

International Collaborative dual MS degree program

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International Collaborative Dual MS Degree Program

Rose-Hulman Institute of Technology (RHIT) has been offering Optical Engineering BS and MS degrees since 1990 and 1985 respectively. The MS program draws only a few students annually and around 2010 we worried that we would not have enough students to run the program. At the same time the university in Korea with which we had ties, Seoul Tech, changed its mission from 'Technical University' to 'National University'. The new designation meant it had to expand its graduate programs. The time was right to develop the dual degree program which has successfully solved our mutual problems. Working together the students receive an MS in Optical Engineering (OE) from Rose-Hulman and a degree in Mechanical Design and Robotic (MDRE) from Seoul Tech.

In this paper we describe our international collaborative dual MS degree program with Seoul National University of Science and Technology (SeoulTech).

The academic content of the program was easily agreed because of the benefits that we both expected to obtain from collaboration. Rose-Hulman wanted more and better graduate students in its Optical Engineering Master's program and SeoulTech was nudged by the Korean government to increase its international relationships.

RHIT was known to SeoulTech as a good engineering institution with excellence in ABET implementation and in teaching and learning. Later, SeoulTech was impressed to learn that RHIT had been declared the best undergraduate engineering school in the USA by US News and World Report. These credentials made it easier for SeoulTech to gain internal support for the collaboration.

The initial collaboration was a Summer MEMS program taught in RHIT to undergraduate students from SeoulTech and begun by Dr. Michael McInerney after his return from a year's sabbatical at SeoulTech. SeoulTech has sent between 20 and 30 students to this program every year since 2010. This year, 2017, will be the eighth successive summer school.

Korean engineering colleges at that time, and SeoulTech is mostly engineering, were forced by both industry and government to reduce the gap between industry needs and university education. Innovation and globalization in engineering education were the key words and SeoulTech reached out to RHIT for a partnership. The Summer MEMS program had convinced the RHIT faculty of the high quality of SeoulTech students and their good grasp of English. The Dual Degree MS program was suggested and approved for development on the SeoulTech side by Dr. Rho, the president of SeoulTech when he visited RHIT.

The two degrees were chosen to be RHIT's MS in Optical Engineering and SeoulTech's MS in Mechanical Design and Robot Engineering (Undergraduate department name is MSDE while graduate department name is MDRE). The advantage of combining these two degrees as a dual degree is that only one new course was required.

The argument on the SeoulTech side was that Korea is strong at semiconductor industry but not good at making pre- and post- foundry devices and measurement/ monitoring equipment, in which area many optics engineers are needed. There are only a few universities with optical engineering departments in Korea and the collaboration with Optical engineering of RHIT would be beneficial to SeoulTech as well as to Korea.

On the RHIT side the most important issue was the dearth of good students in the MS OE program. There was also the general difficulty of obtaining industrial experience for the students. The two degrees matched well because the PHOE department in RHIT is also invested in micro and nano engineering. Many of its students are educated in the process of micro manufacturing and use the Institute's clean room as part of their education. The SeoulTech campus has a large FAB as part of the Seoul Techno-Park and the Dual Degree students have access to it.

A general agreement to produce a dual degree is not the same as implementing it. By choosing the particular two degrees mentioned above we did not need to develop more than one new course nor agree on the contents of old ones. The new course is an introductory optics course that the SeoulTech students have to take because they do not have the optics background that we require of our Optical Engineering MS students.

In 2012, an MOU (Agreement on MS Dual Degree Cooperation) was exchanged and the Dual MS Degree Proposal with Seoul Tech was made by RHIT, which described whole structure of the program including Organization, Enrollment and registration, Degree requirements, Grade and credits, Thesis, Internship, Administration, etc. One important request of RHIT in the Proposal is to provide RHIT students an internship for 2 months at a good Korean company or national laboratory to expand their world views. A group of RHIT and SeoulTech faculty was set up to deal with various unanticipated scenarios as they arose.

There were issues due to RHIT being on a quarter system starting in September while SeoulTech uses semesters starting in March representing a gap of 6 months between the two institutions. SeoulTech made its first spring semester a preparation semester for their dual degree students. In particular developing a background optics course to bring their experience to that of our normal MS OE students.

A further set of challenges lay in the division of courses to produce adequate training/learning at the advance-level in optical and mechanical engineering. Travel and living expenses for both US and Korean students were also important considerations of this arrangement.

The program curriculum and course offering is described in Table 1.

Table 1: Shows schedule of courses, location, and quarter or semester of offerings.

Dates	At Rose-Hulman	At Seoul Tech
Spring semester (Mar-Jun)		Advanced Optics (only for Korean students)
Fall quarter (Sep-Nov)	OE580 Lens Design and Aberrations OE592 Fourier Optics OE595 Optical Metrology OE520 Principles of Optics (optional)	
Winter quarter (Dec-Feb)	OE585 Electro-Optics & Applications OE570 Special Topics in Optics Elective (Biomedical Optics) Elective (Intro Image Processing)	
Spring semester (Mar-Jun)		OE594 Guided Wave Optics Elective Elective Elective
Summer (July-Aug)		Internship at Seoul Tech Industrial Park / Seoul industry (required)
Fall/Winter quarters	Thesis work & defense (12 Cr)	
Total Course Credits (Cr)	Course: 30 Cr	Course: 16 Cr (RHIT equivalent)
Total Credits	Course and Thesis: 58 Cr	

The path to approval of the Dual Degree program in Rose-Hulman was, in order: the Physics and Optical Engineering department, Institute Graduate Studies Committee, Institute Curriculum Committee, Institute Faculty meeting, President of Rose-Hulman and ultimately the Board of Trustees of Rose-Hulman. Seoul Tech followed a rather similar path through Department Committee, Graduate Committee, International Program committee, and finally University committee. The first students were recruited from year 2012.

The dual degree is a small program even in the context of Rose-Hulman. It is even smaller in SeoulTech with its fifteen Thousand students. In its five years of operation it has graduated 15 students with 10 presently in the system. Table 2 provides the breakdown of students attending the dual MS program.

Table 2. Number of students participating in the dual MSOE program, each academic year (AY), rows 2 and 3, total number at the end of each year since the program inception 2012.

	2012-13 AY	2013-14 AY	2014-15 AY	2015-16 AY	2016-17 AY
Korean	5	3	4	2	4
RHIT	2	1	3	1	0
Total	7	11	18	21	25

The plan of study (see table 1) for the dual MS degrees requires that a cohort of students begin by spending fall and winter quarters at RHIT, the spring semester at Seoul Tech followed by a summer industrial internship in South Korea. Students have the option to do their thesis research work in optics at RHIT or mechanical design in Seoul Tech. However, all students will have a thesis Advisory Committee that includes RHIT and Seoul Tech faculty. Also, all thesis defenses are public and are broadcast through Skype to the partner institute.

Of course, the major challenge of any international collaboration is funding and financial aspects of various nature. To this end RHIT and SeoulTech graduate students receive a tuition grant for their study at both institutions as long as their cumulative GPA is > 3.0. RHIT also covers the required technology fees for the SeoulTech students. Student expenses, outside the cost of room and board, includes healthcare fee (RHIT paid in 2012 and 2013) and travel expenses. All students are eligible to apply for the graduate assistantship (\$3000/quarter) while working on their thesis at RHIT and their cumulative GPA must be > 3.5 to qualify. However, RHIT's graduate students do an internship in Korean industry for 5 weeks and are paid \$1,000 for their work. To kick-off the program successfully RHIT, for the first 3 years, provided financial aid that included stipends ranging 150-\$600 per month to all participants for room and board cost at RHIT and provided the cost of airfare to RHIT's graduate students.

As it is the case in many collaborations, the interpersonal faculty contacts are very important. Luckily for our program, the main Korean collaborator, *Prof. Wonjong Joo*, travels regularly to the USA. We usually manage two meetings a year as a result; one after Christmas and the second during the summer when Rose-Hulman hosts an annual Korean Summer School.

Moreover, Rose-Hulman faculty regularly visit SeoulTech and meet with the involved faculty there. Most of these visits are adhoc depending on the travel arrangements of the people involved. But SeoulTech hosts a Capstone Design competition every fall to which Rose-Hulman sends a team with financial support from both institutions. The telephone and email are used to resolve 'emergencies', of which there have been very few.

The most valuable benefit of this program to SeoulTech is to give students wonderful opportunities to study and experience at the best university. All students from this program have gotten good jobs or entered good Ph. D programs. Faculty of Seoul Tech has learned from RHIT the best practice of education.

Small though this program is, it has had the important effect of *doubling* the number of graduate students in Rose-Hulman’s Optical Engineering MS program and restoring the continuity of the research, collaborating with the faculty. Rose is no longer struggling in recruiting graduate students to this MS; it now has a certain supply of good students from Korea and supply of students specifically choosing Rose-Hulman because of the opportunity of studying abroad and gaining cultural experiences in Korea.

One of the major challenges is in the recruitment of US students. At the moment all of our US students have been undergraduates at Rose-Hulman where they learned about the program. This fact points to a lack of publicity for the program. At present we have developed a brochure (see Figure 1 below) and attend regional graduate fairs. In the future we will spread our fair attendance to the coasts and advertise through nationwide Korean-American societies. The former strategy will allow us to reach students who want to make a career with companies operating in Korea and the USA; the latter strategy will allow us to reach the large Korean-American community many of whom want to give their sons and daughters an ‘experience of Korea’ as part of their education.



Figure 1. Shows the dual MS degree program brochure developed by RHIT.

SeoulTech has benefited from the dual degree moving it toward the government mandated goal of increased international collaboration; developing a mechanism by which some of its students could study in the USA; making optical engineering field available to its students. So far 13 of 18 Korean students have decided to stay in RHIT and do their theses research in optics. We have developed three additional opportunities for our undergraduate students through collaboration with SeoulTech,. These include summer cultural student exchange, summer MEMS and cultural programs for Korean students, and participation of Rose students in International Engineering Design Competition. For the summer MEMS, 20-30 students come to RHIT for 4 weeks to learn about micro-electro-mechanical systems (MEMS) and fabricate them in our cleanroom. Rose students are invited annually to send 1-2 students and a faculty mentor to participate in the *International Engineering Design Competition* fully funded by the SeoulTech.

We have also had couple of students go to spend a summer in SeoulTech campus studying Korean language and culture without paying tuition for the courses.