

AC 2008-1383: A COLLABORATIVE CURRICULUM ENHANCEMENT WITH RECOGNITION OF CHARACTERISTICS OF CHINESE COLLEGE STUDENTS

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A Collaborative Curriculum Enhancement with Recognition of Characteristics of Chinese College Students

Abstract

This study aims to enhance a software engineering curriculum for a college in China, to eliminate gaps between the curriculum and rapidly changing requirements by foreign companies in China, and to ultimately help Chinese students to be prepared for their professional careers in the dynamic global economy.

Research is carried out to first examine common characteristics of Chinese students in this program in order to identify their strengths and weaknesses. The study recognizes Chinese students' strengths and particularly their success in mathematics and science based on literature reviews on other's work, personal experience interview and observation. It also reveals an important finding that overemphasis on understanding and memorization in mathematics and science in existing software engineering curriculum has become barriers for Chinese students to receive sufficient training in critical thinking and problem solving. Survey data analysis confirms the same finding by the fact that Chinese students have demonstrated lower performance on critical thinking and problem solving compared to their counterpart, American students. Outcomes of this assessment suggests to accept the hypothesis that Chinese students do not get sufficient training on critical thinking and problem solving and as a result generally they are less imaginative or creative in their professional careers despite the fact that software design scenarios involve open thinking and decision making.

Based on this research results a curriculum development task force comes up with a recommendation to address these issues. This recommendation consists of a set of new learning components with strong emphasis on critical thinking and problem solving. A number of successful learning components from reviewed American engineering curricula are identified and integrated into the Chinese software engineering curriculum.

Introduction

Prior to this study a preliminary research by a task force in a Chinese software engineering program realizes that it has become a trend that more and more higher education programs in China start to modernize their curricula in order to prepare Chinese students to meet the new demands as a result of rapid growth of global economy. This preliminary research suggests that it is crucial to first investigate the weakness of Chinese students in the program as well as the curriculum and then look for a proper way to integrate successful experiences from American higher education into the software engineering curriculum as a solution.

This research was first carried out to review other researches to find out common characteristics of Chinese students. A number of research publications summarize experiences to bring Chinese students into American engineering programs. Almost all

the researches share the same findings that Chinese students are hardworking³ and perform well in science and technology, especially in mathematics, logic reasoning and other related disciplines.^{2,5} Some studied the cause of Chinese student's success in these areas even further and believed that this is due to the unique philosophy in Confucian.² Research also indicated that Chinese student's strength in science and technology roots from their intensive education training from as early as their elementary school, middle school or high school.³ In addition their commitment to learning is outstanding and their eagerness to learn new technology is remarkable.³ Like most of Asians Chinese students are team oriented and easily fit into any role in a team with the nature of organization oriented spirit.⁴

Some note in their research that there is an urgent need to specifically help students to obtain needed resources and experiences in reinforcing their progress, building their sense of self efficacy, encouraging goal setting behavior and a commitment to remain competitive in a global economy.² The rapid changes in new global economy suggest the necessity to routinely upgrade existing engineering curricula to reflect these changes, and even send students abroad to experience different cultures and changes in business world.³ All the research firmly believe that there is no doubt that new ever changing global economy and multi-culture concepts have become key elements in any engineering curriculum. In addition to that successful experience of American higher education could be a great asset to Chinese engineering curriculum development.^{3,4}

Based on these literature reviews engineering curricula in China is no exception to reflect this change. As a result the author was recently involved in a number of projects and worked for a Chinese higher education institution to enhance its undergraduate software engineering program curriculum with introduction of global economy and multi-culture concepts. The general approach is to first identify weakness of Chinese software engineering students by comparing differences in characteristics between Chinese students and American students. The second step is to investigate causes of the weakness and to discover what are missing in the existing curriculum. The final step is to come up with a recommendation to choose proper learning components from American engineering programs and apply their successful experiences in the curriculum to optimize outcomes of the curriculum. The ultimate goal is to develop a new curriculum experimental model to constantly update this software engineering curriculum based on successful experiences in American engineering curricula and meet the needs by the future "global" engineers who will comfortably maneuver in an international environment.

Research on Chinese Engineering Student's Strength and Weakness

Needless to say studying traditional Chinese education methods is the pathway towards to findings of Chinese student's strength and weakness. Weakness can be easily identified by investigating unique characteristics of Chinese and American engineering students and measuring differences between them. Thorough examination of their strengths and weaknesses assist to discover the differences which will be used to guide this research

and discover solutions for existing Chinese software engineering curriculum by manifesting strengths of American academic programs.

Identification and analysis on student characteristics merely starts from personal experience and observations by polling views from author and other Chinese instructors who have taught Chinese students for years. This work also includes curriculum review, interview, observation, evaluation, survey design, data collection, data analysis and scientific reasoning to identify weaknesses for future enhancements in the software engineering curriculum. This analysis particularly includes examining:

- Team projects
- Senior student capstone project reports and Master's degree thesis
- Curriculum for software engineering
- Student end of course survey

Curriculum Review, Interview, Observations, Evaluation, and Survey Studies

Although this study mainly relies on quantity data analysis from observation, evaluation and survey, it is still feasible to review existing curriculum, interview Chinese instructors for their valuable personal experience and observe a sample of student's project work first. Personal experience is always easy to obtain and results could be directly used to gather findings. Interviewing Chinese instructors to obtain their personal experience is an important step in this study since they have first hand experience in curriculum and characteristics of Chinese students. Team project reports and thesis are reviewed to measure levels of student's critical thinking and problem solving skills.

Findings are gathered from interview and more than 90% faculty members interviewed agree that it is essential to recognize the fact that technology and globalization have significantly changed the work environment in China and reshaped the map of workforces in China. All firmly believe that critical thinking and problem solving ability can not be trained by simply memorizing concepts or theory of software engineering. They substantially support this initiative to help their students to become a critical thinker and a problem solver. As traditional barriers to introduction of western learning model have been removed, Chinese engineering program should include successful experiences that are carefully selected from American higher education programs to meet the challenges of this dynamic global economy. The curriculum needs to be constantly updated to provide sufficient training on the 21st century skills to their students.

A number of interesting findings that coincide with other's findings from literature review are summarized below:

- **Commitment to Learning and Motivation:** Most of Chinese students are self-motivated and committed to their learning.
- **Learning Methods:** Chinese students demonstrate amazing ability to comprehend and memorize difficult concepts in their textbooks and make a full use of examples in solving problems in their assignments independently. They even can grasp most of key concepts through their reading assignments prior to their class.
- **Critical Thinking and Problem Solving Skills:** Most of Chinese students need clear instructions and similar examples to guide them throughout their projects.

Their strength is clearly demonstrated by the fact that they are capable of solving the problems similar to the examples in their textbooks. When they encounter any difficulty of a problem that is not close enough to any example in their study, their reactions have quickly become negative because they often have difficulty to be a self learner to search for a solution on their own. They are not any effective communicators to be able to seek help from available resources either.

- **Modern Project Management, Team Work, Collaboration, and Communication Ability:** Their ability to communicate and share their thoughts and ideas as well as to collaborate team efforts is not as strong as American students due to lack of training on effective communication and collaboration. Most of time they try hard to save their faces instead of communicating with their instructors well enough to obtain help or guidance.
- **Global Awareness:** The curriculum was never specifically geared to meet the general criterion of student understanding of the impact of engineering in a global and societal context. As matter of fact it failed to demonstrate any interest to raise any awareness of global economy.

Observation and evaluation include evaluating software engineering curriculum and examining senior Bachelor’s degree capstone project reports and Master’s degree theses. Both senior capstone projects and Master’s degree thesis samples are randomly selected from last four academic years. Creative problem solution is hardly found from existing student’s capstone project or even Master’s degree thesis or existing curriculum.

Each criteria in evaluation 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 was converted and represented on the scaling. The sum and average numbers calculated from raw data are also used in this study to gather findings. This information in Table 1 provides a baseline of characteristics of Chinese software engineering students as they are going through their academic program.

Comparisons between Chinese Engineering Students and U.S. Engineering Students	U.S. Students	Chinese Students
Classroom Participation and Discussion	4.5	3.0
Self-Motivated and Individual Efforts	3.5	4.5
Cross-cultural Experience	3.0	2.0
Problem Analysis and Solving	4.0	1.5
Critical Thinking	3.0	2.0
Mathematics Skills	2.0	4.5
Communication and Presentation Skill	4.0	2.5
Team Oriented	3.5	3.0
Totals	27.5	23.0
Average	3.4375	2.8750

Table 1: Observations and reviews for comparisons of characteristics between Chinese and American students

Two calculated sample means from all measured results indicate that Chinese students are predominantly lower than their U.S. counterpart. Analysis on Figure 1 that is built based on Table 1 reconfirms the evidence of significant differences in selected learning categories between U.S. students and Chinese students probably caused by different academic training approach and knowledge development philosophy. This coincides with the finding from personal experience interview. Preliminary research on differences concludes:

- Chinese students are self-motivated and complete their assignments without any comprise as long as methods used in their assignment are related to course contents. However their ability to effectively communicate in classroom to enhance their learning is not impressive compared to American students.
- Chinese students have strong logical reasoning benefited from mathematical training, but insufficient experience in critical thinking prevents them from dealing with open ended problems successfully and many encounter enormous difficulties to tackle problems that are beyond examples in their textbooks and additional experiences are required.
- There is no evidence that Chinese students are capable of coordinating team efforts due to their insufficient training on communication and team work.
- Chinese students have strong mathematics skills due to strong emphasis on mathematics through entire education system in China. However their ability to utilize their mathematics skills in problem analysis and solving is not impressive.

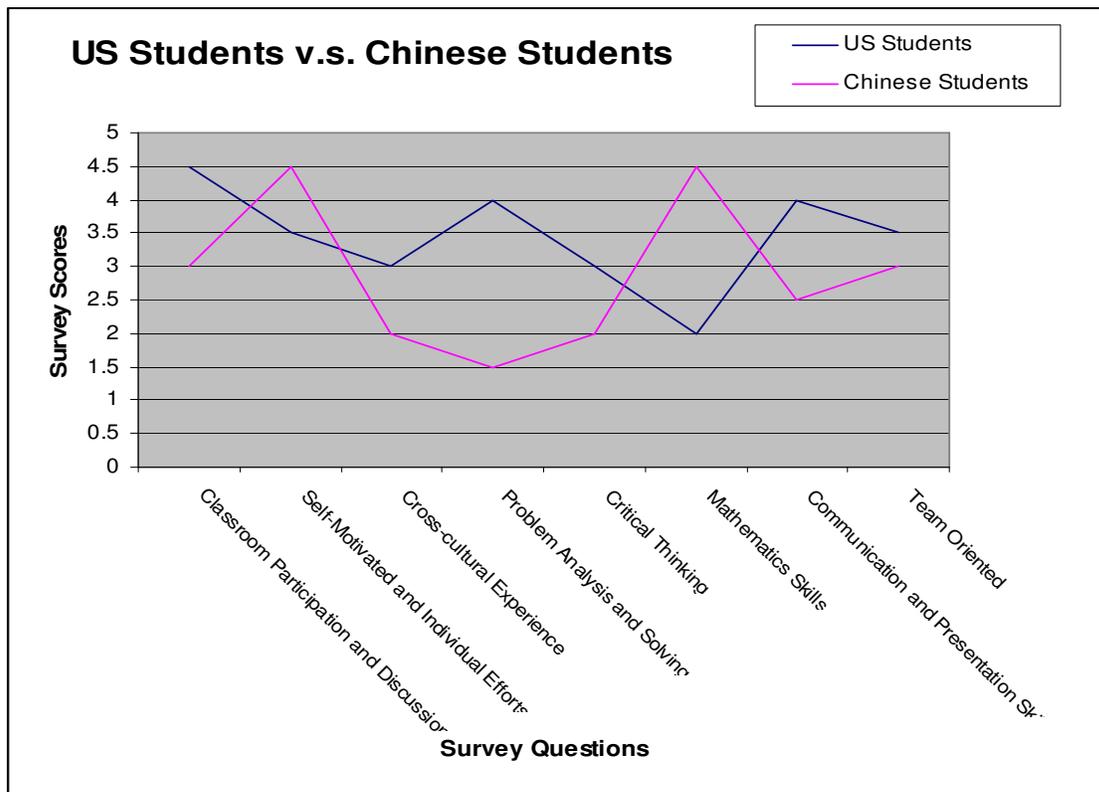


Figure 1: Responses on the comparisons between Chinese and U.S. students

A significant finding is that Chinese student's ability to tackle problems is way below American counterpart and aptitude in critical thinking skills is below their American peers although Chinese engineering students exhibit higher achievement in mathematics than their American counterparts. All the evidences tend to prove that ability to solve practical problems is beyond mathematical skills. Insufficient critical thinking and problem solving training makes Chinese students become passive learners.

Further analysis reveals that while success in mathematics and science can be attributed to the Chinese teaching methods, overemphasis on textbook study and previous experience has reduced and even eliminated their opportunity to enhance their ability in independently solving problems. This is supported by the finding that their knowledge on using other resources is extremely limited. When Chinese students encounter difficulties, they are unable to optimize usage of available resources due to over emphasis on relying on course contents and lack of training on communication or coordination skills. Clearly overemphasis on textbook study and previous experience has compromised development of their creativity in problem solving and has caused Chinese students to become less imaginative. Lack of emphasis on effective communication among a team copes with challenges of sharing thoughts and experiences on critical thinking and problem solving. This confirms negative impact caused by neglecting importance of team oriented training in the software engineering program. Another interesting finding (not shown in Figure1) is Chinese students are not familiar with project management concepts like constraints on time, human power, finance, and budget due to lack of project management training.

Survey

A survey is a scientific tool to collect opinions from a sample or a population and provides a snapshot of viewpoints on a designed subject from participants. Statistics analysis on quantitative and qualitative performance data collected from a Chinese student study group can reveal findings and finally helps to reach a conclusion.

A survey was administered as another main assessment in order to evaluate Chinese student's status and to determine how reliable original assumptions and findings from literature review, interview and observation are. Preliminary data analysis starts during data collection while the survey is being conducted in this research. The survey consists of a series of attitudinal questions where each student was asked to indicate their extent of agreement or disagreement with the statements on a five-point rating scale. The five-point rating scale is a set of categories designed to elicit information about a quantitative attribute in survey question design. To reflect the perceived quality of a survey question in this survey Likert scaling (5 = Agree and 1=Disagree) is used to test a bank of questions that was developed with a specific group of considerations and questions targeting the original core assumptions.

An initial survey was developed to evaluate student's responses. Since then the survey has been modified over time to reflect more important aspects of the research. This survey includes questions targeted to evaluate the outcomes from curriculum, student learning, student capstone project reports and thesis. Some questions are contrast

different project types and specifically relevant to the team project experience. There are two categories of questions in this survey: Student Responses on Existing Curriculum and Student Responses on Future Curriculum Improvement:

- Number of Response: Total number of students who responded a specific question.
- Total Points: Sum of students' point from their responses on a five-point Likert Scaling (with 1 = Disagree and 5 = Agree).
- Average Point: Total Points divided by Number of Responses.
- Percentage of Response Points in Total Points: Total points from survey response divided by total possible points in survey (15)

Survey Questions	Number of Response	Total Points	Average Point	Percentage of Response in Total Points
Student Responses on Existing Curriculum:				
"I received a basic understanding of principles in Software Engineering"	14	68	4.86	97.14%
"I received a clear understanding of key steps in SDLC"	14	70	5.00	100.00%
"I received a basic understanding of critical thinking and problem solving in Software Engineering"	15	51	3.40	72.86%
"I received a basic understanding of project management"	10	35	3.50	70.00%
Student Responses on Future Curriculum Improvement:				
"I expected an introduction of Cross-Cultural Scenario"	15	68	4.53	97.14%
"I expected a basic understanding of differences of Chinese and Western culture in today's working environment"	15	75	5.00	100.00%
"I expected a basic training on personal communication and Presentation"	14	66	4.71	94.29%
"I expected an introduction of key project management skills in addition to SDLC"	14	65	4.64	92.86%
Totals	15	75	5.00	100%

Table 2: Responses to capstone project-related curriculum questions on the survey by students

Survey Assessment

A total of 32 students completed one category of survey questions and among 32 students some completed both categories of survey questions. With on-going data analysis is conducted, survey assessment from the quantitative results in Table 2 confirms the previous hypothesis and is also coincident with the interview and observation from a qualitative perspective in previous part of this research. Additionally, survey results of

the corresponding perceptions for U.S student group revealed in other researches are used in comparison with survey result assessment in this research.

Survey and curriculum examination did not find any evidence to demonstrate that development of critical thinking has been put at any priority in existing curriculum. Students tend to rely on guidelines or examples from either textbook or lecture to solve similar problems. Teaching content and assignment need to be recreated based on the most negative or lowest results in this survey. Other interesting findings are found in comments section of the survey from Chinese students:

- Chinese students are used to Chinese traditional teaching methods deeply influenced by Confucian. They are proficient at looking for solutions from previous examples from instructors or textbooks.
- Chinese students are not familiar with other cultures although they have no hesitation to embrace other cultures in global working environment.
- Current curriculum does not provide holistic engineering solutions that are sustainable and appropriate to the challenges in global working environment.

Previous Research on Enhancements of Student Study

Survey results have reconfirmed a main issue, i.e. lack of critical thinking and problem solving training in Chinese software engineering curriculum. A number of reputable scholars, such as, J. Mayer, T. Angelo, J. Kurfiss, W. McKeachie, and M. Svinicki, have published their research results on student learning methodology and their research results are used as guidelines in curriculum improvement. All researchers shared their common views on the purpose of study and investigation, that is to explore a situation, phenomenon, question, or problem to arrive at a hypothesis or conclusion about it that integrates all available information and that can therefore be convincingly justified. Regarding to critical thinking, all assumptions are open to question, divergent views are aggressively sought, and the inquiry is not biased in favor of a particular outcome.^{6, 7, 8, 9}

Regarding to college teaching and learning, McKeachie, Pintrich, Lin, and Smith concluded that three teaching approaches can improve students' critical thinking: student discussion, explicit emphasis on problem solving, and verbalization of metacognitive strategies.^{5, 9} Mayer states, "The key to developing critical thinking lies in creating conditions for participation rather than passivity, and in providing opportunities for emotional engagement with the materials".⁶ As Mayer further notes, passive spectators are not especially prone to creative social criticism. Most formal definitions characterize critical thinking as the intentional application of rational, higher order thinking skills, such as analysis, syntheses, problem recognition and problem solving, inference, and evaluation.⁷ All assessments and other scholar's research support to include new learning components that aims to educate students to become:

- A critical thinker
- A problem solver
- An innovator
- An effective communicator
- An effective collaborator

- A self-directed learner

Proposed Enhancements for Chinese Software Engineering Curriculum

Successful experience of American higher education provides us with enormous resources and successful experiences in critical thinking and problem solving. The significance of American higher education is to address interests in the creative and commercial aspects, student motivation, student-instructor relationships, communications, and English proficiency regarding reading, writing, and speech. Project management, planning, team work, time and budget management are integrated into projects in American engineering curricula. Such an approach obviously makes good sense to address issues like lack of training on problem solving skills, ability to deal with conflicts, team organization, and engineering way to organization, project development, finance awareness, and software for project management through a variety of academic activities.

The main goal of this enhancement is to help Chinese students to broaden their views from narrowly designed technical background, develop their critical thinking skills in problem solving and prepare them for their future growth in any type of business environment. A collaboratively improved curriculum includes a great deal of curriculum enhancements with focuses on following three themes:

- **Soft Skills:** Research outcomes indicate that fundamental technical skills and professional skills are both equally important and both need to be balanced although developing fundamental technical skills is still the core of the existing curriculum. Additional training on soft skill, such as project management and communication, enhances fundamental technical skill development.
- **Critical Thinking and Problem Solving Skills:** Students are trained to be able to obtain any resources available and reinforce their progress in problem solution development when they are dealing with any problem.
- **Personal Presentation and Communication Ability:** Students are able to share their thoughts and new ideas with others in a number of effective ways. They should also be able to communicate with others and clearly express their thoughts.

The enhancements fully take advantage of successful experiences from American engineering programs to strengthen student's ability in critical thinking and problem solving. It has to be pointed out that the original curriculum and its structure do have their reasons to exist for years because its core philosophy of providing students with a broad knowledge of software engineering has been invaluable to help students to prepare for their future professional careers. While keep core of existing curriculum unchanged, a number of new enhancements for the curriculum in several aspects are included in new proposal:

- **Critical Thinking and Problem Solving Skills**
Establishment of an area with special interest in critical thinking and focus on to design a core course with clear goals and agenda reflect the American education system philosophy throughout the program.

The project proposal is the most important document involved in numerous critical thinking in any project process. It is the basis for getting the buy-in and agreement from the sponsor and other stakeholders and decreases the chances of miscommunication. This document that will most likely grow and change with the life of the project include analyzing problems, determine goals, setting up scope and preparing document. Because there is not always a model to copy from, critical thinking is essential to success of project proposal.¹ New student assignments should include clear requirements on its structure and every component:

- Project Proposal
 1. Development Goals
 - The goals are usually from the previous design phase and are divided by their functions or applications or customers
 2. Development Resource and Development Teams
 - Organization of Project Teams
 - Organization of Management
 - Main Contacts to Customer
 3. Define roles and responsibilities:
 - Customer contact
 - Project management structures
 - Project development teams
 4. Develop a scope statement:
 - Business need and business problem
 - Project objectives
 - Benefits of completing the project, as well as the project justification
 - Project scope
 - Key milestones
 5. Develop a Project Design document:
It is essential that the system design documents Project Goals, Current State, Future State and Design Specifications
 - System Analysis and Description
 - System Requirements
 - Application Interfaces (Screens, Web Pages and Reports)
 - Development Plan
 - Resource Plan
 - Web Design (if any)
 - Report Design
 - Maintenance Design
 - Database Design
 - Preliminary QA Test Design and Plan
 - Implementation Process and Plan
- Personal Presentation and Communication Ability

Presentation and communication are built into curriculum whereas required. Needless

to say it has been challenging to identify new proper activities for the new curriculum where presentation, communication, and collaborations are essential:

- Team communication to define roles and responsibilities:
 - Customer contact
 - Project management structures
 - Project development teams
- Development Plan Presentation
 - System Plan
 - Team Resource Plan
 - Management Plan
 - Budget Plan
- Cost and Time Management
 - Project Budget
 - Project timeline and milestones
- Define basic components of the project plan:
 - Baselines: These are the project's three approved starting points for scope, schedule and cost. These provide the stakes in the ground, and are used to determine whether or not the project is on track during execution.
 - Baseline management plans: These include documentation on how variances will be handled throughout the project.
 - Other work products from the planning process: These include plans for risk management, quality, procurement, staffing and communications.

Limitations of the Study

At this moment it is still hard to predict the complete outcomes from the new curriculum or determine whether or not all the new objectives have been achieved. After the curriculum changes were made, preliminary results out of the new curriculum are very encouraging. Just as expected it shows the sign that the quality of student projects have significantly improved and it is predicted that over the years the quality of learning will improve considerably with proper contents, style and format. However, it still remains to be seen whether or not this curriculum has provided sufficient training opportunity to students to make them become successful in this global economy. It takes time and effort to prove it and requires further study and endless updates. Therefore, this work is a continuous effort through a critical peer review on feedback and other results in order to meet continuously ever changed requirements in this global economy.

Conclusion

In summary, this research found out some missing puzzles from a Chinese software engineering curriculum in this global economy and tested the new approach to integrate successful experiences from American engineering programs into a Chinese software engineering curriculum. This research proves that it is feasible to apply successful American higher education experiences in a Chinese higher education program development. This new addition to the existing curriculum model not only set up a model

for any computer science related academic program in China, but also may have its impact on other academic disciplines, such as, education, nursing, business management and engineering. The issues addressed in this research, particularly the strengths and weakness of Chinese students and higher education, will bring fresh new components into Chinese higher education and eventually benefit future economic growth in China.

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