

**AC 2010-1106: INTEGRATING COMMUNICATION AS A NEW LEARNING  
COMPONENT INTO CHINESE SOFTWARE ENGINEERING PROGRAM**

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# **Integrating Communication as a New Learning Component into Chinese Software Engineering Program**

## Abstract

Engineering programs in China generally focus on development of student's ability in learning mathematics and engineering theories with limited exposures to their practical skill development. Recent research finds that lack of soft skill training on human communication may severely affect student's ability in conveying their thoughts and proposing solutions and even have negative impacts on their professional achievements.

This course development research is a new addition to a curriculum development research by the author. The research identifies Chinese student's weaknesses and discovers that successful experience from American engineering education programs can be used as a remedy. The solution is to integrate successful teaching delivery methods from American engineering curricula into Chinese engineering curricula.

The research first addresses importance of communication in modern work place and professional career and concludes communication training is crucial in any engineering program. A number of new student learning methods and team activities are selected for a comprehensive course framework. The modifications to existing software engineering project management course contents are made mainly to develop student's communication skills. Another task is to conduct an experiment on feasibility of integrating communication training into the project management course. The research develops a plan to test whether or not the new methods and activities are effective to develop Chinese student's soft skills in general and particularly improve their practical communication skills in the course. Students are required to go through a variety of new team activities and complete newly designed team oriented project assignments with the new focus on developing student's communication skills. Throughout the course student survey and other course evaluations are conducted. Data from the survey and evaluations is then collected and analyzed with help of statistical methods and software to discover scientific outcomes. The data analysis results are used to evaluate student learning outcomes and measure effectiveness of new teaching methods and student learning activities in this new course framework. The results have confirmed that most of goals of this change have been reached.

## 1. Introduction

A number of curriculum studies conducted by the author and other researchers find that engineering students often focus on their specific academic areas throughout their four year college study and even graduate study thereafter. However, rapidly changing global economy and dynamic working environment requires today's engineering graduates to be able to play multiple roles in a project life cycle. More and more engineers are now deeply involved in project management. Most of engineering graduates believe that their college educations do not fully prepare them to play such multiple roles with proper practical experience and soft skills.

This leads to a new demand to include a new focus on development of soft skills, such as communication, in an existing engineering course and curriculum.

## 2. Importance of Soft Skill Training in Engineering Curricula

Recent researches find that soft skills benefit engineer's professional career growth.<sup>1,2</sup> Researches also discover that soft skills and particularly communication skills obtained from college studies are more beneficial to engineering graduate's professional career development than any other engineering theory or method in existing engineering curricula.<sup>2</sup> Although engineering theory and methods have always been important components in any engineering curriculum, it is necessary to include a new focus on soft skills and particularly communication in engineering curricula because engineers are often required to play multiple roles including project managers soon after their entry into professional careers. Another interesting finding is that specially designed teaching components and learning activities can be integrated into existing engineering courses or curricula to help students master soft skills and gain practical experience.<sup>1</sup> Soft skill trainings integrated in team activities and projects may significantly improve student learning outcomes in communication and other soft skills.<sup>1,2</sup>

At the beginning of this research the author conducts a survey among software engineering graduates and uses a statistical method to analyze survey data from 150 survey respondents to first determine the priority of enhancements in the program. The survey result helps reach the conclusion that communication is the most important skill in engineer's professional career besides engineering related theory and knowledge. This matches findings from the research previously conducted by other researchers. Research on curriculum study finds that engineering curricula usually do not include any human communication study because of overemphasis on technology.<sup>1</sup> Lack of emphasis on practical knowledge and human development skills has existed in most of engineering curricula for a long time. It is the time for engineering curricula to adopt new focuses on soft skills, communication, organizational behavior, planning, and project resource management.

To address this important issue an enhancement to existing engineering curricula is imminent. The enhancement to an existing software engineering project management course in this research is designed by following principles and criteria:

- Main purpose of the project management course is to provide students with knowledge and skills that are essential to their future professional career.
- The knowledge and skills that engineering students obtain from their academic study will become the foundation for their future professional career.
- Certain successful methods from the existing curriculum will remain while successful learning methods and team activities from American engineering programs get integrated into the existing curriculum.
- Integrating communication into student learning is a key step to help students develop their practical knowledge and skills for their future professional career.

The main goal of this enhancement is determined to ensure every student graduated from the software engineering program to obtain a set of multi-dimensional soft skills for their future

professional career in the global economy.<sup>10</sup> By the time of their graduation students will not only be able to solve technical problems but also be able to play management roles and solve non-technical problems beyond the scope of engineering and technology.

### 3. Communication and Student Learning Activities in Project Management

Project management includes a set of powerful management methodologies. It ensures accountability, cost-effectiveness, and quality in the constructed project and provides an integrative force for essential teamwork in any project development.<sup>4,6</sup> Communication is an essential tool in every aspect of project management.<sup>5</sup> As information is constantly generated and transmitted through various forms of media to a variety of audiences, today's engineering professionals must become even more responsible for spreading ideas, thoughts, and values to the audiences all over the project life cycle.

Communication is the expression, transmission, and interpretation of knowledge and ideas.<sup>6</sup> A number of broad knowledge and skills in communication are identified and can be further divided into specific skills as follows:<sup>4,5</sup>

- Listening attentively
- Perceiving nonverbal messages
- Writing concisely
- Editing
- Describing feelings
- Expressing ideas
- Speaking effectively
- Negotiating
- Persuading
- Interviewing
- Reporting information
- Facilitating group discussion
- Providing appropriate feedback

To improve student's communication skills a number of team activities get adopted from existing American engineering curricula as new addition to the existing project management course.<sup>2,3</sup> These changes are carried out in this revised project management course by several different types of team activities and their unique focuses:

- Team work – A way to work with people with different personalities
- Interpersonal relationship management – A key skill to motivate people and receive support
- Body language and eye contact – An easy neglected factor in team work
- Discussion – A way to listen and speak out
- Meeting – A way to share ideas and interact with others
- Reporting – A way to communicate with readers
- Presentation – A way to communicate with audiences

- Leadership – An ability that a project manager must have to lead other software engineers

#### 4. The Enhancement in an Existing Software Engineering Project Management Course

As an experiment the software engineering project management course is selected to integrate the new focus on student communication into student learning and team activities because of its nature and contents. The new course module distinguishes itself from conventional engineering courses with new emphasis on communication with newly designed business case studies and team practices.<sup>3</sup> Each case study or team practice analyzes entire spectrum of a particular project and demonstrates the interrelationships among policy makers, planners, designers, implementers, managers, and team members throughout a project development life cycle.

Author realizes that a complete introduction of project management concepts and life cycle is still the core in the course. It is difficult to interpret key concepts of communication without studying classic business cases and typical issues from real life software project management.<sup>7</sup> Therefore, the course still keeps traditional description and technical overview of software engineering project management along with guidelines for improving software process management overall. The newly enhanced project management case studies and team activities clearly concentrate on communication and promote its importance as an essential tool to establish accountability for quality execution of project development, managements, and policies.<sup>6</sup>

Main goal of the enhancement is to provide sufficient information through student activities designed to help students understand entire process of project management and successfully perform their unique roles to manage projects. Adequate feasibility studies ensure that new enhancement is structured in the maturity framework presented in the same course more formally.

The course enhancement presents a new practical view of managing a successful software engineering project and builds a framework for project management case studies and team activities based on planning, organizing, staffing, directing, and controlling model.<sup>8</sup> It first provides information designed to help students understand foundation of project management and then includes software project management cases and practices to demonstrate how to successfully utilize communication skills to perform unique roles of a project manager.

The new project management case studies and team activities offer students sufficient background and instructional material to serve as a main or supplementary guidelines for their project management activities in software engineering project management. The case studies and team activities provide a scientific basis for preparing guidelines and checklists in both project management and interpersonal communication. Lessons learned from student project management case studies and team activities reinforce student's learning outcomes that well-managed communication is crucial to complete quality projects on time and within budget. Student team activities further reflect the importance of interpersonal communication that not only covers the usual technical perspective but also include administrative/managerial, environmental, social, political, economic, and financial perspectives.

The innovative approach to case studies and team activities represents the first attempt to research and develop a series of project management cases and team practices based on the integrated project life cycle from inception to completion. This course design teaches students that project managers in any software development must focus on the five functions of general management by first describing each function and then detailing the project management activities that support each function through five project phases:

- Initiation
- Planning
- Execution
- Control
- Closure

Course framework enhancement includes demonstrating student teams how a team manages a software development project with unified experience and efforts, discussing current software engineering management methodologies and techniques, and presenting general descriptions and project management problems in the six main project management areas:<sup>9</sup>

- Project initialization and scope management
- Project time and cost management
- Project quality management
- Project human resource and project communication management
- Project procurement management
- Project delivery

An example of course framework enhancement is that quality is a complex and multifaceted concept that can be described from different perspectives depending on the context peculiarities and the stakeholders. Although measuring quality is not a new theme, asking a software engineer to measure the quality of a software product may generally sound like an unknown or even a new aspect to the software development activity. The new course framework includes an attempt to emphasize importance of communication by presenting students various pertinent aspects of software quality from different points of view. New team activities are planned and designed for students to develop their communication skills by working on a number of software quality control case studies and team activities. Team activities further force students to actively participate in this important software development process by including member assessment and team project evaluation as a part of quality control process. Student team members take their turns to perform as a software development manager and a client in addition to a software practitioner to experience multi-dimensional communication from different perspectives.

One of highlights in this enhancement is to form student teams with multi-personality members to demonstrate that mixed personality does exist through team buildup. The mixed personality in specially designed team activity may become a negative factor in team work and cause miscommunications among team members. More importantly students learn to eliminate miscommunication and to reduce the chance of mismanagement in project development in these activities.

The new course framework is designed to demonstrate students all key elements of an effective software development process with an evolutionary improvement path for software development from an ad hoc, immature process to a mature, disciplined process. The path emphasizes on effective communication, team efforts, and full commitments. With the new course framework and its delivery methods software engineering students are expected to develop their ability to identify, adopt, and use sound management and technical practices for delivering quality software on schedule and at a reasonable cost.

## 5. Technology Focus in the Enhancements

Previous course module gives a very thorough description of project management, its key processes and levels. However, it does not give any practical advice on implementation. Newly developed course framework includes new emphasis on practical advice on implementation to make it much close to real life software project management.

An example of the new emphasis is to explore software project management practices to students and provide students with an in depth description on top of their basic understanding of software project management. Several new features can be applied to establish a picture of best practice resource planning in a project development and students would find it very useful to start dialogue with any business partner who shares interests in this issue.

Business often conducts discussions, meetings, seminars, and presentations for any size of project. To deliver, moderate, and control this kind of process can be a challenge to anyone without sufficient training. For example, participants in a presentation are often in different locations and only view presentations remotely through a screen via the Internet. The training to simulate this kind of communication activities becomes an important part in the new course framework.

Since today's communication media often relies on technology, any successful academic course of this type always includes trainings on effective usage of technology and helps student to master a simple presentation tool or choose effective delivery ways before they start to tackle project problems in every phrase of project life cycle. Communication tools, such as an Excel spreadsheet build and control a project budget including cost and time. A Gantt chart from Microsoft Project is often used to plan and track a project. The charts and graphs may become extremely helpful in presentations. However, students must figure out exactly what the graph is supposed to illustrate. The use of any graph in their project report and presentation is very applicable to any software development project. A graphical tool can be used for team members, business partners and particularly upper level management to understand how their organizations quantify development project resource in terms of capacity, demand and capabilities as well as to inform management process of project planning and status. With help of computer tools in project management a clear resource planning process helps upper level management gain their confidences in their decision making process.

Project management software is introduced in this course to demonstrate how to manage project and its resources efficiently. It provides different levels of functionality and efficiency even though there is always a trade-off among those attributes. Resource-constrained and multi-

project scheduling software has specific functions, powerful graphic features, and particularly budget features. Resource management software can manage from small to large scale projects with certain resources extending over many months. Resource management software can manage certain number of tasks involved in those projects and share resource control information across multiple projects. Resource management software can show critical path items in a project design, prototyping, testing and implementation. Most software can be used to control resources and usually show resource, time, and budget constraints at the same time. Majority of them concentrate heavily on resource management and generally do not involve juggling resources - simply time and money. Microsoft Excel meets most of requirements on resource management. If Excel does not meet all the project management requirements, alternative solution is a more sophisticated and powerful software, such as Microsoft Project. Microsoft Project can build a Gantt chart for project design, prototyping and task management in addition to cost and time management.

## 6. An Experiment in a Project Management Course with New Focuses

Traditional project management course uses lectures as a main teaching delivery method by introducing basic concepts of project management and five key phases of project management. Recent research finds that traditional teaching methods, such as lecture and quiz are no longer sufficient to develop student's practical knowledge and soft skills, such as communication. Lecture in this new course framework is kept at a very minimum level in this experiment.

Since the enhancement includes many student team activities as main delivery method for soft skill development, student team formation is viewed as the first key step prior to any team activity. Properly forming student teams with blended personalities can maximize student learning outcomes.

DISC is the four quadrant behavioral model based on the work of William Moulton Marston to examine the behavior of individuals in their environment or within a specific situation. It focuses on the styles and preferences of individual behavior. Research finds that characteristics of behavior can be grouped into these four major personality styles and they tend to exhibit specific characteristics common to that particular style. The assessments classify four aspects of behavior by testing a person's preferences in word associations. DISC is an acronym for:

- **Dominance** – relating to control, power and assertiveness
- **Influence** – relating to social situations and communication
- **Steadiness** (submission in Marston's time) – relating to patience, persistence, and thoughtfulness
- **Conscientiousness** (or caution, compliance in Marston's time) – relating to structure and organization

Students are divided into different student teams based on the results from their characteristic evaluation test DISC. Students are expected to experience different ways of communication and different approaches to problem solving and gain unique experience through working with other students with different personalities and characteristics of behavior in a number of team projects and activities.



New team projects and activities are added into the project management course. The team projects and activities are designed to lead students to go through entire project development life cycle and accomplish team assignments in every phase in project life cycle by using their soft skills:

- Team work and coordination
- Interpersonal skills
- Communication skills
- Critical thinking and problem solving skills
- Other professional career related skills

Certain communication skills are required in team projects and activities, such as defining an audience, working with collaborators, organizing presentations, drafting documents, developing graphics, and sharing ideas or facts with others in an efficient way. The team projects and activities provide students with ample opportunities to develop their language in general communication and share and promote their thoughts and ideas with other team members.

In the 21<sup>st</sup> century communication practices have been transformed to a new level by computer technology. Most of modern correspondence is transmitted electronically via electronic media. The change in this course also reflects this transformation based on the fact that today's workplace heavily relies on highly advanced technology to provide a variety of communication channels to support project development.

Besides multi-dimensional communication channels and communication technology deployed in team activities, interpersonal relationship is another focus point because multiple parties are often required to participate in all the development activities in the same project.

Other new activities are embedded into course teaching framework via a variety of new means:

- Team brainstorm session
- Interesting topic discussion
- Video demonstration
- Classroom discussion
- Speed discussion
- Discussion museum
- Team and individual presentation
- PowerPoint presentation techniques
- Critical thinking question
- Review question
- Problem-solving exercise
- Web exercises
- Case studies
- Project reports
- Presentations
- Career exercises

Team projects and business cases from work places are vital in improving student’s ability to convey their ideas and thoughts to others. Real life experience and examples enhance teaching scientific and practical communications to bridge the gap between the university novice and the seasoned professional.

To determine effectiveness of the new course framework and teaching delivery methods student’s opinions are collected via a variety of means and data is then processed by statistical methods. A survey usually provides a direct and effective way to gather student’s opinions on designed criteria. A number of surveys are designed with certain purposes and conducted at different phases of this course. Student team project scores are also used as an additional input to survey result analysis.

Each criteria or achievement in the end of course survey indicates extent of agreement or disagreement with the statements on a five-point Likert Scaling (1= Disagree and 5 = Agree). Participant’s perception from a qualitative perspective is converted and represented on the scaling. The sum and average numbers calculated from raw data are also used in this study to gather and support findings. Processed data in Table 1 provides a baseline of characteristics of software engineering student’s viewpoints on their course achievements as they are going through this specific designed course. Five criteria with highest scores in Table 1 are considered as five significant successes out of new project management course framework.

<b>regain confidence</b>	<b>4.9</b>
communication technique	4.4
team work	4
importance of communication	3.8
Leadership	3.5

Table 1: Software engineering student’s viewpoints on their course achievements

A bar chart in Figure 1 helps discover this finding easily. One of the most interesting findings out

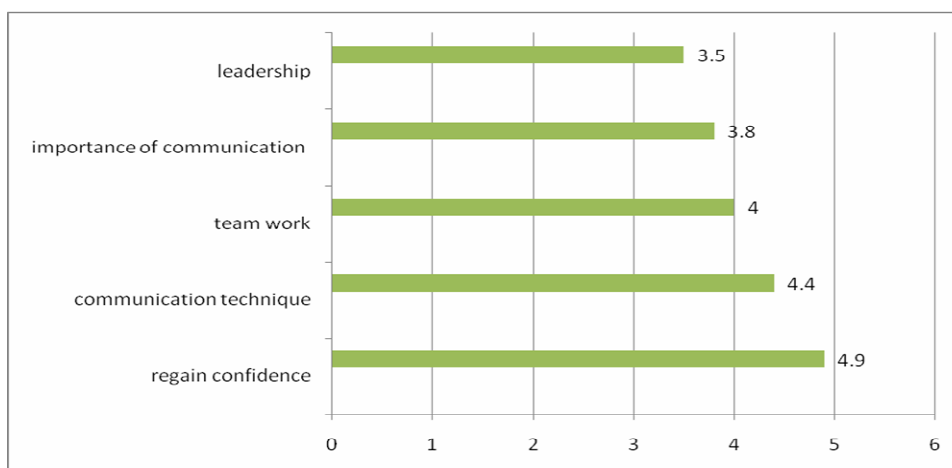


Figure 1: Software engineering student’s viewpoints on their new course module

of the end of course survey is that student's confidence level has reached to a much higher level. Many students agree that it is not difficult to master basic communication skills and have gained their confidence to master other communication techniques at the end of this class.

Another measurement used in this course evaluation is to trace scores of student team project work from beginning to the end of this course. Comparing two average scores in the same category at beginning and at the end of this course may provide useful information to determine which aspect of new course framework benefits students most. Student's soft skills are measured by their scores from their team project reports, presentations, and other activities at beginning and end of this course. An example of the Student Team Project Report and Presentation Rubrics in Table 2 is used to grade student team presentations. Grading in each category ranges from the lowest score 2 to the highest score 5.

Student Team Project Report and Presentation Rubric					
Category	2	3	4	5	Total
Organization	Audience cannot understand presentation because there is no sequence of information.	Audience has difficulty following presentation because student jumps around.	Student presents information in logical sequence which audience can follow.	Student presents information in logical, interesting sequence which audience can follow.	
Subject Knowledge	Student does not have grasp of information; student cannot answer questions about subject.	Student is uncomfortable with information and is able to answer only rudimentary questions, but fails to elaborate.	Student is at ease and answers most questions with explanations and some elaboration.	Student demonstrates full knowledge (more than required) by answering all class questions with explanations and elaboration.	
Visual Aids	Student uses superfluous visual aids or no visual aids.	Student occasionally uses visual aids that rarely support the presentation.	Student's visual aids relate to the presentation.	Student's visual aids explain and reinforce the presentation.	
Mechanics	Student's presentation has four or more spelling errors and/or grammatical errors.	Presentation has three misspellings and/or grammatical errors.	Presentation has no more than two misspellings and/or grammatical errors.	Presentation has no misspellings or grammatical errors.	

Eye Contact	Student makes no eye contact and only reads from notes.	Student occasionally uses eye contact, but still reads mostly from notes.	Student maintains eye contact most of the time but frequently returns to notes.	Student maintains eye contact with audience, seldom returning to notes.	
Verbal Techniques	Student mumbles, incorrectly pronounces terms, and speaks too quietly for audience in the back of class to hear.	Student's voice is low. Student incorrectly pronounces terms. Audience members have difficulty hearing presentation.	Student's voice is clear. Student pronounces most words correctly. Most audience members can hear presentation.	Student uses a clear voice and correct, precise pronunciation of terms so that all audience members can hear presentation.	
Group Work	Cannot work with others in most situations. Cannot share decisions or responsibilities.	Works with others, but has difficulty sharing decisions and responsibilities.	Works well with others. Takes part in most decisions and shares in the responsibilities.	Works very well with others. Assumes a clear role in decision making and responsibilities.	
				<b>Total Points (up to 35 points):</b>	

Table 2: Software engineering student team project report and presentation grading rubrics

An average score in each category from all student teams is calculated for evaluation purpose. Among the seven categories three categories show significant improvements. Student organization of their work, team work and visual aids usage are the areas where they have made significant progresses. This also helps prove that new course framework and teaching delivery methods benefit students work as a team and communicate with other team members well.

Soft Skills	Beginning of Course	End of Course
Organization	2.2	3.5
Subject Knowledge	4.5	4.7
Visual Aids	3.1	4.5
Mechanic	4.1	4.2
Eye Contact	2.3	3.8
Verbal Techniques	3.2	3.6
Group Work	2.9	4.6

Table 3: Software engineering student team project score comparison between beginning and end of course

Other areas, such as eye contact has improved significantly too. This indicates that students have understood importance of simple communication technique, mastered this kind of basic techniques in communication, and gained more confidence from their team activities.

Figure 2 illustrates comparisons on average scores in seven evaluation categories between beginning and the end of the course. The results conclude that original goals are reached to develop student's software skills.

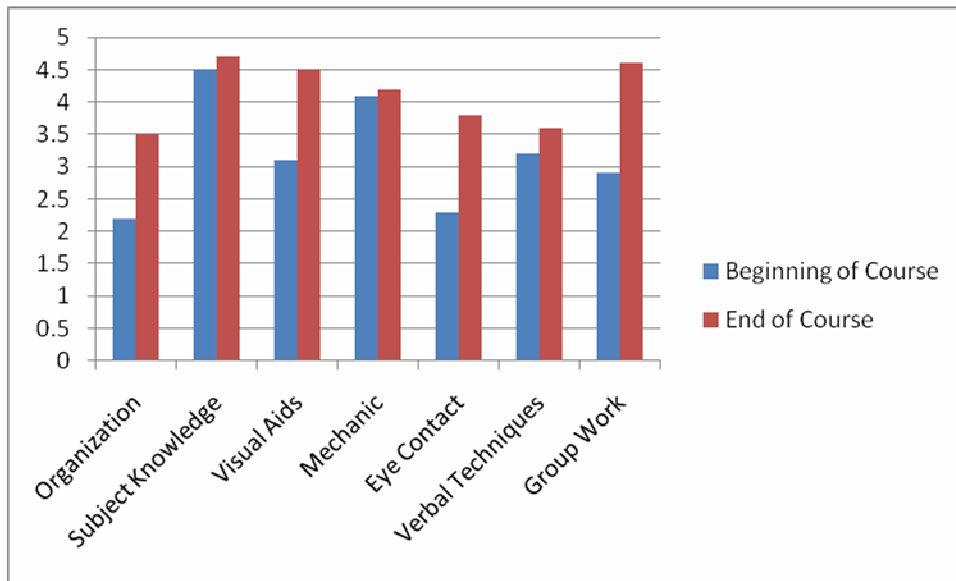


Figure 2: Software engineering student team project score comparison between beginning and end of course

In summary, as long as proper training and learning activities are provided to students to improve their skills in communication, they can achieve most of goals through these training activities. Student team project activities create such unique atmosphere to allow students to share their knowledge and experience. Students feel more comfortable to learn from others and are willing to help each other in a student team format. Observing each other's work helps students make their progresses together as they all move forward as a team.

## 7. Limitations of the Study

This experiment is mainly to test feasibility of the enhanced course framework with new focus on student's communication skills. Raw data is collected from a small sample of one instructor and eighty three software engineering students in this experiment. After data analysis preliminary results reveal that the experiment is successful and most of goals have been reached. However, it is still difficult to predict complete and accurate outcomes from a large engineering student population to support the findings from the experiment in this enhanced course module at this moment. Thus, further tests in a larger engineering student population are necessary in order to obtain more reliable test results for future engineering curriculum development with a special focus on communication and other soft skills.

## 8. Conclusion

This research develops and tests a new course framework for an existing software engineering project management course. The experiment focuses on development of student communication skills with newly integrated student team software development project, team activities, and software project management. The unambiguous evaluation and assessment on student project design and planning, project process issue handling evaluation, and project management reveal empowerment of human soft skill building and development. Preliminary results from the student course work, classroom activities, discussions, meetings, presentations, tests, and team project reports have met original expectations. The outcome evaluation, based on student team project reporting and survey results, proves that the new enhancement to the curriculum is effective and successful. The lesson learned from the experiment has laid out a solid foundation for additional course improvements and experiments in a larger student population in the future.

High quality of student team projects and activities can help engineering students master certain soft skills that are crucial in their future professional career. This experiment also sets up a model for any closely related academic discipline in engineering education. It is feasible to select proper soft skill trainings and build these trainings into student team projects and activities for another engineering course, curriculum or academic program.

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