Integrating Chinese Students into an American Capstone Engineering Technology Design Course

by

Rebecca P. Blust,
University of Dayton
rblust@udayton.edu

Scott J. Schneider
University of Dayton
sschneider@udayton.edu

Abstract

In 2006, the Engineering Technology Department at the University of Dayton (UD) entered into an articulation partnership with Shanghai Normal University (SHNU). This agreement enabled the Chinese students at SHNU to complete a Bachelor of Science in Engineering Technology degree from UD by attending and completing coursework at both institutions.

The first cohort arrived in June 2006. During their first semester at UD, students were streamlined into standard courses, including lecture, laboratory, and blended format classes. These students had to overcome challenges in not only language but also cultural differences with their American peers and professors. Despite these challenges, the performance of the Chinese students versus their American counterparts was surprisingly comparable.

During the second semester of this blended learning experience, the Chinese students were enrolled in the Engineering Technology Senior Capstone Design course. This course assigns teams of multi-disciplined engineering students to an industry-sponsored design project. Teams navigate through the design process, starting with the project proposal and terminating with the construction of a final working prototype or device. This experience was the first time the Chinese students had been exposed to solving open-ended technical problems. Likewise, for many of the American students, this was their first experience working on a multinational design team. Both the Chinese and American students in this course were receptive to working together because they understood the benefits of this experience.

This paper discusses a variety of communication and cultural challenges experienced by the Chinese and American students while working in a dynamic team environment for industry clients. In addition, the methodologies and philosophies for supporting the student management of such multinational teams is examined and evaluated. Finally, lessons learned

from this experience, including course modifications and necessary student preparation for future offerings, is addressed.

I. Articulation Program Background

UD and SHNU entered into a "3 + 1" articulation agreement where students study traditional engineering curriculum for three years at SHNU, and in their final year, they are integrated with students at UD. At SHNU, students must decide to enter the articulation program during their first year of study. Those students that enter the program are not guaranteed the ability to study at UD until they pass the Test of English as a Foreign Language (TOEFL) and receive their U.S. visas. After completing this agreement and the associated course credits at both universities, the SHNU students would receive a baccalaureate degree from both institutions. The SHNU students are required to fulfill all UD graduation requirements. Therefore, SHNU students must complete the required technical, humanities, and general education courses [1].

As part of the articulation agreement, the SHNU students must successfully complete the Engineering Technology Senior Capstone Design course while at UD. This course replaces the senior thesis requirement that SHNU has for all of its engineering students. Therefore, to fully satisfy the SHNU thesis requirement, each of the students must give a final presentation of their Capstone Design course project to the faculty at SHNU upon their return from UD. This presentation is in addition to the presentations and reports required for the course at UD.

Currently, two cohorts of Chinese students have successfully completed the articulation program, receiving both their SHNU and UD degrees. A third cohort is scheduled to begin at UD in June 2008. Cohort 1 included 12 students, Cohort 2 included 13 students, and Cohort 3 will include 31 students.

II. Chinese Student Preparations at SHNU

A large amount of research on the higher educational system in China currently exists. From this research material, it is evident that engineering students trained at Chinese universities experience a different learning environment than those trained in the United States. For instance, it has been documented that the Chinese educational system is relatively homogeneous in its formats and methods, relying heavily on the Confucian heritages of learning, which include memorization and disciplined recitation [2]. Furthermore, the Chinese classroom is typically teacher-centered with little emphasis being placed on group problem solving methods or peer-to-peer learning. This teaching practice contrasts the American higher education system where critical thinking and open-ended problem solving skills are more common, and students are taught to not only understand the material but also how to apply the knowledge that they have gained [3].

Recent efforts have been made within the Chinese higher education system to emphasize more of the practical applications of knowledge into their undergraduate curriculums. This

shift is still in keeping with the traditional Confucian learning methodology in which the rote-learning phase would be followed with time for reflection and independent interpretation of the new knowledge. This shift is still in contrast to the modern American higher educational system where understanding is seen much more as a sudden insight rather than a long, multifaceted process [2, 4]. Furthermore, even as the Chinese higher education system evolves, group work and student participation are still often found lacking in the classroom setting [3].

To gain additional insight and experience, faculty members from UD have routinely guest lectured in engineering courses at SHNU, as required by the articulation agreement between both universities. The added instruction by American professors is considered a learning process by the Chinese faculty and provides the students that are accepted to UD an early exposure to Western instruction methods and expectations. This arrangement has also provided UD professors the opportunity to gain firsthand exposure to a Chinese university classroom and laboratory environments. From these experiences, several observations have been made about both the student and faculty involvement.

Chinese instructors predominately lecture directly from the associated course textbooks, with little outside information or application of the material being covered. The classroom is very teacher-centered, with the students asking minimal questions during class. Likewise, the students receive only limited feedback on their learning achievements, mainly through midterm and final exams. Overall, the instructor-student interactions are primarily limited to the classroom environment because the instructors do not post or hold regular office hours. The laboratory-based activities are scripted, where the students are expected to follow a set of instructions and comment on their observations with no design or development activities.

Two of the courses taught by a UD professor during the Spring 2008 semester at SHNU are a Microprocessors I course and a Microprocessors II course. The SHNU students take these courses during their junior year of study. Each of these courses had the same population of students, with 19 of them scheduled to attend UD as members of Cohort 3. Within both of these courses, a design exercise was performed by the UD professor to help gain a better understanding of the Chinese students' engineering capabilities and to identify areas that will need reinforcement prior to full integration into the engineering technology courses at UD.

The first design exercise was administered during a scheduled laboratory experiment for the Microprocessors I course. This assignment required that the students modify a distributed assembly language program to perform a new task on their development system. Associated with the modified code, the students were also asked to determine and implement a modified wiring diagram. The requirements for this design exercise were provided using a flowchart portraying the new system functionality.

Most of the students had difficulty starting the design exercise, and none of the students were able to complete the design exercise. Following this exercise, a survey was administered to quantify the root causes of the students' difficulties in successfully performing the task. The survey asked the students to rate three possible sources of their difficulties in completing the task. The results of this survey are listed in Table 1 and demonstrate that 71 percent of the

students had difficulty understanding where to start the design process, 37 percent had difficulty understanding the English instructions, and 45 percent had difficulty understanding the engineering requirements and notation. While there are both spoken and technical communication difficulties, the main issue hindering the students from successfully completing the design task was a lack of application skills; in other words, they did not how to start the design process.

Table 1: SHNU Student Survey Results from Laboratory Design Exercise

	Disagree	Neutral	Agree
Understanding the English instruction from the instructor was difficult	21%	42%	37%
Understanding the engineering documentation (flowchart) was difficult	18%	37%	45%
Understanding how to start the engineering design process was difficult	8%	21%	71%

The second design exercise was administered during a lecture in the Microprocessors II course. This assignment required the student to complete an assembly language program using an associated schematic and operational requirements document as a guide. The same questions from the first survey were asked after this design exercise, and the results can be seen in Table 2. Similar to the first survey results, 63 percent of the students had difficulty understanding how to start the design process, 26 percent had difficulty understanding the English instructions, and 37 percent had difficulty understanding the engineering requirements and circuit documentation.

Table 2: SHNU Student Survey Results from In-class Design Exercise

	Disagree	Neutral	Agree
Understanding the English instruction from the instructor was difficult	34%	39%	26%
Understanding the engineering documentation (schematic) was difficult	18%	45%	37%
Understanding how to start the engineering design process was difficult	8%	29%	63%

III. **Chinese Student Preparations at UD**

Prior to enrolling in the Senior Capstone Design course, the Chinese students took a full semester of technical courses along with their American counterparts. These courses included a project management course, a data measurement and acquisition course, an advanced digital electronics course, an automotive engineering course, and a digital communications course.

Within these courses, the Chinese students were exposed to American-style lectures, laboratory design exercises, and group projects. The data measurement and acquisition course includes a laboratory exercise during each class meeting. Therefore, to aid the cross-cultural learning process, this class purposefully paired each of the Chinese students with an American student as a laboratory partner. When evaluating the Fall 2006 course offering, it was realized that the multinational laboratory teams performed better than those teams solely comprised of American students. It was further noted that most of the Chinese students

demonstrated a strong desire to fully understand the material being covered, including the hands-on laboratory exercises. As a result of this desire to learn, and given their weak English communications and applied engineering skills, the Chinese students often relied heavily on their American laboratory partner to supplement or explain the instructor's lecture material. Therefore, the increased performance of the multinational team members was directly attributed to peer-to-peer learning for both the Chinese and American students [5].

During the project management course, students were placed on a multicultural team comprised of American and Chinese students. The purpose of the project management course was to provide students with the experience of running a successful, non-technical project for a community client. These projects allowed students to focus upon the successful elements of managing and completing a project versus focusing on the technical elements of design. The majority of the Chinese students enjoyed the experience. However, their American counterparts had difficulty communicating effectively with the Chinese members of their teams. A few team leaders attempted a variety of strategies to overcome these issues, which included but were not limited to the following:

- Pairing up American and Chinese students to accomplish tasks that would normally be done independently
- Taking a large amount of time to review in detail the tasks that were assigned to each team member independently
- Avoiding giving the Chinese students any meaningful project tasks

Unfortunately, the most successful teams in terms of project success and completion were the teams that did not rely on their Chinese partners. However, the majority of the students, both Chinese and American, stated that they did not expect communication, neither written nor oral, to play such a large role in the success of their project. Nor did the students anticipate communication to be such a large problem. Therefore, in the Fall 2007 semester, a philosophical component was added to the final report. Each of the students was required to write about his or her experience independent of other team members. The rationale was to provide the students with the opportunity to reflect upon their experience, providing further insight for working in teams during the Senior Capstone Design course.

Overall, the Chinese students from Cohort 1 faced many challenges during their integration into UD courses, including English communications, understanding of the technical documentation being used, unfamiliarity with the teaching and learning environment, non-standardized testing formats, and non-structured learning tasks. However, the Chinese students were found to be hard working, have good analytical skills, and genuinely enjoy learning by doing. These observations lead to a number of faculty suggestions for instructing the Chinese students within an American classroom environment. The recommendations include purposefully integrating the Chinese students into the classroom discussions, scheduling question and answer meetings with the Chinese students outside of class, and supporting Chinese and American student collaboration when possible [6].

IV. Senior Capstone Design Course Overview

Students take the Senior Design Capstone course the semester after the Project Management course has been completed. Similar to the Project Management course, the students are placed on teams that are comprised of multi-disciplined and multinational students. Unlike the Project Management course projects, the capstone projects are design-oriented and technical in nature. Additionally, the sponsor is a paying client with a real industry problem that requires a design solution. Senior capstone design teams are, therefore, responsible for developing proposals, preparing conceptual designs, selecting the final design attributes, and building and testing the working prototype or final product. During the Winter 2007 semester, the first cohort of Chinese students entered the Senior Capstone Design course. This was the first exposure the Chinese and American students had to working in multinational design teams. Both contingents of students were receptive to working together because they understood the benefits this experience offered.

V. Chinese Student Integration into the Senior Capstone Design Course

From the experiences during the Fall 2006 semester, the faculty advisors for the Senior Capstone Design course determined the best methods for integrating the Chinese students into the project teams. Likewise, course modifications were made to properly support the multinational student design teams.

Students were presented with a description of each of the projects that were selected for the semester. Each student filled out a survey that stated their interest level for a leadership position, as well as their top three project choices. The course advisors listed the discipline type and number of students needed on each team, attempting to match the class profile with the appropriate number of students required to successfully complete the project. Once the advisors selected the members and team leaders for each team, the advisors conducted an informal problem solving exercise. This exercise served as an ice-breaker, allowing students to get to know one another. Next, the student teams met with their client, developed a proposal, and began to work on potential design solutions. Finally, the students selected a design and developed and tested their prototype. Throughout the duration of the course projects, feedback from the American students indicated several teaming issues related to the Chinese students, including the following:

- Dealing with different practices for developing new concepts and ideas
- Team member's inability to communicate within the engineering environment (vendors, suppliers, client, etc.)
- Frustration due to their Chinese team members' inability to know where to start, as well as their lack of understanding of the design process (as corroborated by the experience accounted above in the Chinese classroom at SHNU)
- Inability to understand or address a student's lack of motivation

- Inability to address issues in a timely manner

Likewise, during the senior capstone design project, the Chinese students provided feedback related to teaming issues, including the following:

- Lack of respect for engineering skills or contribution to team
- Not being included in team decisions, or being side-stepped
- Unfamiliarity with the design process and expectations

During the following semester, the advisors requested some changes to the SHNU students' curriculum at UD to remedy the negative experiences encountered during the Winter 2007 Senior Capstone Design course. Some of the recommendations included the following:

- Requiring the Chinese students to utilize outside resources in the Introduction to Engineering Technology course to increase their ability to effectively communicate with American vendors and suppliers
- Adding information that articulated the engineering design process in other required UD engineering technology courses
- Increasing the number of open-ended design problems throughout the curriculum

Additionally, the advisors made changes to the Senior Capstone Design course during the Winter 2008 semester that included the following:

- The addition of monthly team leader meetings designed to specifically assess teaming issues, including Chinese student integration issues
- Sharing the individual team members' evaluation scores with the team leaders, so they can manage team members more effectively and guard against possible discrimination
- Invitation to former team leaders to discuss their experiences with multicultural teams, including those tactics that worked well and those that did not

Even with these curriculum and course modifications in place, many teaming issues still remained unresolved, including the following:

- Lack of initiative or engagement on the part of the Chinese students
- Inability of American students to recognize and respect valid technical input by Chinese team members
- English and technical communication problems

At the end of the Winter 2008 Senior Capstone Design course, a survey was administered to the Chinese students and the project team leaders; the results are shown in Table 3 and Table 4, respectively. The questions within the surveys were formulated to provide additional insight into the observations witnessed throughout the semester. The results from the surveys clearly demonstrated a discrepancy between the perceptions of the Chinese team members and the project team leaders.

Table 3: Chinese Team Member Survey Results from 2008 Senior Capstone Design Course

	Disagree	Neutral	Agree
This course improved my technical engineering skills	0%	0%	100%
This course improved my ability to work within an engineering team	0%	0%	100%
My engineering skills were utilized by my team members	0%	27%	73%
My team members respected my input	0%	18%	82%
Communications was a factor impeding my involvement with the team	0%	0%	100%
I could have contributed more to my project if there was not a language barrier	0%	0%	100%

Table 4: Project Team Leader Survey Results from 2008 Senior Capstone Design Course

	Disagree	Neutral	Agree
The Chinese team members were engaged in the project	43%	14%	43%
The Chinese team members were self directed (motivated)	57%	43%	0%
The technical skills of the Chinese team members were comparable to those of the American team members	72%	14%	14%
The Chinese team members had valuable technical skills	43%	29%	29%
Communications was a factor in working with the Chinese team members	14%	14%	72%
Working with Chinese team members was a valuable learning experience	14%	14%	72%

There were 11 Chinese students that responded to the survey, and unanimously, each one agreed that the Senior Capstone Design course improved their technical engineering and teaming skills. Seventy-three percent of the Chinese students also reported that their team utilized their engineering skills, and 82 percent of the Chinese students found that their team respected their input.

The seven team leaders that had Chinese team members answered the team leader survey. Based on their survey results, the team leaders had a less favorable perception of the Chinese students' contribution to the team and project. Only 43 percent of the team leaders found their Chinese team members to be actively engaged in the project, and none found them to be self-directed. Furthermore, only 14 percent of the leaders would classify the Chinese team members as having comparable skills to those of their American counterparts, and 29 percent found them to have valuable technical skills.

In trying to discern the root cause of the disparity in perception of the Chinese team members' engagement, effort, and capabilities, it was clear that communication was a large factor, with 100 percent of the Chinese students and 72 percent of the team leaders agreeing that communication was a limiting factor. As a result, the Chinese students unanimously agreed that they could have contributed more to the team had there not been a language barrier. Although the team leaders did not feel that the Chinese students adequately supported their projects, 72 percent did agree that working with them in this project environment was a valuable learning experience.

Finally, the team leaders were asked to provide, in their own words, a list of the strengths and weaknesses they saw in their Chinese team members. Some of the weaknesses listed included their perceived deficiency in technical skills, limited experience outside of bookwork,

quietness, lack of initiative, and English communications. The listed strengths of the Chinese team members included their diligence, genuine interest in learning, willingness to work long hours, punctuality, and helpfulness.

VI. Lessons Learned

Given the disparity between the learning environments at SHNU and UD and its impact on the Chinese students' performance in working within American engineering teams, several salient issues have been raised. The prevailing obstacle for integrating Chinese students into any American engineering classroom environment is communications, both verbal and with respect to technical literacy. Furthermore, integrating Chinese students into an open-ended design environment adds cultural and academic training issues, especially related to problem-solving exercises. Based upon these impediments, the American students have been found to misinterpret the capabilities and engagement of their Chinese team members. From these key findings, a few recommendations can be made.

First, provide supplemental technical literacy and engineering application training to get the Chinese students to the same level as their American counterparts. Not all training should be sink-or-swim by directly integrating them into an American classroom. In some cases, supplemental training prior to the class may be beneficial or even necessary. For example, in the Senior Capstone Design course, the team leaders often start the semester trying to tutor their Chinese team members through the early design stages. As the semester wears on and deadlines begin approaching, the team leaders often begin to bypass the Chinese team members and do the work themselves or outsource it to other American team members. Therefore, preliminary supplemental training related to the engineering design process could positively impact the level of contribution the Chinese team members are able to provide to their respective teams.

Second, encourage Chinese-only teams, along with multinational teams, in prerequisite engineering courses at UD when solving open-ended design and analysis problems. Try to encourage the Chinese students to stand on their own and not always take the role of student in the witnessed student-teacher model that typically unfolds between the American and Chinese team members.

Third, encourage team leaders to account for a Confucian approach to selecting design options. While American students feel comfortable with rapidly firing out suggestions during team brainstorming sessions, the Chinese students, trained under a Confucian model, are more comfortable with deeply understanding the problem and subsequent technologies prior to making public recommendations. Teams need to find ways to perhaps integrate brainstorming with periods for deeper reflection to allow all team members time to fully participate in the early project stages.

VII. Conclusion

While the inclusion of the Chinese students into the UD Senior Capstone Design course has not been without difficulties, overall both the American and Chinese students have routinely acknowledged its benefits. Anecdotally, several American students have reported that the experiences from this class aided them in their professional work, most notably working within multinational engineering design teams or with foreign based organizations. Likewise, the Chinese graduates have expressed many new skills including critical thinking and a better understanding of interpersonal communications within an American engineering design team.

Half of the of the students from Cohort 1 were interviewed in China one year after graduation to discern what the most beneficial aspect of their study at UD was for their professional career. Unanimously, the students found developing their critical thinking and engineering teamwork capabilities to be the most beneficial outcomes from their UD studies. Furthermore, they attributed these benefits directly to their Project Management and Senior Capstone Design courses.

Seven of the members of Cohort 1 are now employed in China in engineering-related positions, two are employed in other professional fields in China, and three are continuing their studies in the United States. All of the employed students are working at Fortune 500 companies, many of which are headquartered in Western countries.

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Biography

REBECCA P. BLUST is currently an Associate Professor for the Department of Engineering Technology at the University of Dayton and Coordinator for the School of Engineering's Design and Manufacturing Clinic. Blust participated in the University's Summer Study Abroad Program in China in 2006 and Germany in 2009. Blust has extensive industry experiences in lean manufacturing, engineering management and project management systems.

SCOTT J. SCHNEIDER is an Assistant Professor of Electrical and Computer Engineering Technology at the University of Dayton. In the summer of 2008, he was a guest lecturer at the Shanghai Normal University. Schneider has extensive industrial experience in the areas of software development, embedded real-time system design, and automotive technologies. He also performs research in the areas of computer and software engineering pedagogy.