

Project-Based Learning in Photonics for Tertiary Students of Other Engineering Disciplines

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ABSTRACT

The principal aim of the Photonics Centre at NgeeAnn Polytechnic, Singapore, is to provide a broad-based and practice-oriented education and training in photonics and laser technology. Students who choose to do their final-year project in this field, do not have any photonics background at all at the start of their project. However, the Centre's project-based learning programmes have been successfully tried and tested. Through a series of specially selected lectures and experiments, the students are eventually led into the project proper. By the time the students complete their project, they would have gained immense knowledge and hands-on experience in photonics and laser technology. Some examples of completed projects include development of a fiber laser using erbium-doped fiber, polarimetric sensors for damage detection of aluminum materials and concrete structures, development of holographic optical elements and external cavity semiconductor laser sensor. The students have gone on to participate in R&D competitions and have been awarded either the second or top positions. The aim of this paper is to examine the methodology used that has made this form of training successful.

Keywords: project-based learning, skills, photonics, education

1. BACKGROUND

NgeeAnn Polytechnic¹ is a tertiary institution in Singapore offering both business-related and technology-based diploma and advanced diploma programmes, ranging from engineering to business, maritime studies, biotechnology, mass communications, information technology, computing and e-commerce. In addition, the polytechnic also offers many short courses for working professionals. Students who gain entry at the age of 17, do a 3-year programme.

The Photonics Center² is one of the technology centers in the School of Engineering of NgeeAnn Polytechnic. It was established in 1995. The principal aim of the Photonics Center is to provide a broad-based and practice-oriented education and training in photonics and laser technology for our students and to promote Photonics and Laser Technology in Singapore.

In the final year, the students sign up for their final-year project. Those who choose to do their projects in the Photonics Center, have no background in photonics. In the previous two years, they would have covered only areas of electronics, computers and communications. Photonics would be a totally new experience for them.

Students who sign up for their final-year projects do so in groups of 3 to 4. The 3rd Year starts in July and the students are expected to complete their projects by March the following year. They are allocated one day a week for project development. However, they are expected to work on their project everyday for 6 weeks during the November-December break.

2. PROCEDURE FOR PROJECT DEVELOPMENT

Students who have been selected to do a project in the Photonics Center are requested to spend a week after the release of their 2nd Year results at the Center for a series of lectures and practical work. After this, they are asked to do a literature survey on their project.

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Most of the projects that are done in the Polytechnic are of the nature of product development. However, the Photonics Center has decided to go for the applied R&D approach.

The reason for this is because

- a) it will provide our students with additional skills in analytical thinking;
- b) it will provide our students the opportunity to explore all possibilities rather than restrict them to a specific product;
- c) it will allow them to also collaborate with the local universities so as to widen their level of thinking;
- d) it will prepare them to support the R&D done in industry when they start to work.

Upon completion of the project, the students will have to do a project presentation as well as submit a project report. However, prior to the final project presentation, the students also participate in the Electronic & Computer Engineering (ECE) R&D Competition where they compete with other centers in the ECE Programme that have also introduced applied R&D for project development.

3. TRAINING METHODOLOGY

Before the start of the project the students have to attend a series of lectures and practical work. This spans for a week. The lectures are as follows:

1. Laser Safety – the human eye, irradiation effects on the eye and skin, laser classification, and laser safety measurements
2. Geometric optics – particle nature of light, Snell's Laws, reflection, refraction, dispersion of light, and lenses
3. Wave optics – wave nature of light, interference, diffraction, and polarization
4. Basic Laser Operation – energy levels, spontaneous and stimulated emission, population inversion, and the operation of the Helium-Neon laser
5. Interferometry – optical path distance, Michelson interferometer, and Mach-Zehnder interferometer
6. Holography – transmission holograms and reflection holograms (for projects related to this field)
7. Photodetection – types of photodetectors, characteristics of photodetectors
8. Fiber Optic Sensors (for projects related to this field)

As all these are very new for the students, the lectures have to be pitched at the right level. Students who have been studying electronics for the past two years have to switch their way of thinking from electrons to photons.

The lectures are further enforced with the following practical work:

1. Determination of Brewster angle for glass and Perspex
2. Using Malus Law to determine the quality of polarizers
3. Determination of the coherent length of a He-Ne laser using the Michelson Interferometer
4. Development of a transmission and reflection hologram (for students doing holography-related projects)
5. Laser alignment

The lab work provides the students the following skills:

- familiarization in handling optical components (mirrors, beamsplitters, polarizers, lasers, etc.)
- an understanding of concepts such as interference and polarization
- using MS Excel to plot graphs
- analyzing data and providing inferences
- confidence building

To add value to the projects, the Photonics Center has sought collaboration with the local universities in Singapore. Over the years, the Photonics Center has worked closely with the Mechanical and Production Engineering Department of the Nanyang Technological University, Singapore, collaborating in a number of R&D projects.

Some of the projects include:

- a) Tunable semiconductor laser for coherent communications
- b) External-Cavity Diode Laser Sensor
- c) Holographic Optical Elements
- d) The Use of Polarimetric Sensor for Damage Detection in Aluminum and concrete structures
- e) The Development of a Fiber Laser using Erbium-Doped Fibers.

These projects are of a high standard and would not normally be perceived to be undertaken at a Polytechnic level in Singapore. However, students have shown to be able to cope with the level of difficulty. They are given the freedom to investigate various methods to get good results. They maintain a logbook and have periodic meetings with their supervisors.

The Photonics Center also allows the students to come in during their free time to work on their projects. They are allowed to use all the facilities in the Center and lockers are provided for them. They are also given the freedom to use the lab to study for their exams. This way, the Photonics Center provides a friendly environment for the students to work independently and confidently. This in turn, makes the project work more productive.

All the supervisors have also decided to be stationed in the lab, i.e., they have moved from their designated office locations and set up office in the lab. This way, they are available to provide immediate technical advice and support to the students.

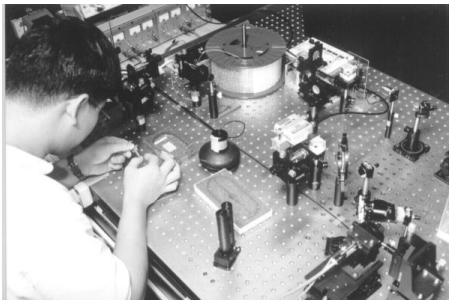


Fig 1. Project student designing a tunable semiconductor laser.



Fig. 2 Project Students working in the holography laboratory.

4. CONCLUSION

We have found this approach rewarding, both for the students and staff. Students have gone on to participate in the ECE R&D Competitions and have always been awarded either the first or second prize. They have also published papers and presented at conferences. This is especially unique for polytechnic students, as the objective of polytechnics in Singapore is primarily to provide industry with graduates with practical experience in software and hardware development. The publication of research papers is normally left to university research students.

The Photonics Centers also conducts a module on Photonics and Laser Technology for the 3rd Year students who have chosen this as their elective module. The module lasts a semester, and it covers lectures, tutorials and practical work. However, we have found that students who participate in the final-year photonics projects have a far better understanding of photonics and excellent practical skills.

Upon completion of their projects, the students would have acquired the following skills:

- capability to source for relevant resource material
- analytical thinking skills
- troubleshooting skills

- oral presentation skills
- report writing skills
- good team player
- interpersonal skills

Above all, they would have learnt a leading technology in the 21st Century. Some of our graduates who did their projects at our Center have taken on jobs related to photonics even though their primary diploma is in electronic and computer engineering.

REFERENCES

1. <http://www.np.edu.sg>
2. <http://www.np.edu.sg/ece/oelt/>