NEXCESS: Nagoya University Extension Courses for Embedded Software Specialists

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Abstract— **In October 2004, Nagoya University has started an extension program on embedded software, called NEXCESS (Nagoya university EXtension Courses for Embedded Software Specialists). NEXCESS aims at education of engineers in industry, and is financially supported by the government. This paper describes the organization and course design of NEXCESS. Also, our experience of the first half year is reported.**

Index Terms—Education, Embedded, Software

I. INTRODUCTION

Due to the ever increasing demand for the development of embedded software, it is an urgent issue to increase the number of embedded software engineers as well as to improve their skills. Since embedded software is usually developed under very limited hardware resources, specialized skills are required for the embedded software engineers. The complexity of embedded software has been growing, while the time-to-market pressure has been strengthened. Needless to say, the reliability or quality must not be compromised.

In Japan and many other countries, however, few universities provide sufficient classes on embedded software development. Students graduate from their universities without acquiring enough skills on embedded software even if they major in computer science or electronic engineering. In most companies, on the other hand, OJT (on-the-job training) is only the method for training unskilled freshmen. The OJT is seldom systematic, so they can hardly acquire wide knowledge.

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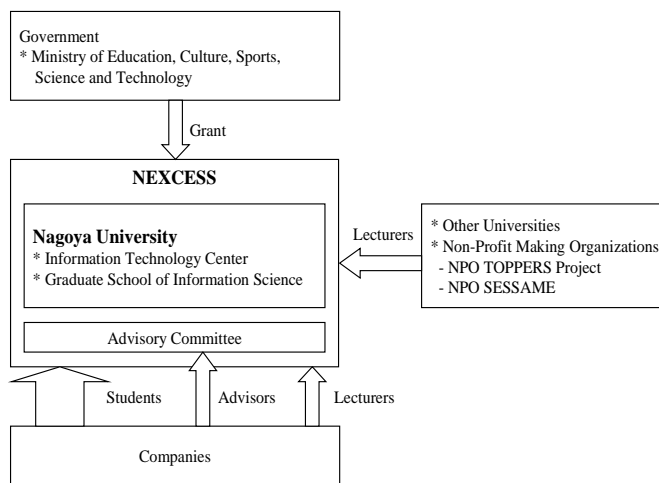
Fig. 1.   Organization of NEXCESS

program on embedded software, called NEXCESS (Nagoya university EXtension Courses for Embedded Software Specialists) [1]. NEXCESS is targeted towards embedded software engineers in industry. We have designed eight courses on embedded software and developed teaching materials for the courses.

This paper presents an outline of NEXCESS and also reports our experiences from October 2004 to March 2005.

The rest of this paper is organized as follows. Section 2 described the organization of NEXCESS. Section 3 presents how we have designed the courses. Section 4 reports our experience of the first six months.

II. ORGANIZATION

The organization of NEXCESS is depicted in Fig. 1. NEXCESS is composed of one center and one graduate school at Nagoya University. At present, eight faculty members (three full professors, two associate professors, one senior researcher, one young post-doctoral researcher and one doctoral researcher) and one research assistant are involved in NEXCESS. In addition, there is an advisory committee with 11 members invited from industry. The advisory members are typically senior managers in their companies.

The faculty members in Nagoya University offer most of the courses. However, some courses are partially supported by engineers in industry, professors of the other universities and members of Specified Nonprofit Corporations (NPOs).
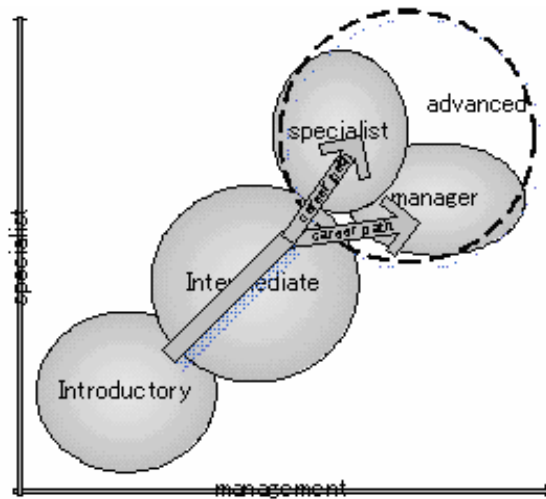
Fig.2. echnical levels and career paths

Specifically, NPO TOPPERS Project [2] and NPO SESSAME [3] are primary contributors to NEXCESS.

NEXCESS is financially supported by the Japanese government. An approximate total of 300 million yen is granted for five years from 2004 to 2009.

III. DESIGNING EDUCATIONAL COURSES

A. Classification of Technical Skills and Careers

When we designed extension courses, we first classified technical skills as follows.

(1) Introductory Level

An engineer at this level can accomplish his/her duties under directions by his/her superior. Typically, engineers with an experience of less than five years fall into this level.

(2) Intermediate Level

An engineer at this level can promote his/her projects by his/her own judgment. Typically, engineers with an experience of five to ten years fall into this level.

(3) Advanced Level

An engineer at this level can lead his/her company. Typically, engineers with an experience of more than ten years fall into this level.

Here, the number of years of experience is not an absolute criterion but just a rough one. It may vary depending on companies and individuals.

We also classified career paths for engineers as follows.

(1) Administrative Managers

Some engineers will become administrative manager who promote their company's business through managing their teams.

(2) Technical Specialists

Some other engineers will become technical specialists who promote their company's business through developing leading technology.

An advanced-level engineer understands his/her ability as an administrative manager and as a technical specialist. Thus, we assume that the career path is decided at the advanced level. Fig. 2 illustrates the relationship between the levels of technical skill and the career paths.

B. Designing Overall Courses

In many company, an engineer at introductory level works for the programming and testing process. We planed the introductory engineer must study structure programming, embedded C programming and testing. These skill are useful in the programming and testing process.

In many company, an engineer at intermediate level works for design and requirement process with his subordinate. We planed the intermediate engineer must study the structure design, requirements analysis and project management.

And In many company, an engineer at advances level works for the special technical field. We planed the advanced engineer must study real-time OS, C-based hardware design and other special technologies.

In 2004, eight courses have been developed. The courses are classified based on the levels of technical skills as follows.

(1) Introductory class (one course):
   "Fundamentals of the embedded software development technology"
(2) Intermediate class (two courses)
   01: "Design methodology and management of embedded software"
   02: "Software design technology with a real-time OS"
(3) Advanced class (five courses)
   01: "Internal structure of a real-time OS"
   02: "C-based embedded hardware design"
   03: "System control middleware and application"
   04: "Software engineering for embedded systems"
   05: "Ubiquitous interface and embedded software programming for image processing"

As mentioned in Section II, five professors and thee researchers at Nagoya University are involved in NEXCESS. Each of the professors is responsible to one advanced course, while three researchers are primarily in charge of introductory and intermediate courses. Additionally, external lecturers from other universities, NPOs and companies are invited whenever necessary.

Terms of the courses are designed to be short so that engineers in industry can attend the NEXCESS courses without largely sacrificing their job. Introductory and intermediate courses are four days long, advanced-01 is three days, and the other advanced courses are two days.

The eight courses are independent of each other. A student does not have to attend all the courses. One can take one or more courses which he/she needs.

C. Designing Individual Courses

It is widely recognized that project-style education is very effective. However, it generally takes a long time (typically more than two weeks) and it is not easy to complete a realistic project within a few days. However, more than two weeks are
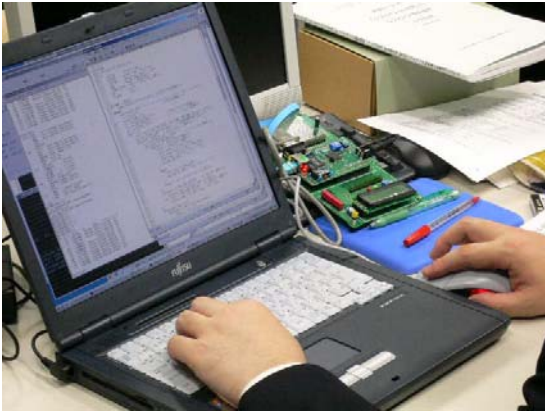
Fig.3. programming with a microcontroller board

Fig.4 Number of applicants

hardly acceptable for industry. Therefore, we have prepared a set of small workshop for most of the NEXCESS courses so that it does not take a long time to complete each workshop, but still one can experience key points in embedded system design. A few workshops are team-based, while the other workshops are done individually. Several workshops use microcontroller boards for programming and some other workshops are discussion-based requirement analysis and code review.

For example at the introductory course the small workshop is making TMER. The TMER notices of termination at preset time. This TMER has two SWs and two LEDs. First SW is for TMER start and second SW is for finish time length. The TMER program is only 500 lines C programming. And the student can learn how to initial a microprocessor, how to use microprocessor timer, how to get a switch, how to turn on a LED, how to build program and how to write flash ROM.

We have also developed textbooks for the courses. The textbooks are based on presentation slides. Each textbook consists of 196 to 652 pages.

IV. EXPERIENCE AND ANALYSIS

As mentioned above, NEXCESS is a five-year project (exactly, four years and a half). This section describes and analyzes our experience of the first half-year.

A. Practice

We held nine courses from November 2004 to March 2005. We held the introductory course two times. Each of the intermediate and advanced courses was held once. The courses were carried out weekdays from 9:30 to 17:00. Each day was composed of four time periods each of which is 90 minutes long.

The capacity of the introductory and intermediate classes is 30 persons, while that of advanced classes is 20.

Applications to the NEXCESS courses were received through the Web site. We have received a total of 369 applications.

Since the applications largely exceeded our capacity, we have selected 227 persons. Out of them, 13 persons cancelled,
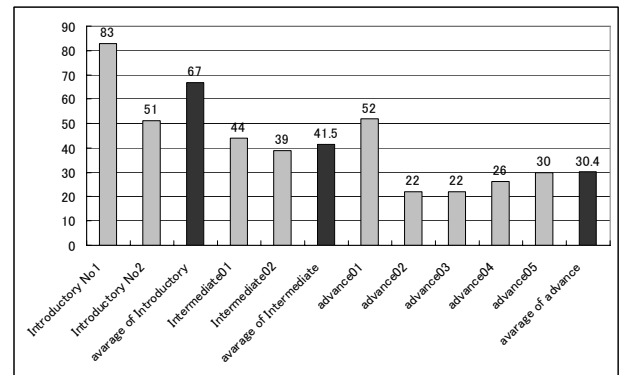
so the number of persons who have completed their course was 214 in total.

For a project with microcontroller boards, we have prepared one board for each learner. In addition to lecturers, four teaching assistants (TAs) assisted the projects on the average. All the TAs are graduate students in Nagoya University.

Through the courses, we requested the learners to answer a detailed questionnaire via the Web site. We found that a web-based questionnaire is more effective than a paper-based one. A large number of detailed comments were given by the learners.

All the courses were recorded with a digital video camera which was synchronized with the presentation slides. After the courses, we have created e-learning contents so that the learners can review them at home or office through the Internet. The e-learning contents were provided to the learners for two months after the course.

B. The Number of Applicants

The number of applicants for each course is shown in Fig.4. The average numbers of applicants for the introductory, intermediate and advanced courses were 67, 41.5 and 30.4, respectively. Thus, applicants tend to decrease as the technical level rises. This tendency is very natural since the scope of the course inevitably narrow as its technical level arises.

Applicants for the second round of the introductory course were largely decreased. This is mainly because the interval between the two practices of the introductory course was close.

The number of applicants for advanced-01 was much larger than that for the other advanced courses. As described in Section 3, advanced-01 is a course on RTOS internals. Thus, it is revealed that skilled embedded software engineers have a strong interest in RTOSs.

C. Ages of Applicants

The average ages of applicants for the introductory, intermediate and advanced courses were 28.5, 32 and 35.2, respectively. If we assume that they join their company at 24 years old, the numbers of years of experience are 4.5, 8 and 11.2. These numbers are very close to our assumptions shown in Section 3.1.
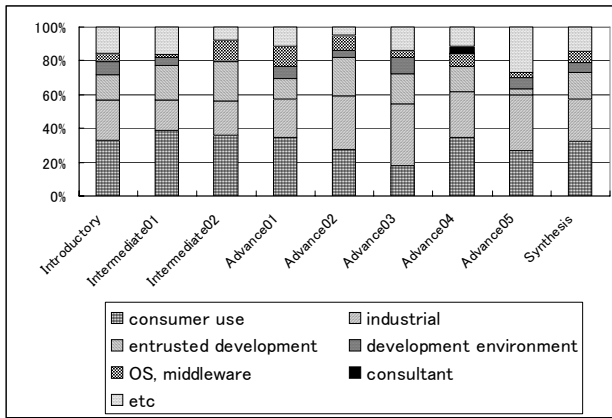
Fig.5 Types of companies

consumer use   industrial
entrusted development   development environment
OS, middleware   consultant
etc

D. Types of Companies

Types of the companies to which applicants belong are summarized in Fig. 5. Consumer and industrial electronics manufactures account for about 60%. Specifically, there were a large number of applications to the introductory and intermediate courses from consumer electronics companies.

61.9% of applications were from the Tokai area where Nagoya University is located. 19% were from the Kansai area (including Osaka, Kobe, Kyoto and so on), and 15.2% were from the Kanto area (including Tokyo, Yokohama, Kawasaki and so on). We received some applications from the Kyushu (Fukuoka, etc.) and Tohoku (Sendai, etc.) areas.

E. Analysis of e-Learning Review

After the courses, we provided e-learning contents so that learners could review them at home and office. About 57% of the introductory course learners have accessed the e-learning contexts, while those of intermediate and advanced courses were 32% and 27%, respectively.

F. Evaluation by Learners

We requested the learners to rate the courses from 5 (highest) to 1 (lowest) in terms of interest, usefulness, easiness to understand and overall evaluation. The results are summarized in Fig. 6. The average score of overall evaluation is 4.4, which we think is a very high score.

G. Easiness to Understand

The score of easiness to understand is generally lower than that of interest. Especially, the difference between easiness and interest is more than 0.6 points at the second round of the introductory course, intermediate-02, advanced-03 and advanced-05. We have in depth analyzed comments by those who gave a low score to easiness. The analysis reveals that the low rating is mainly due to practices of programming. On the other hand, easiness of advanced-02 which also has a programming practice is 4.3, which is not low. Some learners of advanced-02 wrote that the programming was easy, so the practice needs to be increased.

If one feels difficulty in programming, he/she tends to give a low score to easiness. In general, giving a low score to easiness
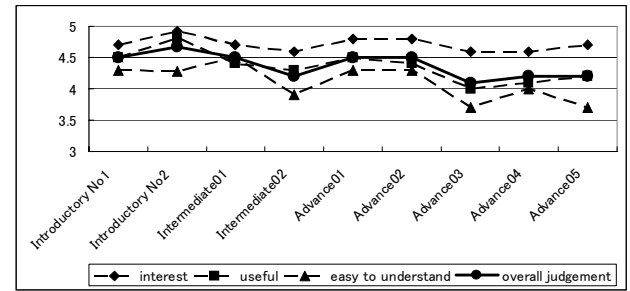

Fig.6 Evaluation by learners

interest   useful   easy to understand   overall judgement

is not always negative because one can realize what he/she does not understand.

H. Usefulness

Fig. 6 shows that the score of usefulness is located between interest and easiness, and is a strong relationship with the overall score.

For advanced-03, 04 and 05, the score of usefulness is more than 0.5 point lower than that of interest. This is mainly because most learners were very conscious of how to apply what they learned to their daily work, and they felt that some part of the advanced courses are not directly applicable.

On the other hand, the contents of the introductory and intermediate courses are fundamental, so the score of usefulness is generally high.

I. How to Get to Know NEXCESS

44% of applicants were directed by their superiors. It should be noted that the percentage is up to 63% for the introductory courses. Since the courses were held weekdays, understanding and permission by their superior is necessary. However, 9% of applicants confessed that they did not obtain permission by their superior.

J. Reasons for Cancellation and Absence

Since the number of applications exceeded the capacity, we have selected attendees for most of the courses. However, 17 persons (five for intermediate courses and twelve for advanced courses) were cancelled or absent.

We have asked the reason to them, and received responses from seven persons. Four answered that it was because of some urgent work. Three out of them judged it by themselves, and one was directed by his superior or customer.

V. SUMMARY

Education of engineers in industry as well as ordinary students is one of important responsibility of universities. Nagoya University has started an extension program on embedded software, named NEXCESS, with financial support by the government. From October 2004 to March 2005, we have held in total nine courses. The evaluations by the attendees were generally high.

NEXCESS is now in the second year. We are continuing to improve our courses. Especially, this year, we plan to open a new course for educating future educators so that they can educate young engineers in their companies.

REFERENCES

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