



## **How to Build an American Classroom Environment in a Chinese Engineering College**

**Dr. Wangping Sun, Oregon Institute of Technology**

Dr. Wangping Sun is an associate professor at Oregon Institute of Technology.

**Dr. Qi Zhang, Yangzhou University**

An Assistant Professor from School of Mechanical Engineering at Yangzhou University

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## Abstract

The engineering education in China has made a lot of promising changes recently. The Chinese educators are actively aligning their teaching styles, course materials and utilization of available resources with the popular practices in the western countries (such as the US). The authors of the paper piloted a graduate course, Advanced Manufacturing Systems, in spring 2014 at Yangzhou University in China. An American classroom environment was simulated in this course. It was taught in English and covered a wide range of up-to-date manufacturing topics. It was also project-based and involved large amounts of in-class discussions. The student feedback was exciting. In this paper, the authors will introduce how the course was designed and taught. They will also share their plan for the future research.

## Introduction

The primary goal of engineering programs is to prepare the engineering students for their professional careers in the global setting<sup>1</sup>. Ideally, the educators should teach in a well-managed, student-centered environment with reasonably structured framework. They should stress fundamental knowledge, equip the students with solid skills and expose them to cutting-edge technologies<sup>2</sup>. It has been found that obtaining practical knowledge from college is more beneficial to the students' professional career than mastering any new technology<sup>3</sup>. An effective learning environment should help the students enhance their ability to solve practical problems<sup>2</sup>.

Globalization of the engineering enterprise has not only impacted its practices but also the engineering education in unbelievable ways<sup>4</sup>. Engineering professionals must be able to function in a multi-cultural, diverse business environment. The higher education must be responsible for providing an environment that enhances the students' professional development<sup>2</sup>. As a "global manufacturing factory" and an enormous market, China has become an important training base for engineering and technology<sup>5</sup>.

Traditionally, the Chinese engineering educators only focused on "their specific fields and ignored building a broad basis of development and research methods"<sup>2</sup>. Overemphasis on theories and lack of training in practical knowledge, innovation capability and interpersonal skills have existed in engineering curricula in China for a quite long time<sup>1,5</sup>. Therefore, it is of high priority to enhance the ability of the Chinese engineering students in critical thinking and practical problem solving<sup>1</sup>.

More and more educators have advocated for a change in the styles of teaching Chinese engineering students. They believed that professors should be encouraged to alter the traditional hierarchically-structured "cramming method of teaching". A combination of new teaching strategies should be explored and applied, including: in-class lecture, self-study, open discussion, self-directed research, hands-on learning, and innovation activities.<sup>6</sup> Some educators have found that introducing American engineering education style could stimulate the Chinese

students' creative thinking and help them apply their knowledge at a higher level <sup>1,5</sup>. They believed that the application of the successful experiences of American higher education could be an asset to the development of the Chinese engineering curriculums <sup>7</sup>.

During the last decade, the Chinese higher education programs started modernizing their curricula to meet the demands from the rapid growth of the global economy <sup>7</sup>. Through the collaboration among Chinese universities and universities in western countries (especially American universities), engineering educators tried to integrate the best practices from the American engineering education with the existing engineering curriculums in China. For example, Zeng et al designed a comprehensive test plan in a junior software development project. Their research showed that it was feasible to apply American higher education experiences in the Chinese higher education programs <sup>5</sup>. Zorowski believed that the differences between American and Chinese education styles can make these two cultures cooperate effectively to achieve better student performances and higher educational goals <sup>4</sup>. All the recent research has indicated that when merged in the American engineering education environment, the Chinese students can more effectively learn how to function within the American culture and develop traits (such as innovation, management skills and organizational leadership) that are hard to cultivate in the Chinese culture <sup>2</sup>.

After literature review, one important question remains unanswered. What specifics are needed so that an American classroom environment can be effectively and systematically be integrated with an existing engineering curriculum in a Chinese engineering college? In following sections, the authors will answer this question through a case study piloted in spring 2014 at Yangzhou University, China.

### **Building an American classroom environment at Yangzhou University**

Yangzhou University is a public school founded in 1902 in Jiangsu Province, China. It has 2,000 faculty members and 31,000 students. There are 92 undergraduate programs, including art, music, humanity, natural science, business, engineering, architecture, computer science, medicine, agriculture, animal husbandry, etc.  
([http://en.wikipedia.org/wiki/Yangzhou\\_University](http://en.wikipedia.org/wiki/Yangzhou_University))

In spring 2014, the College of Mechanical Engineering gave the approval to the authors of the paper to design and pilot a graduate engineering course, *Advanced Manufacturing Systems*. It was a 40-hour, lecture-based, interdisciplinary course that covered material processing, process improvement and process optimization. The course was taught in English and the American engineering teaching style was adopted.

#### Approach to build the American classroom environment

In the US, the instructor usually uses project-based learning to motivate the students' interests <sup>8</sup>. The class is more flexibly-structured and the instructor is less authoritarian <sup>9</sup>. There are more open-ended questions for the students to discuss and interact with the instructor. A lot of real applications of the theories are demonstrated in class <sup>10</sup>.

However, the Chinese learning style is drastically different from that in the US <sup>2</sup>. Sometimes, it is just the opposite of the American style. Under such a circumstance, the Chinese students have formed their own uniqueness <sup>1, 2, 7, 11, 12, 13</sup>:

- 1) Their commitment to learning is outstanding and their eagerness to learn new technology is remarkable.
- 2) They have strong mathematical and logical reasoning skills, which they benefited from the mathematical training since their early childhood. They are more comfortable with the technical details, such as computer programming and data analysis.
- 3) They are more permissive and passive since the Chinese education system is built on an ancient teacher-centered system that goes back thousands of years. There is less student involvement or interaction during class.
- 4) They demonstrate lower performance on critical thinking and problem solving. They have insufficient experience in decision making. Many of them feel difficult to tackle the problems that are beyond the examples from textbooks.

It can be seen that placing the Chinese students in an American education environment will help them overcome their academic weakness. Also, the class environment can be better nourished by the students' academic strength and capability.

However, the American teaching style creates challenges for the Chinese students as well <sup>1, 2, 7, 11, 12, 13</sup>. These challenges are primarily reflected by the language and cultural barriers, such as lack of written and oral communication skills in English, unfamiliarity in English technical terminology, and lack of involvement in classroom dynamics. The authors of the paper believed that if the instructors can effectively help the Chinese students get over these barriers, the students will gain much more from the American classroom environment. To build such a learning environment, the instructors built a three-step model: 1) set up the practical pedagogical goals, 2) select the suitable topics and 3) utilize motivating strategies in the classroom.

#### Setting the practical pedagogical goals

The ability of critical thinking and the practical knowledge for problem-solving can be acquired through the training in four areas <sup>1</sup>: 1) communication - the expression, transmission and interpretation of knowledge and thoughts; 2) research - the ability to conceptualize problems and search for specific knowledge to find solutions to solve those problems; 3) human relations - use of interpersonal skills to resolve conflict, network with and help people; 4) organization, management and leadership - ability to supervise, direct individuals to complete tasks and fulfill goals.

By following this guidance, the instructors of the Advanced Manufacturing Systems set up the goals of the course: foster the problem-solving and critical thinking ability of the students by 1) enhancing the training in the above-mentioned four skill areas; 2) introducing the up-to-date engineering philosophies and technical methods in modern manufacturing systems; 3) making the full use of the students' strength in analytical skills and explore their creativity. After taking this class, the students should achieve the following learning outcomes:

- 1) Master the fundamental knowledge of different manufacturing processes, and be able to use the qualitative and quantitative approaches to evaluate and improve their operations.
- 2) Interact frequently in English with the instructors.
- 3) Experience the American classroom environment.
- 4) Be able to write technical reports and present these reports in English.

### Topic selection

The instructors put forth four criteria for selecting the specific topics to be covered. Firstly, the topic should help address the weakness in the Chinese teaching style. It should provide them with an opportunity to demonstrate their creativity. Secondly, the topic should open up the students' mind and demonstrate the latest trend in manufacturing. Thirdly, the topic should be engineering-oriented that fully utilizes the students' intellectual potentials in math and analytical skills. Fourthly, the concepts should be understandable and acceptable by the Chinese students without any overwhelming cultural barriers.

After screening among the prospective topics, four were chosen: 1) Introduction to Manufacturing Systems; 2) Exemplary Manufacturing Processes; 3) Non-traditional Machining processes and 4) Lean Manufacturing. It is worthwhile noting that Lean Manufacturing meets all four criteria above. The instructors saw no barrier for the students to comprehend and apply this concept since it was originated from the Oriental culture <sup>14</sup>.

### Strategies in the classroom

Specific teaching strategies were made to motivate the students:

- 1) Communication and human relations skills: a) students were rewarded verbally or with chocolates for their active interaction with the instructors; b) every student was required to do a real-world project; the project was preferably team-based; to ensure the project to go forward continuously, the students were required to give project update in every class.
- 2) Research skills: the students were encouraged to relate what they learned in class with their research; the students were rewarded with chocolates and bonus credits if they came up with any creative suggestion to improve their current research.
- 3) Organization, management and leadership skills: the students were required submit a complete project report in English at the end of the course; each report must be presented (preferably in English) to the whole class; the team lead of the project was rewarded with chocolate and bonus credits.
- 4) Talents in math and computer programming: several programming assignments were assigned when production optimization was taught; the students could choose any language (C, Java, Visual Basic, MATLAB) to finish the assignments. Two representative assignments were: the Travelling Salesman Problem <sup>15</sup> and Direct Clustering Algorithm<sup>16</sup>.
- 5) Language barrier: the instructors anticipated that the students may have language difficulty if the course was completely taught in English. Based on their previous experiences to teach the Chinese and American students, the instructors prepared three plans to overcome the language barrier: a) when a straightforward subject matter (e.g. a

production process, a flow chart, a diagram, an equation or an algorithm) was introduced, the instructor would teach it in English thoroughly; b) when a concept with a moderate mindset challenge was introduced (for example “why should a pull system be used in manufacturing?”), the instructors would use English to explain the concept. During the instruction, real-world examples should be used to help the students visualize and digest the concept more easily; the instructors should also write down all the keywords on the blackboard; these keywords would ensure the students to follow the lectures closely without getting lost; c) for the concept with a sharp mentality contrast (such as Jidoka, one-piece flow), the instructor should use Chinese (the students’ native language) to clarify the most ambiguous part or the essence of the concept.

- 6) Final reward: at the end of the whole course, the instructors and the students would nominate the outstanding students. The criteria of choosing these students are: interaction in class, creativity of the projects, and innovative findings in their research areas. University T-shirts were given to these students as a trophy to appreciate their hard work and creativity.

### Implementation of the teaching strategies

Teaching of Lean Manufacturing took 70% of the course load. The introduced concepts included: muda, value added analysis, WIP, 5S, setup reduction, preventative maintenance, cellular manufacturing, one-piece-flow, Kanban, Kaizen, Takt time, JIT, pull/push systems, Jidoka, Poke-Yoke, etc. The textbook was *The Kaizen Revolution* by Michael D. Regan (ISBN-13: 978-0966354973)

The instructor divided each lecture into three parts: in-class discussion, case study, and project update/presentation. The students were required to read the textbook before every lecture (3 chapters, about 25 pages) and write 5 Aha’s for each chapter they read. An Aha is anything that the student felt surprised, pleased, true or false that they wanted to comment on and share their real-world experiences with the whole class. Figure 1 is an example of the Aha’s from a student homework.

Chap/page of the quote	Quote from the book	Your comments	Real world case you found
1.chap1, p.3	An overseas supplier who can meet the delivery and quality goals we are asking for.	It is so common in our world. It is the goal of many enterprises.	Some companies, such as Adidas and Nike, moved their manufacturing factories to the Asian countries where they could get cheap raw materials, pay less money to the workers and spend less in transportation.
2.chap1, p.3	We have chosen another vendor. I will walk you out now.	Because of the pursuit of profit, even the partnership between two close friends could be broken at any moment	The worldwide fashionable game “World of Warcraft”. The company changed its agent from the Ninetowns to Net Ease in 2009.

Figure 1. An example of student homework.

It took a student about half an hour to read through three chapters for each homework assignment. However, to find five distinctive Aha's from each chapter was not easy because each Aha had to be associated with real life experiences or observations. Some students spent two hours to write 15 Aha's. They needed to read all the chapters a few times, digest all the concepts thoroughly, link these concepts with the real world cases, and write down their comments. By the time they finished 15 Aha's, they had formed a deep understanding of the course materials they had learned.

The second part of each lecture was case study. The students watched the SME (Society of Manufacturing Engineers) video series that introduced Lean Manufacturing implementation cases in the real world. The students watched each video twice. When watching the video the first time, the students were asked to answer a list of questions. After that, the instructors led the whole class to go through these questions with the answers, explanations and discussions. Then, the students watched the video for the second time to clarify and strengthen their understanding. Figure 2 shows sample questions of a case study.

#### **Poke-Yoke: Mistake Proofing**

- Poke-yoke aims at ...? (get rid of process errors)
- The benefits of eliminating the production errors include ...? (C, Q, D improvement; reliability, predictability, schedulability, )
- The first step to do to build a Poke-Yoke system is to ...? (understand why the mistakes happens, the root cause analysis)
- Sometimes to get a line worker involved to build a poke-yoke system because ....? (she can come up with a simpler solution than yours)
- The second step to build a poke-yoke system is to ... (analyze the data logically)
- The method used in the second step to build a poke-yoke system is called ...? (fish bone diagram)
- Another method used in the second step to build a poke-yoke system is called ...? (5 whys technique)
- How does the 5-whys method work? (each time a deeper question is asked, the root cause can be found out as the whys go along)
- The third step to build a poke-yoke system is to ...? (record the root problem simply)
- What is this tool called? (go-no-go gage)

Figure 2. Sample questions and answers of a Lean Manufacturing case study.

The third part of the lecture was project update and presentation. Each student must find a project related to the implementation of the Lean Manufacturing concepts. The project should focus on improving manufacturing process, service quality, engineering design and research. In each lecture, the students were required to report their project progress to the whole class. The students must give two presentations. The first presentation should introduce the problem statement, project goals and objectives, and project schedule. In the second presentation, the students should give a full report of the project achievements. As observed by the instructors, doing project was the most enjoyable part for the students. They spent hours on the project,

visiting the project sites, discussing with their colleagues, thinking about problem-solving methodologies and researching the academic literature.

The teaching strategies were fully implemented from day one. After the first lecture, there was a slight drop in the class attendance. The students who dropped the class seemed intimidated by the different learning environment. Despite the challenge, around 15 students did stay through the whole course. As the course went on, there was a rapidly-growing interest from the students. The students interacted actively with the instructors in English. They were eager to share their Aha's. They were proud to present their project findings. They brainstormed ideas on how they should do research more effectively. Some students even invited their colleagues and friends (a couple of undergraduate students, one high school graduate and one middle school student) to audit the class. The enthusiasm of the students was easily noticeable in the class.

### Some examples of the student projects

The student projects covered a wide spectrum of fields. Here are some examples:

- Figure 3 shows the product design of a whiteboard marker. The purpose of the project was to design a re-fillable marker without a pen cap. The design idea was triggered by the re-fillable lighter and the ketchup bottle.

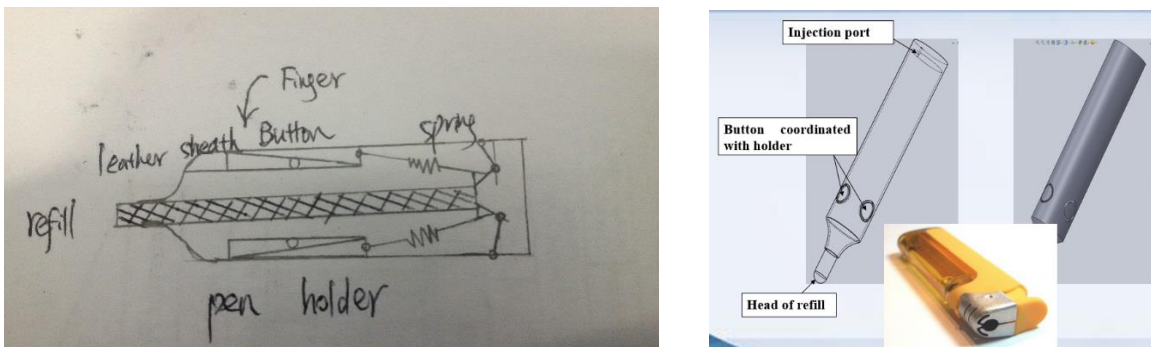


Figure 3. Capless marker.

- Figure 4 shows the design of an innovative extendable clothes hanger with the finite element analysis. It is a Poke-Yoke device for different sizes of clothes. The student was thinking about claiming a patent for the design. Due to this consideration, the authors are unable to disclose any proprietary detail of this design.



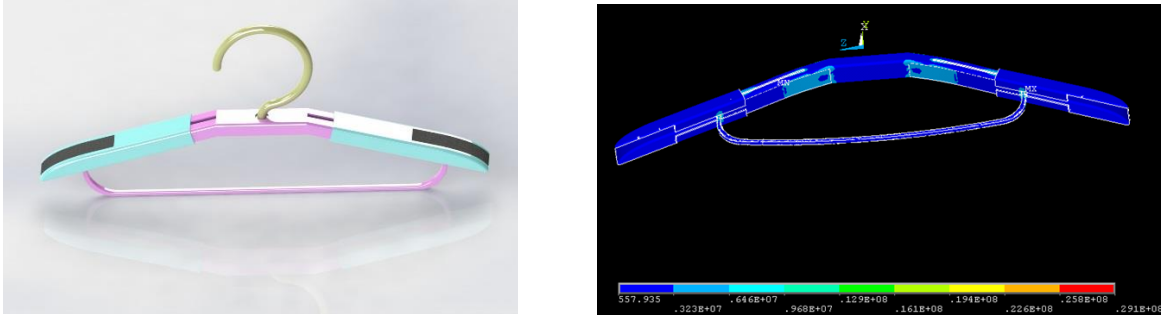


Figure 4. An innovative clothes hanger.

- Figure 5 shows a new research idea on stress analysis of a farm vehicle shaft. The idea was inspired by the thought of Kaizen. The student was encouraged to publish his research achievement in the ASME (American Society of Mechanical Engineers) conference.

## The kaizen

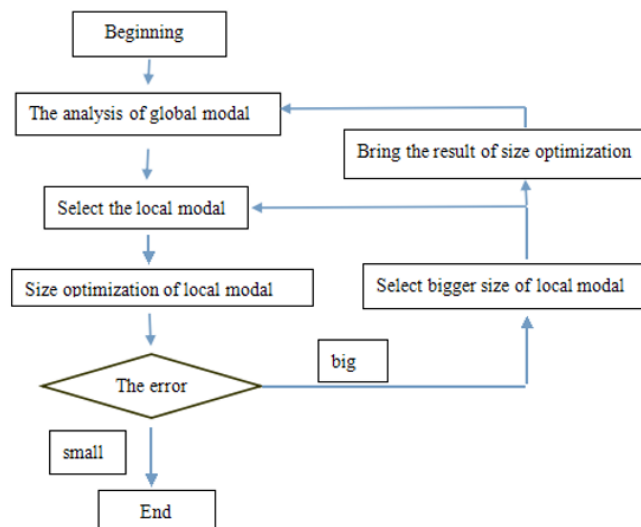


Figure 5. A research idea on stress analysis inspired by the Kaizen concept.

- Figure 6 shows one of the pictures from the Lean Manufacturing implementation proposal for a local manufacturing company. Even though this was a 70-people plant, the Lean Manufacturing implementation would generate \$3,000 (RMB 20,000-) of saving each month! It was equivalent to the monthly salary of two senior engineers. The student was determined to apply for the manager position at this plant to implement his ideas after he graduated.

# How much time does it waste?

morning			afternoon		
work	times	time	work	times	time
electric	2	6' 48"	electric	4	4' 55"
No:2 assem	6	7' 02"	No:1 assem	2	9' 17"
grinding	2	3' 59"	to be assem	4	4' 40"
welding	1	1' 7"	welding	1	1' 07"
testing	1	1' 38"	testing	9	13' 17"
milling	1	57"	welding	1	1' 04"
	15	21' 26"	tech	8	15'
				38	59' 20"

Figure 6. Value stream mapping in a local manufacturing company.

## Student feedback

A unanimous student survey was made at the end of course. Here is the summary of the survey:

Survey Questions	% of the students who agreed
I like this course; the instructors are enthusiastic	100%
This course is very helpful for my future professional development	100%
This course trains the students how to think	100%
This course trains the students how to do research, how to write papers and how to express themselves in English	90%
More courses should be offered by using the American teaching styles	100%

The students also included in the survey some encouraging comments and suggestions on how to improve the teaching:

- “Practice makes perfect. You asked us to observe things around and find problems, and then try to solve them. I like this style.”
- “You started from the examples in our life and then led us to think about these examples from the Lean perspective. It made the class interesting.”
- “The lecture attracted us with the topics we were interested in. Then it gradually and systematically discussed the topics of Lean. It was hard to feel bored.”
- “I’m grateful that you appreciated our innovative ideas that we shared with the whole class.”
- “I will keep on learning Lean Manufacturing in the future.”
- “You inspired us a lot. Here is the statistics of the words you used in class:”

	Always used 总是用到的	Often used 经常用到的	Usually used 通常用到的	Sometimes used 有时用到的	Seldom used 很少用到的
鼓励用语 Encouraging words	VERY GOOD!	I AGREE!	SURE!	EXCELLENT!	ABSORLUTELY!
启发用语 Inspiring words	FIND YOUR PROJECT/ANY (AH-HA'S)	QUESTIONS?	WHAT ELSE?	MAKE SENSE?	—

- “The relation between two different Lean concepts or definitions should be explained more so that we can see how they are connected.”
- “Please spend more time to introduce the previous projects as they are the examples we can follow when we solve real world problems.”
- “The course should be made longer. We wanted more interactions with you and more real cases from you!”
- “More theoretical analysis of the lean implementation should be provided.”
- “More failure cases in lean implementation should be introduced. We could learn more from these failures.”

One student sent an email in November 2014 (after 6 months the course was finished), saying that she was offered a manufacturing management job by Schneider (a Fortune 500 company) because she said that “I received lean manufacturing training in your class!”

## Conclusions and future plan

The teaching of the Advanced Manufacturing Systems was a success. This course explored several engineering disciplines with a reasonable depth of discussion for each topic. It refreshed the students’ minds by introducing the latest trend, state-of-art philosophies and concepts in manufacturing field. It also provided the students with a systematic way to creatively combine theory and applications to solve practical problems.

By integrating the American teaching style, a student-centered environment was created and it provided a positive atmosphere to enhance student learning. The students showed high learning passion, strong interest in solving open-ended questions, significant self-motivation of using Lean concepts to address their research challenges and improved self-confidence in handling the real world problems. The authors of the paper were convinced that applying the American classroom environment had helped the Chinese students demonstrate their engineering talents and would help them be outstanding in their engineering professions in the future.

The Advanced Manufacturing Systems has provided a successful model to integrate American teaching style into a Chinese engineering class. The authors will replicate this model in other graduate courses. They will do further research to study formal assessment methods and the broader impact (pedagogy-wise and society-wise) of bringing the American classroom environment to the Chinese higher education system.

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