Independent-Study Module for Electrical-Engineering Students at National University of Singapore

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Abstract: To inculcate students with a self-learning mindset that will prepare them for the rapid technological changes they are going to encounter during their future careers, the Electrical Engineering Department at National University of Singapore has recently launched a flexible independent-study program which requires every student to pursue a series of self-proposed projects. The key feature of this new program is that each student is allowed to develop himself in accordance with his own interests and pace of learning.

Keywords: independent study, project-based learning, student competitions, creativity

1. Introduction

It is likely that the electronics, communications and computer industries will continue to enjoy rapid growth rates in the foreseeable future, with each new year offering exciting discoveries and innovations that bedazzle researchers and laymen alike.

How should this relentless outpouring of new knowledge be assimilated into a university curriculum designed for training undergraduate students in those disciplines loosely classified under the generic term of electrical engineering (which can be regarded as encompassing communications, computers, control, microelectronics and power)? There must, naturally, be ongoing efforts to periodically update – or even revamp – the curriculum in order to maximize the exposure of students to the latest developments before they graduate. However, a far more effective approach is to inculcate in students a self-learning spirit that will help to steer them through the vagaries and challenges of future technologies after they have left the university cocoon and embarked upon their engineering careers.

2. Preliminary Considerations

National University of Singapore (NUS) used to base its engineering curriculum on the traditional pillars of prescribed lectures, tutorials, experiments, projects and industrial attachment. A comprehensive review initiated by the Electrical Engineering Department (EE Dept) in 1996 concluded that there was a need to enhance certain elements of its curriculum in order to prepare students for the New Economy**:**

- emphasis on process skills instead of knowledge content
- additional opportunities for creativity and enterprise
- participation in brainstorming sessions and other group-based projects
- independent learning through self-proposed projects
- allowing students to experiment with non-traditional modes of learning
- flexibility for students to reinforce (or de-emphasise) selected components of prescribed curriculum.

The review task-force decided that a radically innovative program was required to supplement the structured diet of prescribed lessons and projects. Before this could be implemented, it was necessary to trim

the amount of material included in the curriculum – by as much as 20-30% – so as to provide free time for students to develop themselves via other non-structured modes of learning. The administrative machinery required for monitoring students' independent-study progress must be able to handle the wide range of self-learning formats available (such as those examples discussed in Sections 3-4) as well as the different rules for processing special categories of students (such as those on direct admission, accelerated tracks, student exchange and the like).

3. Independent-Study Framework

After completing its curriculum-trimming exercise in 1998, EE Dept launched the EE1000 series of independent-study modules which are compulsory for all its undergraduate students. Unlike the regular modules, there are no prescribed lessons or assignments for EE1000. Instead, the onus is on each student to plan for himself a number of self-proposed projects which, if satisfactorily completed, will allow him to satisfy the academic requirements stipulated by the task-force for this particular series. Ideally, there should not be any restrictions on the type of independent-study project that the student may attempt. The only criterion is that these self-proposed projects must be related to engineering and the following list of examples has been drawn up to illustrate the different possibilities permitted under the EE1000 umbrella**:**

- literature search on recent developments in a particular area of technology
- group discussion on a challenging problem which has been extracted from textbooks or journals for students who wish to probe further
- extension of a particular laboratory experiment that has kindled the student's interest
- development of a software package (*e.g.* multimedia courseware)
- design and fabrication of hardware module (*e.g.* amplifier for electric guitar)
- conduct of short course (*e.g.* on programming languages) for fellow students
- participation in a recognised competition (*e.g.* robotic games).

This list is not intended to be exhaustive and other suggestions are always welcome**;** *e.g.* one of the EE3 students joined Singapore's Mount Everest expedition and provided technical support for the core team of climbers.

To help EE Dept monitor students' progress, credit points – referred to as Independent Study Points (ISPs) – are awarded for each independent-study project. A student is deemed to have passed EE1000 if he has accumulated a minimum of 25 ISPs. There is no prescribed timetable but the students are advised to collect 4-6 ISPs each semester so as to give themselves more time to focus on their final-year projects during the fourth year of study. They are also allowed to undertake EE1000 projects during vacations or even whilst on student exchange at overseas universities.

The characteristic feature of EE1000 is that each student decides for himself how (or even when) he wishes to collect his ISPs. Outlined below is the administrative procedure specially set up by EE Dept for this independent-study module (which, for ease of tracking every student's progress, has been partitioned into three sub-modules identified as EE1001, EE1002 and EE1003)**:**

(a) The first step is for the student to submit (electronically via a web-based template) a brief proposal setting out what he hopes to achieve for the independent-study project that he intends to embark on. To be included in his proposal are details such as project objectives, expected benefits, choice of methodology, resources required and period of execution.

(b) The EE1000 Coordinator will decide on the suitability of the student's proposal. Brief interviews will be conducted wherever necessary. If approved, the independent-study project is then allocated N_1 ISPs (where N_1 is an even integer not exceeding 12). If the student is dissatisfied with the initial N_1 figure, he is allowed to negotiate with the EE1000 Coordinator for a higher allocation.

(c) The student will have to arrange for a minimum of two progress meetings – an interim session mid-way through the project as well as the debrief session at the end – with his personal tutor who may be asked to endorse requests for resources or reimbursement of expenses.

(d) Upon the successful completion of the work, the student is required to submit to his personal tutor a report (not exceeding five pages) on what has been accomplished. There are only three assessment grades for EE1000 projects - satisfactory, marginal or fail.

(e) The student's personal tutor will submit the assessment grade (electronically via another web-based template) and the corresponding ISP credit (*viz.* 0 for fail grade, $\frac{1}{2}N_1$ for marginal grade and N_1 for satisfactory grade) will be entered into the student's EE1000 record.

(f) The student is allowed to abandon his independent-study project if he loses interest whilst working on it. No penalty is to be imposed on him for having resorted to this course of action as otherwise there will be general reluctance to venture into unfamiliar fields.

The student repeats this procedure for additional independent-study projects until the total ISPs earned by him exceeds the minimum of 25 ISPs in accordance with the following progress milestones**:**

- he is deemed to have passed EE1001 if he collects at least 8 ISPs
- he is deemed to have passed EE1002 if he collects at least 16 ISPs
- he is deemed to have passed EE1003 if he collects at least 25 ISPs.

To encourage students to participate in competitive events, the EE1000 Coordinator meets with the judges and organising committees of competitions to arrange for the award of bonus N_2 ISPs (in addition to the pre-agreed N_1 ISPs) to students who submitted prize-winning entries. The usual recommendation is that N_2 should be 4 ISPs for first-prize winners, 3 ISPs for second-prize winners, 2 ISPs for third-prize winners and 1 ISP for those with commended entries**;** *e.g.* if the EE1000 Coordinator has already agreed to $N_1 = 8$ ISPs for all participants in, say, a robotic competition, each member of the team which wins the first prize will be entitled to 12 ISPs for this particular independent-study project.

4. Benefits Accrued

Although there were various teething problems that had to be resolved after its launch, the program has reaped benefits since then and EE Dept is constantly looking for possible ways to expand its scope. There was initially some concern over the 20-30% reduction of the pre-trimmed curriculum but students have been able to make up through literature-survey projects on topics of special interest to them**;** *e.g.* an EE2 student, surprisingly, selected Green's functions as the subject of his technical report. The trimming exercise affected the prescribed experiments as well but students are given the opportunity to sign up for extended laboratory sessions (under EE1000) on those experiments that appeal to them. To minimize the administrative hassle in arranging for students to gain access to laboratories for extended experiments, EE Dept has constructed special-purpose websites that provide virtual instruments for students to work on (even from the comfort of home).

It is encouraging to find motivated students rising to the challenge offered by EE1000. Many have undertaken independent-study projects that allow them to explore other aspects of engineering that cannot be formally taught in class. The most popular thus far are the annual robotic competitions (organised by NUS Engineering Club) which have been attracting more than 100 teams over the past few years**;** each team (comprising 3-5 students) is at liberty to decide on the specifications of the robot and the problems encountered during the design, construction and testing of the prototype are consequently different from those faced by the other teams. Also popular are the IT-related projects, especially those dealing with the development of websites and courseware packages. With the recent media blitz on dot-com companies, technopreneurially-inclined students have combined forces to pursue their goal of becoming the next Bill Gates**;** in fact, two groups of EE3 students have already launched their own start-up enterprises and they have

been so successful in securing venture capital and business deals that one of the students has decided to apply for a year of academic leave (from his EE4 studies) so as to focus on business development on a full-time basis. Other enterprising students have managed to work on commercial projects for both ISPs and remuneration (*e.g.* an EE3 student was engaged by an outside company to compile a stock-inventory database).

It is evident that some of the EE1000 work undertaken by students may have commercial potential and EE Dept has recently set up a showcase website for deserving students to publicise their independent-study projects. In addition, there is a match-making website for companies which are keen to tap on this pool of raw talent; the listing provides information such as the companies' general interests and contact details, and interested students can directly approach the contact person(s) to draw up independent-study projects that are of mutual interest.

Another benefit of this program is that student bodies (such as NUS Engineering Club and the local IEEE student branch) have been propelled to the forefront and are nowadays involved in the planning of project-based events that are suitable for their fellow students. EE Dept has sought to maintain a passive (but supportive) role in the organisation of independent-study activities lest it be perceived as compelling students to take on yet another series of prescribed projects. With their fingers on the pulse of the student community, the elected leaders of these student bodies are well placed to play such a role. Although they do not earn any ISPs for organising EE1000-related events, these extroverted student leaders benefit from the experience of managing large-scale functions – especially the popular robotic competitions which can attract more than 500 participants.

The EE1000 program is still in a state of flux and it is anticipated that there will be more exciting developments ahead. With further improvements in virtual-instrument technology, students will be able to gain access to an extensive range of experiments by simply dialling up from home. The future may see students from far-flung countries coming together via the web (or other electronic communication means) to work jointly on the same project; at the time of writing, there is already such a trial involving teams of NUS students collaborating with their Dutch counterparts at Eindhoven University of Technology. There is also no reason why pioneering students should not look beyond the confines of NUS to pit themselves against other like-minded students in national or international competitions (*e.g.* Texas Instrument's DSP contest and IEEE Region 10's student-paper competition). EE1000's open format readily allows all these new challenges (as well as any other variations) to be adopted by students who wish to stretch themselves in their self-development pursuits.

5. Concluding Remarks

Students may no longer presume that their studying days are over once they graduate and leave the university environment. Life-long learning is a must if they are to stay abreast of technological advances. To help them cultivate this self-learning mindset, EE Dept has introduced the novel EE1000 Independent Study module which requires all students to plan for themselves a combination of self-proposed projects that suit their own interests. The flexible format of this program has opened up a wide range of exciting learning opportunities that are not commonly available under the conventional curriculum structure. EE Dept is encouraged by the response and it is constantly looking for other possibilities to further enhance the effectiveness of the EE1000 program in producing graduates who are able to forge ahead in the New Economy.