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# An Advanced Teaching Methodology to Improve Student Learning Outcomes in Core Discipline Content and Soft Skills

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# An Advanced Teaching Methodology to Improve Student Learning Outcomes in Core Discipline Content and Soft Skills


## Abstract

The research paper addresses the existing gap between employers' expectations and the competencies of college graduates. According to recent reports, there is an increasing need to adopt new methodologies in teaching to help students improve their career readiness. Contemporary requirements to engineering workforce, besides the core discipline skills, include proficiency in complex open-ended problem solving, interdisciplinary collaboration, and management and leadership skills.

The proposed methodology is based on a role-play simulation of a workplace situation. This approach has been used in many disciplines, but not in the engineering management programs, such as Industrial Management, Operations Management, and Supply Chain Management. A pilot study was conducted to test the proposed methodology. We integrated three different classes within one undergraduate program. Students from these classes participated in the simulation as employees of different companies-partners of one supply chain. Students played roles of members of different departments in a company, including the departments' and company's leaders.

Both quantitative and qualitative data were collected and analyzed to evaluate the project outcomes and to assess the students learning outcomes. The paper will highlight the methodology of the teaching approach, how it helps to achieve better learning outcomes for both core and soft skills, and how students perceive an effectiveness of this teaching approach.



Keywords: Soft Skills, Inductive Teaching, Career Readiness


## Introduction

New college graduates face myriad challenges as they start their careers. It is not enough anymore to be proficient in the technical elements of their major discipline. Employers expect college graduates to possess professional skills as an important prerequisite for students' employability and long term success. Recent analytical reports world-wide show a perception gap between employer expectations and graduates' actual level of preparedness for the work environment: although 87% of graduates feel they are workplace ready while only 50% of managers feel that graduates were prepared for a full-time job.[1,2]

The tremendous development and adoption of new technologies coupled with the high rate of change add up to a complex and dynamic workplace. As a result, employee experience-level and preparedness has evolved .[3,4] Employers expect new employees to possess higher levels of transferrable ('soft') skills in addition to the core discipline ('hard') skills.[2,5,6] LinkedIn® professional network analytics reported the demand for soft skills in1.4 million professional job postings based on analysis of 100 metropolitan areas. Communication skill was reported as the most frequently listed quality in professional job listings.[7]

Recent trends in employability of engineering students indicate the added emphasis on soft skills in addition to the core technical (hard) skills. To effectively cultivate student proficiency in complex open-ended problem solving, interdisciplinary collaboration, and management and leadership skills, our engineering pedagogy must be revised.

The goal of this research was to design a new teaching framework to address the gap in soft skills and to promote career readiness of college graduates. The proposed teaching framework was designed based on a unique combination of student-centered approaches which were proven as effective methods for learning of core discipline skills. The addition of specific features of the framework makes it an efficient learning environment for development of soft skills, which was proven in the pilot study to test framework efficacy.

## Students Skills and Competencies

The literature offers different classifications of people's skills. There are two big clusters organized under hard and soft skills. Hard skills are also called as core, discipline, or technical skills. They are related to specific technical qualifications required to perform the discipline-specific elements related a job. Soft skills are also called as enterprise or transferrable skills, which characterize an individual's personal qualities, can be applied to a variety of jobs, as they can be 'transferred' from one discipline or workplace to another. The skills development model is presented in Figure 1.

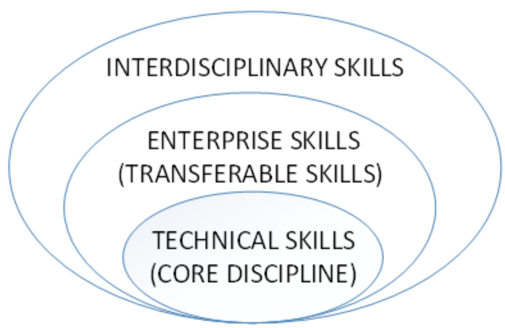


*Figure 1.* Skills model. Adapted from the Agency for Strategic Initiatives report (2017)[8]

The model represents three stages of skills development with the basic or foundational level that include the core discipline skills. Enterprise or soft skills are more difficult to develop as they usually require some technical background for effective professional growth.[9] Interdisciplinary skills is the highest or most mature skill level. They are more challenging to develop as it requires broad understanding of different technical and managerial application in combination with effective soft skills level.[8] Higher education in the United States has established a high level of competence in teaching the core technical skills, but new methodologies are still required for effective teaching of soft skills, and ultimately, interdisciplinary skills.

There are differing classifications of soft skills noted in the relevant literature. Some researchers list soft skills as independent competencies. Some researchers propose groupings or clusters of soft skills, defining subsets of skills in various categories. The authors posit that all soft skills are interconnected and influence each other at some degree. Thus, good collaboration skills include listening, task and time management, and conflict resolution. At the same time, strong leadership skills assume the same competencies. In a comparative study of soft skills in new graduates, Crawford et al defined seven group of soft skills:[10]

- Communication skills;
- Decision Making/Problem Solving Skills;
- Self-Management Skills;
- Teamwork Skills;
- Professionalism skills;
- Experiences; and
- Leadership Skills.

The proposed research project does not include all these classifications skills, but rather focuses on the skills that have the greatest impact on employability, specifically communication skills, problem solving, collaboration, and leadership.

## Student-Centered Learning

This study is based on constructivist theory combined with inductive teaching methodology. According to constructivist theory, each person has different interpretation and construction of the knowledge process. The interpretation depends on a learner's background knowledge and beliefs. Every new piece of information is connected to existing knowledge after subjective interpretation to fit their existing beliefs. Thus, new information can be connected appropriately and will reflect each person's objective reality; it can also be connected to the incorrect beliefs and interpreted subjectively; or, it will be rejected (not retained), if it contradicts the learner's beliefs.[11]

Inductive teaching methodology is an active learning methodology which allows the instructor to expose mistaken perceptions and beliefs of learners, and lead them to reframing their beliefs before new information is introduced and connected to the learner's background knowledge. For a successful transformation process of the learner's mistaken perceptions, an instructor will gently lead a learner to make the correct conclusion or interpretation without telling them what is wrong. A learner should come to the conclusion that their perception was wrong and then be willing to adjust them.[12,13] The effectiveness of inductive teaching of engineering students was studied and published in the literature as it relates to core discipline skills.[14,15,16] However, there remains a gap in the literature that substantiates that inductive teaching is reliably effective in teaching soft skills to undergraduate engineering students.

Teamwork and collaboration have researched extensively by researchers for the last two decades, including both psychological/sociological and learning styles. Researchers have studied methods for effective group formation, efficient and reliable assessment tools for group versus individual effort, and students' competencies gained from group work.[17,18,9] Interesting findings include there are two attributes of group learning: the collaborative and collective learning environment which are aimed to develop different set of skills for participants.[9]

Simulation is another approach for active learning in the classroom. In 1999, Ferrari, Taylor, & VanLehn completed a meta-analysis of computer-based simulations taught in English.[19] They analyzed 142 simulations and divided them into three categories: development of academic skills, strategy games, and development of work-related skills. They concluded that there are only nine simulations designed with the idea for easier transition to the workplace. The authors listed several limitations to teaching these concepts with computer simulation which include difficult user interface with a need to learn the software, limited feedback on students' performance, and predetermined scenarios.[19] Role-play simulation can be a good alternative to computer-based simulations. This approach was acknowledged as a powerful tool which is used for various ages to promote learning process and engagement.[20,21] Benefits of role-play as a learning tool include relaxed, less stressful learning environment, some unplanned situations or questions students need to accommodate for during the simulation, and the need to integrate previous knowledge and experience for better role-play outcomes.[22,23]

There are several studies that reported initiatives in improvement of students' soft skills and career readiness in Europe, Canada, Malaysia, Australia, and the United Arab Emirates.[24,25] Some studies propose to integrate teaching soft skills early in the programs, e.g., for freshmen students to early expose them to the required skills.[25,26] As outcomes they reported improved overall students' performance and higher retention rates. Most of the recent studies on soft skills proposed integration of a specific course in an academic program, which is dedicated specifically to teaching a variety of soft skills. Several studies investigated curriculum integration where soft skills teaching is included in most of the academic program courses.[27,28,29]

## Integrated Teaching Framework

Curriculum integration was practiced and proven as an effective approach to teaching interdisciplinary skills.[27,28,29] The integration was considered as a common theme in a set of courses, or as an application of knowledge from one course to teach another course in an academic program, or as an industry based projects such as internship or capstone projects. The application of industry teaching approaches used to train employees versus teaching in an academic setting was also described in the literature.[30,31]

In this research we propose an integration as a required connection and collaborative learning of students from two or more independent classes to work on one project with a common theme, while completing only one part of the integrated project related to their subject matter specific for each course. The proposed framework is unique due to combination of inductive learning, simulation, and role playing while connecting students from three independent classes to complete a shared integrated project. Although there is an evidence that engineering management programs successfully incorporate learner-centered teaching techniques to improve students' discipline-related skills, there is a gap in the literature whether these methods help to develop soft skills. Inductive teaching of soft skills is the pivotal component of the proposed methodology which is promising for effective facilitation of soft skills development. One of the key principles of inductive teaching is to reveal a learner's wrong perceptions before teaching new concepts. As recent analytical reports[1,2] indicate that majority of students believe that their soft skills are well developed and that they are proficient in communication, teamwork, and problem solving, this is not necessarily the case. It is commonly found these beliefs contradict employers' assessment of soft skills of new college graduates. If students did not reveal their wrong perceptions they do not put effort to learning and improvement. Also, if an instructor tells that students need to improve their soft skills, the students usually do not accept this critique. It is important to gently lead learners to self-discovery and that they have a need to improve. The novelty of the proposed methodology is in the inductive teaching of soft skills, which supports self-revealing and admitting when the level of soft skills is not sufficient. Therefore, students are more likely accept the need to improve and become open for teaching intervention.

The following features are incorporated in the framework:

- Students' authority to make decisions;
- Students' diversity in leadership role in the simulation;
- Dynamic nature (student-generated contents);
- Students' research to successfully complete the project;
- Development and application of both core and transferrable skills:
    - Application of knowledge and skills from other courses of the program;
    - Preparing students to professional activities/job. Role-playing in close-to-real-world workplace settings.

These features were implemented in the design of the integrated project and the new teaching framework was tested in a pilot study.

## A Pilot Study

A pilot study was conducted with three classes within an Operations Management program in the Jerome J. Lohr College of Engineering, South Dakota State University. Supply Chain Management (SCM) class, Manufacturing Cost Analysis (MCA) class, and Design for Production (DFP) class were integrated via a shared project within a one-semester time frame. The Supply Chain Management class was the central class for data collection and analysis. Student learning outcomes assessed in the pilot study are presented in Table 1.

Table 1. Student Learning Outcomes Assessed in the Supply Chain Management Class

| Student Learning Outcomes | Associated Skills |
|---|---|
| Understanding of SCM | Core discipline skills |
| Knowledge of supply chain design, operations, and strategic management | Core discipline skills |
| An ability to apply knowledge of supply chain design, operations, and strategic management in practice | Problem-solving skills |
| An ability to find needed information from a variety of sources | Problem-solving skills |
| An ability to effectively communicate in various ways to achieve goals | Communication skills |
| Teamwork and collaboration abilities | Collaboration skills |
| Ability to function in multidisciplinary teams | Collaboration skills |

The Supply Chain Management class played a shoe-making company with five departments responsible for sales, manufacturing, procurement, logistics, and warehouse management. Their goal for the project was to design a supply chain based on the provided input data which included 3-year demand forecast, shoe specifications, and the initial manufacturing process parameters. The Manufacturing Cost Analysis class was divided into four groups which played the cost consulting companies competing against each other to prepare the best proposal for the customer – the shoe-making company. Their goal for the project was cost reduction and investment analysis of proposed improvements. The third class, Design for Production, represented another 'consulting company' which worked on the warehouse expansion design proposal for the shoe making company. Input data for the two classes, consulting companies, came from the 'shoe company'. All three classes were required to communicate between each other to complete their project. The Supply Chain Management class had three levels of communication: within a small group (department), internal class communication (between departments), and external communication with other classes (consulting companies). Professional written communication and oral communication were required for all three classes. Figure 2 shows the information exchange patterns between three classes and within the SCM class.

Other teaching methods used in the SCM class included Reading, Lecturing, Video Examples, Discussions, Case Study, and Problem Solving (well-structured). Also, an Industry Speaker was invited to present in the SCM class, and a Plant Tour was organized in the middle of the semester.

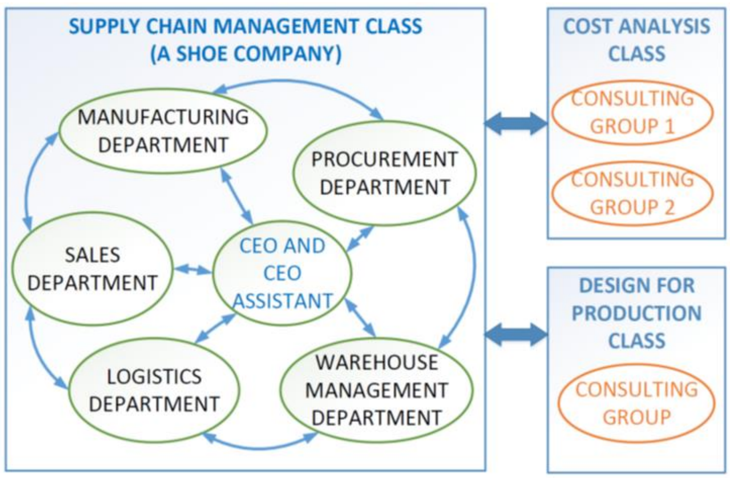


*Figure 2.* Information exchange model for the integrated project

**Objectives**

The following objectives were stated for the pilot study:

- To test the new teaching framework and receive students' feedback (their perception of the teaching method);
- To test and validate questionnaire as a data collection instrument;
- To get preliminary results about effectiveness of the integrated project teaching method in supporting students career readiness and developing the required core and soft skills.

**Research Hypotheses:**

1) Students learning outcomes will improve with the integrative project approach;

2) Students will better understand the workplace requirements after practicing such soft skills as communication, collaboration, leadership, and problem-solving in the company-simulated project.

### Participants

Data were collected from the Supply Chain Management class as a central class of the integrated project. There were 22 students participating in the class. All the students were enrolled in the Operations Management program in the Jerome J. Lohr College of Engineering (CIP code 15.1501 Engineering/Industrial Management). Nineteen students responded to survey including Juniors (13%), Seniors (64%), and Graduate Students (23%).

### Data Collection

***Student self-assessment survey***

An online survey was conducted at the beginning and at the end of the semester (IRB-1709019-EXM). Students responded anonymously to assure less biased responses. Data were collected via QuestionPro.

Pre and post evaluation questionnaires were developed to collect data on students' self-evaluation of their knowledge and skills. There were four sets of questions:

1) Student Demography and Background. This set of questions was aimed to determine students' level of preparedness for the class and their learning styles (preferences).
2) Students Interests. This set of questions helped to determine student's motivation in taking the class and their attitude to the field of study.
3) Student self-evaluation of their knowledge and skills. These questions were related to the assessed learning objectives for both discipline and soft skills.
4) Student perception of the teaching methods. For this set of questions students indicated how helpful different components of the course were for their progress for all learning objectives.

For the post-evaluation survey students additionally answered one optional open-ended question to reflect on how their project learning experience can be helpful for their career goals.

External validity of the questionnaire was evaluated by two experts. Reliability of results was evaluated via comparison of the responses with another independent survey – IDEA evaluations. Statistical analysis showed no significant difference in students' responses regarding their progress on learning objectives in both the research and the IDEA surveys conducted independently.

***Variables***

Independent Variable for the study was 'Teaching Methods'. Dependent Variables were 'Student Learning Outcomes' and 'Student Progress on SLOs'. The following Extraneous Variables were included in the analysis: 'Students' Motivation', 'Experience', and 'Learning Style Preference'.

***Observations***

Observations were conducted by two instructors during the semester. There were several in-class sessions for the role-play simulation where students had meetings as an entire company. Also, the instructors attended two out of class meetings for the department heads and CEO of the company. There were individual meetings of the students with the instructor, and the final project presentation was observed at the end of the semester. The following matters were the major focus of the observations: students' attitude to team work, students' motivation and willingness to participate, students' perception of the importance of soft skills, students' self-assessment of their soft skills and abilities, and the relationships between teammates within and across departments.

***Rubric to assess SLOs***

An Integrated Project grading rubric was designed to assess the students learning outcomes. The rubric included an assessment of a collaborative part of the project. The rubric assessment was conducted twice in the semester. A first draft was evaluated in the middle of the semester, and the final submission was assessed at the end of the course.

**Data Analysis**

Data analysis indicated that 50% of respondents had full-time or part-time work experience prior to taking the course, 28% of students had an internship experience before taking the course, and 22% had no industry experience. Regarding students' motivation, 77% reported some level of interest in the SCM field and 23% were not sure or not interested, with 72% who consider their career in the SCM versus 28% not interested/not sure about this career path.

The group of respondents had no strong preferences in learning styles. The class average rating for learning style preference is within 55-65 range (out of 100) for most of the methods used in the class with the lowest value of 44 for Reading, which was the least preferred, and 75 for the Project/Problem Solving, which was the rated highest preference, which is depicted in Figure 3.

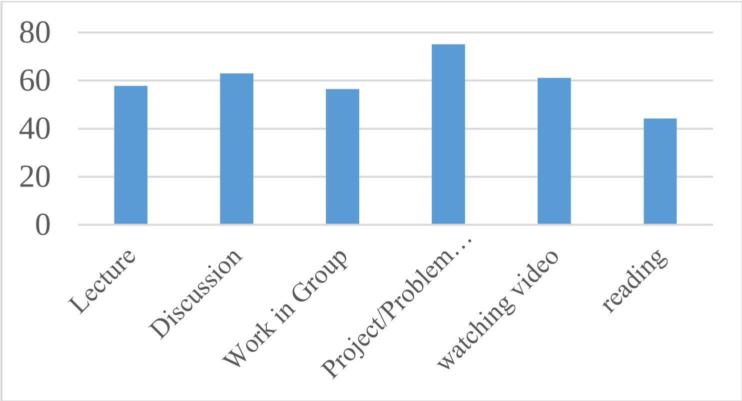


*Figure 3.* Learning style preference rating (0-100 range)

Statistical analysis of the relationship between the extraneous variables and student progress on learning objectives did not confirm influence of the extraneous variables on progress, except the 'industry experience' variable effect on most of the learning outcomes. The negative coefficient in the regression analysis indicated that progress on learning outcomes was greater for students with less industry experience.

***Quantitative Analysis***

The following quantitative data were analyzed in the pilot study:

1) Collaborative part of the project. The project rubric was utilized to grade two submissions of the project report. After the first draft submitted by students, the instructor evaluated the submission. The class score was 50 % for the collaborative portion of the project. In comparison, the final report score was 78%. This allows the authors to conclude that communication was

improved and students were able to align goals of all departments with corporate strategy, as well as coordinate all departments' functions and decisions to support supply chain effectiveness.

2) Teammates evaluations. At the end of the project all students were asked to complete a teammate evaluation, where they rated their small group (department) members' contribution to the group work and their collaboration skills. They also rated the project leaders (department heads and CEO) performance, including their leadership skills. From the evaluations, the authors concluded that majority of students were comfortable with the teamwork and were satisfied with their teammates performance. From the leaders, they expected better performance for task clarification, maintaining a spirit of teamwork, and time management.

3) Students self-assessment of SLOs level at the beginning and at the end of the course, and their progress on SLOs during the semester. Statistical nonparametric analysis was conducted to compare students self-reported level of learning outcomes in the pre and post survey.
For hypothesis testing we conducted the Whitney-Mann test, which showed statistically significant differences in post-assessment versus pre-assessment for the following SLOs at $\alpha=0.05$:

- understanding of SCM;
- knowledge of supply chain design, operations, and strategic management;
- an ability to apply knowledge of supply chain design, operations, and strategic management in practice;
- an ability to find needed information from a variety of sources.

The results are shown in Table 2.

Table 2. Statistical Analysis of Student Learning Outcomes

| Student Learning Outcomes | Associated Skills | Mean | | Median | | *P*-value |
|---|---|---|---|---|---|---|
| | | pre | post | pre | post | |
| Understanding of SCM | Core discipline skills | 2.1667 | 3.7895 | 2.0 | 4.0 | <0.0001 |
| Knowledge of supply chain design, operations, and strategic management | Core discipline skills | 3.111 | 3.9474 | 3.0 | 4.0 | <0.0001 |
| An ability to apply knowledge of supply chain design, operations, and strategic management in practice | Problem-solving skills | 3.1667 | 3.8421 | 3.0 | 4.0 | <0.0009 |
| An ability to find needed information from a variety of sources | Problem-solving skills | 3.5000 | 4.0000 | 3.0 | 4.0 | 0.0299 |
| An ability to effectively communicate in various ways to achieve goals | Communication skills | 3.5000 | 3.8947 | 4.0 | 4.0 | 0.0741 |
| Teamwork and collaboration abilities | Collaboration skills | 3.7222 | 3.9474 | 4.0 | 4.0 | 0.2483 |
| Ability to function in multidisciplinary teams | Collaboration skills | 3.6667 | 3.7895 | 4.0 | 4.0 | 0.4161 |

Although we cannot reject the null hypothesis at the $\alpha$=0.05, but $p$=0.0741 is still a good sign of improvement at the 90% confidence level. We expect that the further testing and a larger sample of participants accompanied by qualitative data analysis will provide a better picture regarding this learning outcome.

The Mann-Whitney test did not result in a statistically significant difference for teamwork and collaboration abilities, nor for the ability to function in multidisciplinary teams. The teammates evaluation supported this conclusion, where 91% of students graded their teammates at the level ‘C’ or better for their contribution to the group work and their teamwork abilities. Nevertheless, in the self-assessment survey 74% of respondents reported their progress in teamwork and collaboration abilities as ‘substantial’ or ‘exceptional’, and 79% of the respondents reported ‘substantial’ or ‘exceptional’ progress in their ability to function in multidisciplinary teams. These contradictory results can be explained by the fact that the participants were juniors and seniors in the program, and they have been exposed to various teamwork exercises during their study in other courses in the program. Thus, they came to the course with a perception they possessed a high level of these skills which was reported in the pre-survey. During the course, it is likely students realized their perceived level was not as high as they thought, so in the post-survey they reported their new beliefs on the achieved level, but there was no significant difference in comparison with the pre-survey. A modified data collection approach should help to avoid this situation in the future by collecting self-perception data at the end of the course for both pre- and post- levels for all learning objectives. Also, this will allow authors to perform a paired test for these anonymously collected data.

Multiple regression analysis was performed to determine relationship between teaching methods used in the course (independent variables) and students’ self-reported progress on learning objectives (dependent variables). Three methods, integrated project, lectures, and discussions, were found to be statistically significant variables for students’ progress for most of the learning objectives with $p<0.05$. Although we cannot state conclusively that the results are valid because the regression test assumption of data normality was violated. Nevertheless, this is an indicator that the project was perceived as a helpful method to improve learning outcomes, including communication and collaboration skills. Qualitative data collected via optional open-ended question support this conclusion.

***Qualitative Analysis***

Post-evaluation survey contained one optional open-ended question: *Briefly describe your learning experience from the supply chain design project that, you feel, will help you with your career goals.*

There are samples of student responses to the open-ended question:

- “Communication within an organization and being able to lead others and be confident in my decision making will greatly help me in my future career. Also, the ability/courage to ask and confront others with questions”.
- “The project taught me communication between classmates as well as between other classes”.
- “The importance of preparation, communication, and organization of efforts”.
- “This class has helped me to understand working with other people in a different group as part of the bigger team. When I didn't communicate, I did my team a disservice; when we were all on the same page, progress was swift”.

- “I learned and enjoyed learning a lot about supply chain management. I think I will be able to use what I learned and take it over to my future job”.
- “Getting the entire supply chain to work together efficiently is a much more complex problem than I initially thought”.

From the responses the authors can conclude that development of communication skills was the most frequent response. Students recognized the importance of communication at the workplace, as well as acknowledged that their communication skills improved as a result of their participation in the course project.

Observations of the in-class project meetings and out of class meetings of the teams' leaders revealed that students took their roles seriously and played the simulated company as if they were real employees. Besides the required documents (communication plan, memorandums, letters) they prepared and used additional documents to facilitate their work and communication effectiveness, such as meeting agendas and minutes, internal tasks assignments, and deadlines.

Another meaningful event was student-initiated peer teaching on professionalism. The student designated as company leader requested 15 minutes of the class time and delivered a presentation on professional skills, such as being on time for meetings, paying attention, being prepared, being respectful to colleagues, and meeting deadlines. Students' attitude positively changed after this presentation, and most of the students demonstrated improved professional skills during the semester.

Leadership skills development was observed during the semester. An interesting observation was made that students from underrepresented groups expressed keen interest in playing leadership roles in the project. Thus, amongst seven leaders in the class, there were one female student who was a CEO of the company, two African-American students were department heads, and one international (Asian) student played the role of the CEO Assistant. The leadership skills development required the most guidance from the instructor. One of the weak points of the self-selected leaders was delegating/assigning tasks to team members. Some leaders tended to complete most of the department's tasks to assure required performance of their department lacking coordination and control of their employees. Another difficult part of leadership was conflict resolutions and dealing with students who were not willing to contribute equally to their group work.

## Conclusions and Future Work

Based on the data analysis and obtained results, the authors can conclude that the stated objectives of the pilot study were achieved. The new teaching framework was perceived well by students-participants, promoted their progress on learning objectives for both core and soft skills, and improved students understanding of the responsibilities and required competencies at the workplace. Students were able to practice the required soft skills during their role-play integrated project.

The new teaching framework has following benefits:

1) True collaboration. The project methodology requires true collaboration for successful completion of the project. The strategy of dividing tasks between group members and combining results at the end will not work in this setting because all small groups have a common goal and align their small group objectives with the goal. Input from each small group depends on the output from other groups, therefore the output cannot be generated in isolation and independence.

2) Promoting students from underrepresented groups to take an active leadership role in the simulation. The safe environment of in-class simulation in comparison to work in a real company provides opportunities for these students to try the leadership role and undertake challenges associated with being a leader.

3) Preparing students for professional activities/job. Role-playing in close-to-real-world workplace settings provides students the opportunity to understand all responsibilities and expectations. In many cases this approach could be more beneficial in comparison to the internship experience, where often students are allowed only to observe processes and a company employees' work instead of actually performing the work.

4) Application of knowledge and skills from other courses of the program. Besides the multi-class integration, the traditional approach to integration takes place here. Students are expected to use and apply their knowledge and skills from other courses and disciplines to successfully achieve the project goals.

The authors faced the following challenges piloting the integrated class framework:

1) Scheduling of integrated parts of the project to assure timely input from one class to another one.
2) Differing levels of knowledge and experience of participants.

For the future improvements of the methodology the authors plan to:

- Schedule mandatory joint meetings for members of all involved classes;
- Test students' knowledge and abilities to strategically assign group members;
- Require group leaders for all participating classes.

For the research design improvements, pre-test and post-tests of student subject knowledge will be conducted along with the students' self-assessment of their knowledge and skills. Also, additional qualitative data will be collected to study students' perceptions and the transformation process of their skills.

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