

## **The NAU/CQUPT 3+1 Program in Electrical Engineering**

### **Dr. Phillip A Mlsna, Northern Arizona University**

Dr. Mlsna is an Associate Professor in the School of Informatics, Computation, and Cyber Systems at Northern Arizona University. He currently serves as the Faculty Director of the NAU/CQUPT 3+1 program in electrical engineering described in this paper. His research interests are mainly in the areas of image processing, computer vision, engineering education, and academic ethics. He has extensive experience as a computer hardware engineer at Hewlett-Packard.

### **Prof. Fang Cheng, Chongqing University of Posts and Telecommunications**

Dr. Cheng is Vice Dean of the International College of Chongqing University of Posts and Telecommunications. She currently serves as the Sino Director of Academic Affairs concerning the joint program between CQUPT and NAU. Dr. Cheng is a Professor of Information and Communications with her focus on electronic information systems, telecommunication networks, and testing technology.

### **Dr. David R. Scott, Northern Arizona University**

David R. Scott is an associate professor of electrical engineering at Northern Arizona University. He received his bachelor's and master's degrees in electrical engineering at South Dakota State University and his Ph.D. degree in electrical engineering at New Mexico State University. He worked for nine years as a U.S. government plant representative engineer at General Dynamics in Ft. Worth, TX, Rockwell International in Anaheim, CA, and at Honeywell Inc. in Minneapolis, MN, where he was awarded the civil servant of the year award. David joined the faculty at Northern Arizona University in 1990 and became the associate chair in 1998 for two years and then was interim chair or chair for 14 of the last 18 years; the last six of which as chair of Electrical Engineering and Computer Science. As chair, he has overseen dramatic growth in the department and the development of two master's programs and the dual degree 3+1 program with Chongqing University of Posts and Telecommunications. David helped merge the Informatics Computing Program and the EECS Department to form the new School of Informatics, Computing and Cyber Systems including our first Ph.D. program for the department. His research centered on image processing and educational pedagogy. David was awarded the Boeing Outstanding Educator Award with a group of 14 other faculty in 1999 and was awarded the NAU President's Leadership Award on Behalf of Individuals with Disabilities in 2009. He is currently chairman of the board of the Indian Bible College in Flagstaff, AZ.

### **Dr. Jie Yang, Northern Arizona University**

Dr. Yang is an assistant professor of practice in the School of Informatics, Computing, and Cyber Systems at Northern Arizona University. She serves a coordinating role in the NAU/CQUPT 3+1 Program. Her research interests are in wireless communications, signal processing, and engineering education.

### **Dr. Guoquan Li, Chongqing University of Posts and Telecommunications**

Dr. Li is an associate professor in the School of Communication and Information Engineering at Chongqing University of Posts and Telecommunications. He is a co-Faculty in the NAU/CQUPT 3+1 Program. His research interests are in wireless communication, signal processing and engineering education.

### **Dr. Xi Zhou, Northern Arizona University**

Dr. Zhou is an Assistant Professor of Practice in the School of Informatics, Computing, and Cyber Systems at Northern Arizona University and is primarily focused on the NAU/CQUPT dual degree program. He completed his Ph.D in Material Science and Engineering in 2014 at Norfolk State University in Virginia. Dr. Zhou's research interests are in semiconductors and electronics. He also possesses several years of industry experience as a device engineer in a leading semiconductor company in Shanghai, China.

## The NAU/CQUPT 3+1 Program in Electrical Engineering

Northern Arizona University (NAU) in the United States of America and Chongqing University of Posts and Telecommunications (CQUPT) in the People's Republic of China have jointly implemented a dual-degree Bachelor's program in Electrical Engineering (EE). Significant investment in resources, personnel, and commitment have been made by both partners. Students recruited from throughout China study their first three years in Chongqing taking a mixture of courses from CQUPT and NAU. In their fourth year, these students transfer to Flagstaff, Arizona where they complete their studies at NAU. Successful students receive two Bachelor's degrees: one from NAU in Electrical Engineering and the other from CQUPT in Electronic Information Engineering. The background, goals, structure, successes, and challenges of this program are discussed here.

### background

Chinese universities have been partnering internationally with non-U.S. universities for some years and there have been many such partnerships built<sup>1,6,13</sup>. Joint programs in undergraduate engineering disciplines between Chinese and U.S. universities are a recent development and only a small number of them have been established to date. A few have been dual degree or joint degree programs, such as those between Bridgeport University and Wuhan University of Science and Technology, between University of Dayton and Shanghai Normal University, and between Oakland University and several Chinese universities<sup>3,4,7,12,15</sup>.

International partnerships have the potential for major difficulties for a variety of reasons including too much focus on revenue production, too little attention paid to educational quality, and an insufficient level of trust and understanding between the partners<sup>15</sup>. The partnership of NAU and CQUPT, now finishing its third year, has so far been a clear success in part because these difficulties have been anticipated and largely avoided.

NAU's EE program has a primary undergraduate focus and a reputation for high quality teaching. Steady enrollment growth in the past decade has reached about 310 undergraduate students (not counting the roughly 265 in the dual-degree program with CQUPT) with approximately 45 Bachelor's degrees awarded annually. NAU ranks number 42 among U.S. undergraduate Engineering programs<sup>8</sup>. CQUPT is similar to NAU in overall size, each having about 25,000 students on campus. In the telecommunications and related fields of electrical engineering, CQUPT's enrollment is more than ten times the size of NAU's EE program. In a 2012 assessment by the Degree and Graduate Education Development Centre of the Chinese Ministry of Education, CQUPT ranked number 26 in the field of Information and Communications Engineering among universities in the People's Republic of China.

In China, a fresh graduate with a B.S. degree in EE faces a tough and very competitive domestic job market. Facing this reality, students and their parents have become very interested in enhanced competitiveness. They generally view an engineering degree from certain foreign sources, particularly the United States, as very prestigious and highly desirable. Quite simply, the problem is one of cost. How can a general Chinese family afford to support their child through four years of engineering study abroad?

This is the primary problem addressed by the partnership between the two universities. By using a 3+1 structure, the expensive proposition of study in America becomes greatly reduced because the majority of study is completed in China. The students benefit by having both a solid degree from a well-respected Chinese university and an ABET-accredited degree from an American university. This promises graduates a much better competitive position in the Chinese domestic job market and also opens greater opportunities for them in the international job market. Furthermore, it offers improved prospects for pursuing advanced degrees in the U.S.

For NAU the benefits of increased revenue from additional students, valuable lessons learned, higher staffing levels, and opportunities to expand to other majors and other partnerships are very attractive. The NAU School of Informatics, Computing, and Cyber Systems (SICCS), which is the home of its EE program, expects to gain in numerous ways: a substantial increase in its BSEE graduation rate, significant growth in the number of faculty, additional opportunities to incorporate the latest research in engineering education, and a broadening of the set of senior electives available. The 3+1 program establishes an important pipeline for SICCS' fledgling graduate programs and researchers. NAU's accelerated master's program, similar to those offered at many universities, is particularly attractive to the Chinese students. Its high admission standards accepts only well qualified and motivated students. Only a small percentage of each transferring cohort is likely to be accepted into the accelerated master's program.

### 3+1 dual-degree program

Preliminary work to develop the partnership occurred before 2013 and was mainly an effort by mid- and upper-level administrators at both universities and aided by the NAU Center for International Education. Many over-arching issues were settled during that time including student recruitment standards, tuition models for each university, key infrastructure to be provided, and student achievement levels required for transfer. This eventually led to a partnership agreement that was signed in 2013 and approved by the respective governing bodies: the Chinese Ministry of Education for CQUPT and the Arizona Board of Regents for NAU. Shortly thereafter, work began at the college and department levels to develop the 3+1 dual-degree program in detail.

Cohorts of up to 100 incoming freshman students are recruited each year by CQUPT from throughout China. Students must meet significant English proficiency and academic performance standards to be accepted. The program officially launched in fall semester 2014 with a first cohort of 83 students. An NAU professor taught the first NAU course at CQUPT in the spring of 2015. The second cohort of 96 started in fall 2015 and the third of 99 began in fall 2016. Cohort #1 transfers to NAU for the fall semester of 2017.

Students spend their first three years of study at the CQUPT campus in Chongqing, China. During that time they must complete a curriculum of study that includes ten NAU-provided electrical engineering and related courses taught entirely in English and in person by NAU professors, as listed in Table 1. About half of the CQUPT-provided courses are conducted in English by Chinese faculty and the remainder are delivered in Mandarin Chinese. Some English language courses, including a course in technical English, are also required in the CQUPT curriculum. Most of these language courses are taught by native English speakers.

<b>NAU Course</b>	<b>Description</b>	<b>Timing</b>
EE 110 & Lab	Intro. to Digital Logic	Spring, Year 1
EE 188 & Lab	Electrical Engr. I (Circuits)	Fall, Year 2
EE 215 & Lab	Microprocessors	Fall, Year 2
EE 280 & Lab	Intro. to Electronics	Spring, Year 2
EE 348 & Lab	Fund. of Signals and Systems	Spring, Year 2
EE 310 & Lab	Fund. of Computer Engineering	Fall, Year 3
EE 380 & Lab	Fund. of Electronic Circuits	Fall, Year 3
EE 364 & Lab	Fund. of Electromagnetics	Spring, Year 3
Comprehensive Design and Development	Supplemental Projects and Labs (beyond each course's 12 weeks)	After instruction completes in above courses
Career Development Instruction	Continued study and job searching in US and internationally	Spring, Year 3

Table 1: The eight NAU courses plus supplemental activities.

At the end of their third year, each cohort transfers to NAU to complete their studies. Most students plan to finish in two semesters by taking NAU courses with the other EE senior students. These courses at NAU include a writing intensive engineering design course, two capstone design courses, a science elective, and several technical electives. Students who satisfy all requirements are awarded BS degrees from both NAU and CQUPT.

Besides the Chongqing delivery of the ten courses and activities listed in Table 1, significant planning was needed to prepare for the arrival and teaching of the transfer students during their senior year at NAU. Additional class sections and the necessary instructors to cover them had to be arranged. Extra staffing was needed to support increased demand for student advising and admissions processing. This all required coordination and management spanning several levels of administration and involving a variety of supporting players across the university: Admissions, Student Housing, Human Resources, the Center for International Education, Student Advising, several academic departments, and others.

A key factor affecting these planning decisions was an estimate of how many students would actually transfer to NAU. The early estimates tended to assume about 70-80% of each cohort would successfully make the transition. At the beginning of the fall semester of the first cohort's junior year, a detailed survey was used to more accurately determine the level of student interest and intention toward applying for transfer to NAU. The results indicated that 40 to 45 students would likely apply, which proved very close to the 47 who actually applied a few months later.

To transfer to NAU for their senior year, the students are required to meet a TOEFL (Test of English as a Foreign Language) minimum score of 80. For those students who do not meet the 80 score but are somewhat close, admission is possible based on their merits and faculty recommendation. A committee process is in place to consider such cases.

For mostly logistical reasons, NAU course instructional activities at CQUPT are somewhat compressed from the usual 15 weeks down to 12 weeks. One benefit is the ability of deployed faculty to overlap a few weeks at the NAU home campus to maintain good coordination with the courses and faculty there. The decreased length of time that faculty are deployed to China also helps with personal constraints and travel flexibility. The Chinese semester is 20 weeks long while NAU's is 16 weeks, but the timing of their semesters does not match well. The compressed time period of the NAU courses at CQUPT provides some additional flexibility for unforeseen problems, such as travel documents processing or illness. After the completion of the lectures by the NAU professors, there are several weeks that are used by CQUPT to require supplemental related projects and laboratory learning experiences for the students. These are lumped together into a single item near the end of Table 1.

#### management

At NAU, the 3+1 program is managed in several key ways. The program is overseen by the Dean of the College of Engineering, Forestry, and Natural Sciences (CEFNS) and administered by SICCS, the academic entity within CEFNS that contains the NAU EE program. Reporting to the Dean, a Project Director is responsible for details involving budget, logistics, and personnel. A Faculty Director is responsible for aspects involving faculty assignments and related matters necessary for delivery of the NAU courses in China and the successful preparation of students for transfer to NAU. As such, the Faculty Director works closely with CQUPT administrators, faculty, and staff to coordinate details between the universities and jointly address problems as they arise. Another NAU faculty member serves as a local coordinator at CQUPT. A Student Advisor at NAU is assigned to work with students in areas such as admissions, transfer credit evaluation, class scheduling, and degree progress.

A Steering Committee was established at NAU in the first operational year. Its purpose is to deal with strategic issues in a coordinated fashion across multiple levels of management and among the various major participants in this program at NAU. Its membership includes the Dean, the SICCS Director or representative, the Project Director, the Faculty Director, and the Student Advisor. Leadership from the Center for International Education, the University Budget Office, Human Resources, Student Housing, and others are frequently participants at these meetings. Though not a governing body *per se*, the Steering Committee has many times facilitated important strategic decisions and enabled the timely reaction to challenges having broad impact within the university system.

#### faculty

The cornerstone of the 3+1 partnership is the deployment of NAU engineering professors to China to teach courses. This has presented some fundamental challenges at NAU because of the many ways the demands of this program differ from traditional faculty responsibilities. Foremost, there must be enough interest and willingness among the faculty to actually live and

work in China for three months at a time. The additional teaching load presented by the 3+1 program demanded several new faculty hires regardless of teaching location.

By design, it was agreed that the NAU faculty who deploy to China must have some U.S. college-level teaching experience in engineering. Rotation to the home campus would happen periodically to keep the courses well coordinated between the two locations. Participation in data gathering to support ABET accreditation activities would also be an important part of their role. The goal is to provide a course experience at CQUPT as similar as possible to that at NAU while adapting to the particular teaching situations encountered. The faculty who teach at CQUPT currently consist of three Assistant Professors of Practice, one tenure-track Assistant Professor, and one tenured Associate Professor who also serves as the Faculty Director.

There was much initial concern surrounding the rather profound differences in language, cultural expectations, and university procedures that would be encountered by NAU faculty as they teach courses at a Chinese university<sup>2</sup>. To mitigate such problems and to help the program run smoothly, CQUPT assigns experienced Chinese faculty to work closely with the American faculty. Called “co-faculty”, these people are instrumental in a variety of ways: arranging classrooms and equipment, scheduling, satisfying the many procedural requirements of the university, assisting with grading, and helping to answer questions from students. While co-faculty attend every class session, in general they do not serve as translators or intermediaries between the students and NAU faculty. All instruction, reading, assignments, exams, and laboratories are conducted in English. Students are strongly encouraged to ask questions in English during and after class. The co-faculty are also available for student questions in Chinese after class on an individual or small group basis.

The Chinese that teach CQUPT courses in this program are experienced faculty whose student evaluations are in the top 10%. Most have overseas study or work experience. Roughly half are Assistant Professors and the remainder hold the rank of Associate Professor. Specialized training on curriculum and program requirements is provided to those selected. The co-faculty gain experience with teaching methods and strategies that are often new to them. Many of them have reported effectively applying these methods to their own regular teaching activities.

students

The students have shown a wide range of abilities. The first cohort can be divided into roughly equal thirds, with the top third very capable and strong performers, the next third generally good, and the lowest third at high risk of not succeeding. There seems to be a significant degree of correlation between overall performance and English ability. The students who are more willing to ask questions and interact with the professor in class are much more likely to be strong performers in the English-taught courses and better able to pass the English proficiency exam. There are many students who rely too heavily on either the Chinese faculty or their classmates and hence struggle when it comes to applying their knowledge during exams.

One fairly profound cultural difference between American and Chinese students is their level of interaction in class. Chinese students tend to be more studious and better mathematically prepared than U.S. students, but they are often much more passive and quiet in class, ostensibly out of respect for the teacher. The American professors have found that it pays to try to actively engage the students and encourage them to ask questions. Part of that includes paying attention

to some subtle body language that is definitely not part of their past experience as teachers. To be more certain that students understand, it is important to frequently pose relevant questions and allow them to respond. Speaking clearly, rephrasing the question, writing important details on the board, and pausing for what seems an almost uncomfortable length of time are useful strategies to deal with the language barrier and student passivity. The key is to actually get the students to respond, which gives feedback on both attention and comprehension levels.

successes

One of the foundational challenges successfully navigated was that involving the alignment of the curriculum of the two universities. An important goal was to have students transfer with enough credits to graduate from NAU without needing more than 30 semester hours at NAU. Included in these considerations were ABET accreditation requirements as well as graduation requirements from both schools. For example, students from CQUPT did not have the prescribed amount of mathematics and science required by ABET accreditation, so they must take an additional science course. NAU has particular strength in Astronomy, Biology, and Geology and those classes were added as alternatives to Chemistry for all students.

Curriculum alignment and articulation began by CQUPT providing descriptions of all the coursework their students could transfer to NAU by the time they complete the junior year. The affected NAU departments next examined this information to determine which courses would actually transfer. CQUPT and NAU representatives met in both Chongqing and Flagstaff several times over two years to reach agreement on how to strengthen and align the two curricula. One example was in differential equations where CQUPT did not cover an important topic and agreed to change their curriculum to include it. Such adjustments occurred numerous times and were instrumental in bringing the two curricula into alignment.

The first three years of this joint program have been very successful in several important areas. Feedback from students and CQUPT administration has been generally very positive; instruction quality is reported as high. The partnership between NAU faculty and CQUPT co-faculty has been quite strong, accommodating, and productive. The most important enabler of this success is the close working relationship between key players on both sides, especially those involved in day-to-day management of the program at both universities. Open communication, a high degree of mutual trust and respect, and a willingness to identify and address challenges quickly are all contributing factors. In hindsight, the high level of commitment and trust has proven many times to be crucial in the progress achieved.

challenges

Recruitment of the initial cohort proceeded without any established reputation of the new program, just those of the two universities involved. Some of the students and their families were understandably concerned and perhaps unsure about the full nature of the transfer to U.S. study. Consequently, some in cohort #1 have not pursued opportunities to transfer to NAU as strongly as predicted. This seems to be a program startup issue. With two more cohorts in the pipeline and the program's growing reputation, interest and commitment toward transfer is much stronger.

Stability and sustainability of the dual-degree partnership is paramount to its long-term success. Though the challenges in this area have usually been minor, they must always be kept in mind.

One such continuing challenge is to grow the participating faculty to a sustainable level that allows flexibility for rotation. This takes a commitment from NAU to support faculty recruitment without delay, especially considering the time required to conduct faculty searches. Another ongoing challenge is to maintain course coordination and ABET assessment activities across two campuses on different continents. A third is one of responding to the procedures, policies, and laws of two such disparate countries and their respective university systems. Changes in these areas are common and sometimes significant, so it pays to anticipate problems by planning extra time. Such changes have affected visa processing procedures for travelling faculty, internet access, class scheduling, textbook arrangements, courseware availability, and other items.

NAU's Program in Intensive English (PIE) was tasked with testing students for their English proficiency in December, 2016. Cohorts 1 and 2 were tested and many students in each cohort do not yet meet the equivalent of a TOEFL score of 80, as needed to transfer to NAU in Flagstaff. This level is intended to help ensure that students who do transfer can successfully graduate from the program in two semesters. Students who are not able to be directly admitted into the fourth year have the option of entering the PIE program upon arrival to boost their English proficiency.

The NAU EE courses taught in China are essentially the same courses taught at NAU with the same academic standards. These courses are included with the home campus courses in the data collection process for the assessment and continuous improvement work associated with maintaining NAU's ABET accreditation for its EE program. The information is then used as feedback to craft responses and make changes to provide continuous improvement for the program as a whole. Modifications to a course apply to all sections and locations of that course. A challenge in this process has been to integrate the new faculty, some teaching at NAU and some at CQUPT, to understand and participate in these activities. CQUPT's degree program is not currently ABET accredited, but interest and planning toward its achievement is ongoing.

Experience with the first cohort of students has shown the importance of ongoing English language training. Meeting the required TOEFL score of 80 is not straightforward for many students. After some disappointment concerning the number of passing students, both partners have reinforced the English training and test preparation activities. Starting at the end of the freshman year, students' English proficiency levels are measured every six months. Extra training is required for those students who measure below threshold levels that are designed to ensure good progress toward a successful TOEFL score before applying for transfer to NAU.

To help with the language barrier that CQUPT students face in China and many other international students face in our Flagstaff classes, some study materials have been created using audio PDF files in English that students can review to help learn important topics at their own pace. Faculty have not had sufficient opportunity to develop these and other materials, such as automatically graded pre-lecture quizzes and online homework with instant feedback.

conclusion

After three years in operation, the 3+1 dual degree program in electrical engineering between CQUPT and NAU has made much progress and continues to run fairly smoothly. Curriculum articulation has been achieved, many courses have been delivered successfully, and the first cohort of students has applied for their senior year in the U.S. One characteristic that sets this program apart from many others is the degree to which both partner institutions and their key



personnel are committed to work together. The high degree of established trust and the willingness to work hard together have helped the partners through some difficult challenges. Transfer of the first cohort is now imminent. Several important challenges still must be addressed if the program will ultimately succeed: the details of student admission and transfer, the satisfaction of language proficiency requirements, and growth toward adequate faculty staffing levels. The student success rate and hence the program's overall success look to be very promising in the next couple of years as the first students reach graduation.

This work is partially supported by the International Education Research Project of Chongqing University of Posts and Telecommunications (No. GJJY16-2-07).

## references

- [1] L. Cuthbert, Y. Ying, et al, "A Flagship Joint Sino-British Engineering Degree," Meeting the Growing Demand for Engineers and Their Educators 2010-2020 International Summit, 2007 IEEE.
- [2] R. M. Helms, Mapping International Joint and Dual Degrees: U.S. Program Profiles and Perspectives. ACE, CIGE Insights.
- [3] J. Lee, S. H. Patel, B. Lim, R. D. Geng, and Z. Jiang, "Toward Success of Collaborative Program In School of Engineering Between the US and China," ASEE International Forum, New Orleans, LA, 2016.
- [4] Q. Liu, J. Zhu, and B. Yang, "Impact of International Collaborative Engineering Education upon the Epistemological Development of Chinese Engineering Students," ASEE Annual Conference, Seattle, WA, 2015.
- [5] K. Meehan, "Adapting to a United Kingdom Undergraduate Engineering Pedagogical Approach While Teaching at a Sino-Foreign Joint Educational Programme," 2015 ASEE Annual Conference, Seattle, WA.
- [6] K. Meehan, J. H. Davies, et al, "Merging pedagogical approaches: University of Glasgow-UESTC joint education programme in electronics and electrical engineering," Frontiers in Education Conference (FIE), 2014.
- [7] K. Meehan and G. Radice, "Models for International Collaborative Undergraduate Engineering Programmes," ASEE Annual Conference, New Orleans, LA, 2016.
- [8] R. Morse and E. Brooks, "Best Undergraduate Engineering Programs Methodology", U.S. News, Sept. 2016.
- [9] R. L. Mott and T. L. Speicher, "Engineering Education in China –A Summary of a Focused Visit in 2010," American Society for Engineering Education, 2011.
- [10] Y. Rong, "Ten Year Experience of Global Capstone Design Projects in China," ASEE International Forum, Seattle, WA, 2015.
- [11] E. J. Sandell, "Impact of International Education Experiences on the Undergraduate Students," Delta Kappa Gamma Bulletin, 73(4): 12–39, 2007.
- [12] S. I. Segalewitz, "Seven Years of Success in Implementation of a 3+1 Transfer Program in Engineering Technology Between Universities in China and the United States," 2013 ASEE Annual Conference & Exposition, Atlanta, GA.
- [13] I. Smith, L. Thenault, and Y. Zhang, "Realising student potential through a truly international experience: The collaborative programme in civil engineering between Edinburgh Napier University and Shanghai Normal University," Frontiers in Education Conference (FIE), 2014 IEEE.
- [14] J. N. Warnock and G. Melnychuk, "Strategies for Increasing Student Participation in International Programs," ASEE International Forum, New Orleans, LA, 2016.
- [15] M. F. Wyne, "International Academic Collaboration: Why it May or May not work?" ASEE International Forum, Seattle, WA, 2015.
- [16] J. Zhang, L. Zhang, et al, "Collaborating With Chinese Universities on Engineering and Technology Education: Potentials and Issues From a Curriculum Perspective," Proc. of the 2005 ASEE Annual Conference.
- [17] Y. Zhang, "A contrastive study on Chinese and American University Courses Teaching," Computer Science & Education (ICCSE), 2013 8th International Conference, IEEE, pp.599-602.