SQ	Percentage (%)	Percentage (%)	(%)
2	12.90	60.42	47.51
3	58.06	91.67	33.60
4	38.71	63.54	24.83
5	54.03	72.92	18.88
6	55.65	76.04	20.40
7	19.35	57.29	37.94
8	58.87	75.00	16.13
9	40.32	62.50	22.18
10	75.81	83.33	7.53
11	53.23	62.50	9.27
12	48.39	65.63	17.24
13	46.77	79.17	32.39
14	33.06	62.50	29.44

p and r can then be used to compute the F1-score according to the following formula:

$$F1 = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}.$$

Considering the above discussion, different values can be obtained for r, p, and $F1$ metrics depending on the number of correct and incorrect answers provided by the student. Specifically, note that there are three possible outcomes for any given question, namely:

1) the student selects the two correct answers (i.e., $C_S = C_T = A_S = 2$), in which case he/she is awarded an $F1 = 1$, the highest possible score for a question, since $p = (2/2) = 1$ and $r = (2/2) = 1$;
2) the student selects one correct and one incorrect (i.e., $C_S = 1$ and $C_T = A_S = 2$), in which case the student is awarded an $F1 = 0.5$, for $p = (1/2) = 0.5$ and $r = (1/2) = 0.5$;
3) the student selects two incorrect answers (i.e., $C_S = 0$ and $C_T = A_S = 2$), earning him an $F1 = 0$, the lowest possible score for a question, as $p = (0/2) = 0$ and $r = (0/2) = 0$.

It is important to highlight that the case where $A_S < 2$ is not discussed herein since all the respondents to our administered surveys provided exactly two answers per question.

The averages were calculated based on the sample size and then compared by showing the difference in their percentages, identified as Δ, third column. Δ signifies the percentage difference between the likelihood of correct behavior between students who have taken and have not taken the course yet. A total of 110 students participated in the study of which 48 students have taken the course while the remaining have not. Examining the results listed in Table III, we can conclude that there is a stark difference between both groups, with the percentage difference Δ, reaching a maximum of 47.51% which is a remarkable difference. We also note that the students who have taken the course were able to pass almost all the questions, except for one, whereas the students who have not taken the course, failed almost all questions, except for one. This is a noteworthy turnover showing the clear benefits such a course has when implemented within the curriculum.

VI. CONCLUSION

This article introduced the design for a three-credit course that develops teaming and professional skills based on non-technical projects. The method adopted in this course parallels the engineer's approach to learning, through project-based learning, iteration, self and team assessment, and discussions. While technical knowledge is still the primary objective of an engineer's educational journey, the ability to communicate his/her findings and work to a diverse audience cannot be neglected. Students deemed this course not as difficult or technical as the other major courses or topics but they ended up taking it seriously and dedicating several hours a week toward the team-based meetings involved in the course. Moreover, the faculty members who taught this course over the years noticed a significant improvement in team performance and cooperation when it comes to the students that took the course. To further highlight the advantages of the course, a survey was administered, where the responses received from students clearly highlighted the merit and the benefits of the course, which received praise and recognition by ABET in their latest accreditation review of the ECE program at the LAU.

Last but not least, it is important to note that we did not quantify and correlate the impact of MBTI, Tuckman, or Robert's rules of order on our students' behavior and amalgamation of their efforts. Whether MBTI or other indices might have a better impact on the educational process is yet to be explored. The authors will continue however to investigate means for improving this course so as to reinforce its role as a robust method for delivery.

APPENDIX A

Topic	Deliverable
Breakthrough Technologies	• Based on the team evaluation, order the identified three technologies with a description based on their overall significance and foreseeable impact on affecting the quality of life throughout the world • State exactly how each technology influences (positively and negatively) the current global and local, economic, environmental, and societal context as well as the current engineering profession.
Should creationism be taught on par with natural selection in schools?	Each team is expected to present different controversial issues associated with the selected project stating pros and cons.
Should key (political/governmental) positions in Lebanon be constraint to specific religions or only based on suitability, skills and qualifications?	Each team is expected to present common viewpoint on the selected topic and maybe different controversial issues while stating impact on society.

APPENDIX B

In addition to the IRB consent form, the following survey instructions were presented to the students: "You are to select the answers that are representative of your reaction to the following situational stimulus, keeping in mind the following constraints: All teams are heterogeneous and multidisciplinary, management does exist and has the ability to penalize you, factor in time and ensure that your actions are in line with optimizing your behavior and productivity, you are invited to answer the questions in the way you believe satisfies the above conditions."

SQ1: When did you take the course?
- A. Two years ago
- B. One year ago
- C. I have not yet taken it.

Professional Skills: None.

SQ2: As the assigned project manager, how do you let the flow of new ideas happen in a meeting? Please select the most and least likely actions you would take.
- A. *Brainstorming*
- B. Frog leaping
- C. Concrete outline
- **D. Research before the meeting**
- E. Focus group.

Professional Skill: Communication.

SQ 3 How important is it to have consensus in general?
- A. Waste of time
- **B. Very important**
- C. Indifferent
- D. Not important
- E. Consensus does not matter.

Professional Skill: Teamwork.

SQ4: You are the project manager, while meeting with your assigned group you notice a member is reluctant to participate and is reserved toward the others, how would you approach him? Please select the most and least likely actions you would take.
- A. Direct question
- **B. Have a side meeting prior to the group meeting to encourage participation**
- C. Ask for immediate answers or decisions
- D. *Point out why there are not participating and insist they engage*
- E. Try a few times, if it fails ignore them.

Professional Skills: Teamwork and understanding ethics and professionalism.

SQ5: The team you are a part of has failed to meet the deadline set by the client and now you are being confronted by them for justification. Please select the most and least likely actions you would take.
- A. Blame the team for holding you back
- B. *Single out the member responsible for delaying the project alongside evidence for your claim*
- **C. Everyone is responsible**
- D. Refer the client to the management.

Professional Skill: Understanding ethics and professionalism.

SQ6: As the project manager, how do you direct a constructive discussion regarding the project? Please select the most and least likely actions you would take.
- **A. Give everyone an equal opportunity to speak**
- B. Smile and give praise to good ideas
- C. *Point how some ideas illogical and unsuccessful*
- D. Follow your gut feeling while facilitating the meeting.

Professional Skill: Teamwork.

SQ7: You are a team member and you have accepted a task you thought would fit your expertise, but after further inspection you notice that you are unable to finish it on your own. Please select the most and least likely actions you would take.
- **A. Approach the team manager about the issue**
- B. Try to do as much as you can and see where you reach before approaching others
- C. Approach another team member to handle it and exchange tasks without anyone else knowing
- D. Bring up the issue in front of everyone during the next meeting
- E. *Do it to the best of your abilities, so you keep your word in front of the others*.

Professional Skills: Communication and knowledge of contemporary issues.

SQ8: As the project manager, how would you approach conflict within your team? Please select the most and least likely actions you would take.
- A. Restrain comments and vocalize them after the project is over
- **B. Adjourn the meeting temporarily, then after they cool off discuss it face to face**
- C. *Ignore the conflict and move on*
- D. Avoid the people.

Professional Skills: Teamwork and understanding of ethics and professionalism.

SQ9: You are the project manager and you have opposing ideas among your peers regarding the project, how would you proceed to solve the disagreement? Please select the most and least likely actions you would take.
- A. Debate among conflicting sides
- B. Facilitate compromise between the ideas
- C. *Suppress the difference in opinion and stick to one*
- **D. Facilitate cooperation**.

Professional Skills: Teamwork.

SQ10: Which statement best defines leadership in the industry?
- **A. Inspiring and motivating others to work and improve**
- B. Making all the decisions and then communicating them to the members for execution
- C. Rigid rules by the team leader that everyone must abide by
- D. Mediate meetings and document events.

Professional Skills: Lifelong learning.

SQ11: You are a member of a team that is composed of multiple disciplines, while discussing a technical issue you realize some team members are not clear on some ideas you have explained. Please select the most and least likely actions you would take.

A. Directly address them, rephrasing your wording and making it simpler

B. Continue, but then allow for questions and try to explain as clearly as possible

C. *Continue, if they do not understand they should have done their own research*

D. Continue, then send out emails asking if they require clarification.

Professional Skills: Knowledge of contemporary issues and lifelong learning.

SQ12: As the assigned project manager, you realize that a team member is dominating the discussion allowing little time for others to express their points. Please select the most and least likely actions you would take.

A. Have a side meeting prior to the group meeting

B. Reassure the person of their contribution, but ask them to participate less for the sake of others

C. *Force them to be quiet during the meeting*

D. Tell them to come late, so others have time to share

E. Use an organized structure whereby people speak in turn and order.

Professional Skills: Teamwork and communication.

SQ13: Is it important to work with other disciplines then when working on a project?

A. Strongly agree (Provides different perspectives)

B. Agree (They might incorporate useful ideas)

C. Neutral

D. Disagree (It will only clutter the flow of ideas)

E. Strongly disagree (Other disciplines might not be as efficient).

Professional Skills: Knowledge of contemporary issues and lifelong learning.

SQ14: During a meeting, you have suggested an idea, you have done extensive research on and believe would greatly benefit the project. However, one of your colleagues dismissed it as being ineffective. Please select the most and least likely actions you would take.

A. Respond to their allegations and demonstrate the opposite

B. Appeal to the project manager

C. Ask for the meeting to be suspended and address your colleagues' remarks on the side

D. Take out what your colleague noted as ineffective and proceed with what was agreed upon

E. *Do not do anything and accept your colleague's criticism, removing your ideas from the project*.

Professional Skills: Teamwork and communication.

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