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Improving design education at Kanazawa Institute of Technology

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Abstract

A Task Force made up of a multicultural group of visiting professors at KIT worked together with Japanese counterparts to develop materials to improve Design Education at Kanazawa Institute of Technology (IDEA-KIT), Japan. The IDEA-KIT Task Force decided to use the Design Engineering Process that we teach to address the problems related to improving design education. The Task Force mission was to identify problems and needs in Engineering Design Education (EDE), to develop design specifications for educational materials to meet these needs, to generate a large number of concepts for ways to satisfy the design specifications, and select the best and most feasible ones for development to a level appropriate for classroom use in the autumn quarter of 1999. To facilitate implementation at KIT, all materials developed were to be modular, easy to use for both the faculty and students, and provide guidance in managing courses and standardising practices. As with any new programme, there were significant challenges in developing and implementing the EDE programme at KIT. While some challenges were anticipated, most did not show their true difficulty until experience in running the programme was available.

Keywords: design engineering, education, Japan, modular resources

Background

For the first time in their 1999 Cologne Summit Meeting, the Heads of Government of the G8 countries and the President of the European Commission stressed the importance of education in social and economic development for all countries, particularly their own. This was followed by this year's Tokyo Meeting of the G8 Education Ministers and the members of the European Commission responsible for Education with participating observers from the OECD and the UNESCO. They further committed themselves to finding new strategies for improving education, notably from the perspective of "Education in a Changing Society".

As for many countries, "Globalisation" and "Changing Society" put Japan under tremendous pressure and the challenges faced by establishments of higher education are acute. In the early 90s, the Ministry of Education, Science, Sport and Culture of Japan (Monbusho), recognizing the need for new approaches to education, formulated a set of

long term objectives. The Science and Technology Basic Plan (Ministry of Education, Science, Sport and Culture of Japan), enacted in 1995, was part of efforts to promote creative thinking in science and technology.

In response to Monbusho's call for change, KIT decided to reform its curriculum and consider new teaching methods. In this context, in 1996, KIT created a new introductory engineering design sequence modelled on engineering design classes in the United States. The sequences consisted of two sophomore-level classes, Engineering Design I (EDI) and Engineering Design II (EDII). The objectives (Ramdane *et al*, 1999a; Ramdane *et al*, 1999b; Herbeaux *et al*, 1998) were to provide students not only with superior technical capabilities, but also to enable them to identify and solve ill-defined and open-ended problems, generate a set of distinct and creative concepts and understand and implement the Engineering Design Process (EDP), while working as a team. Furthermore, the course series was also to encourage students to develop expertise and abilities for

IDEA-KIT Task Force Mission Statement

The mission of the IDEA-KIT Task Force is to apply the Engineering Design process to the theme of Improving Design Education at KIT. The Task Force will identify problems and needs in Engineering Design Education at KIT, develop design specifications for educational materials to meet these needs, generate a large number of concepts for ways to satisfy the design specifications, and select the best and most feasible ones for development to a level appropriate for classroom use in the Fall Quarter of 1999.

To facilitate implementation at KIT, all materials developed will be modular, easy to use for both faculty and students, and provide help in managing courses and standardizing practices. Preliminary testing of some of these materials is expected to begin by Winter quarter 1998.

Figure 1 The mission statement of the IDEA-KIT Task Force

tackling problems independently, and acquire important skills such as those of communication and leadership.

To develop these skills in students, it was decided to minimize the amount of structure in the classroom and give the students the responsibility for their learning.

However, each of the classes in the introductory design sequence at KIT handles about 2000 students each year, with approximately 60 sections (400 teams of 5 or 6 students) and 30 different faculty members. Moreover, the design experience of the participating faculty members varies widely, as do approaches taken by faculty to reach objectives stated by the Engineering Design Core (EDC). As a result, the educational outcome of the programme was mixed, with some students achieving marginal results.

As part of a university-wide curriculum review, KIT evaluated EDI and EDII during the 1998-1999 academic year. A group of foreign faculty formed a Task Force (IDEA-KIT), and worked together with their Japanese counterparts to improve EDE at KIT.

IDEA-KIT Task Force: Organization and Process

During the 1998-1999 academic year, foreign design faculty members organized a Task Force called "IDEA-KIT". Figure 1 shows the mission of the Task Force.

First the Task Force started by identifying the problems at the EDC by generating a list of

challenges. The process used to generate the ideas (challenges) was the "affinity diagram" technique that has been promoted in the Value Analysis/Value Engineering field (Fowler, 1990).

In a period of about 25 minutes, over 50 ideas were generated. Ideas that were identical were stacked on top of one another; ideas that were similar were clustered together. A title was chosen for each of the groups. Each group of ideas was then assigned to a team member to write up and expand. For the sake of brevity, these challenges are summarized in the next section.

Challenges for EDE at KIT: opportunities for improvement in Engineering Design Education

As with any new programme, there are significant challenges in developing and implementing the EDE programme at KIT. Some of the challenges are unique to Japan and/or to KIT, while others are common within any design education programme.

Over 50 different challenges were identified and classified into nine basic areas: Themes, Qualifications, Culture, Consistency, Materials, Objectives, Timeline, Motivation, and Size.

These challenges are significant, and will require creativity and skill to resolve. In fact, some of the challenges may not be resolvable within the existing constraints. The first step to resolving these challenges is to clearly articulate them. These challenges are listed as follows:

The Size of the Programme

One of the major challenges faced by the EDE programme is its sheer size. Both EDI and EDII were offered to all students of the sophomore year. Each class must support approximately 2000 students in a given quarter. Specific challenges that are directly related to the size of the programme include the following:

- Many different classes for one professor.
- Many different faculty teaching the course.
- Poor communication among the teaching staff.
- Isolation of the faculty.
- Many students per professor.
- Resources to build hardware.

Ensuring Consistency among Sections and Teams

With about 60 sections (approximately 400 teams), and 30 instructors each semester, it is very difficult to ensure that all students have a comparable experience. Among other difficulties, the large number of sections taught using many instructors has resulted in:

- variation of content among sections;
- variation in criteria and requirements for assigning final grades and passing the course;
- lack of a uniform and successful method of combining group and individual performance to determine the grade for individual students;
- lack of uniform session management practices such as organization at the start, periodic reporting of progress, and course completion activities.

Achieving Appropriate Educational Objectives

In order to increase the likelihood that the professors are meeting the objectives of both EDI and EDII, it is imperative that the goals of these classes be clearly articulated. The challenges that were identified in this area were:

- EDI and EDII were perceived to be essentially the same, except for a few small and cosmetic differences;
- the objectives of both EDI and ED II were not clear;
- educational outcome expected from the students were not clearly defined;

- specific educational targets were not clearly articulated for professors to aim for.

Working Within the Short Timeline of the Classes

The quarter at KIT is very short, with only nine weeks to teach the design process. The professors teaching EDI and II have many tasks to juggle and concepts to teach. Several skills need to be learned by students of design. This puts tremendous pressure on the professors and students since those skills have to be mastered within this short period. In fact, most of the work was carried out within 6 to 8 weeks, unfortunately resulting in students' inability to get past the conceptual design phase.

Selecting Appropriate Themes

In achieving successful EDE, it is critical that the student teams have appropriate main and project themes to work with. Choosing appropriate themes is a difficult, subjective process. The following issues are related to the choice of themes in EDI and II:

- choice of Main Theme;
- choice of Project Theme.

Providing Appropriate Educational Materials

The teaching and management of large multi-section classes can be improved if relevant educational materials are provided or made readily available. A challenge exists in fleshing out the relevant sources and information. The challenges that were identified in this area include:

- lack of readily available reference material;
- lack of information regarding successful practices by other professors;
- lack of a textbook that could be followed and used to augment the course materials.

Qualifications of the Teaching Staff

A well-qualified teaching staff is essential for a high-quality educational programme. At KIT, there are significant challenges to maintaining such a staff for the EDC:

- training of new teaching staff;
- preparation time;
- motivation of teaching staff;
- for foreign professors, language barrier and need for translation.

Maintaining Student Motivation

The following challenges with student motivation have been observed in several sections of EDI and II:

- students think that they are given too much work;
- students do not like open-ended problems;
- students do not seem to be motivated;
- some students sleep in the class.

Accommodating Cultural Issues in Design Education

The Japanese educational system is different from that of the United States. One reason for bringing foreign faculty to KIT is to bring experience from a different culture. Part of the motivation for the EDE programme at KIT is to try to make changes in the educational culture of Japan.

Cultural issues in EDE affect both students and faculty at KIT. Any successful educational programme must accommodate and respect the Japanese culture at the same time as it changes the educational process.

Cultural Issues with Students

Individual and group experiences during their youth and prior schooling affect the way the student participates in team design activities. The areas affected by such cultural experiences include:

- communication methods;
- teamwork;
- individual participation;
- creativity;
- class discussion;
- desire for homogeneity.

Cultural Issues with Faculty

As strong as the cultural issues with the students are those with the faculty. Faculty have worked successfully within the Japanese educational system. Some of the challenges that will be faced as the EDE programme is implemented are:

- traditional classroom hierarchy.
- faculty exclusivity.

Design Specifications for Challenges in EDE at KIT

With the challenges clearly identified, the IDEA-KIT task force moved on to developing a set of design specifications.

These specifications were organized in 4 categories, namely, constraints, product constraints, aims (goals), and axioms (self-evident truths).

Two types of constraints were identified, namely, external constraints or required conditions related to curriculum environment and KIT policies, and product constraints or characteristics that the solution must have if it is to serve its intended functions. Aims or goals can be seen as aspiration spaces. They stipulate what the characteristics and properties of the ideal solution should be. Obviously, not all goals can be met as they most often represent unrealistic quests towards unattainable limits. While no attempt has been made to prioritize the aims, it is understood that the relative level of importance or priority of these aims will dictate the design compromises to follow.

The fourth type of consideration, referred to as axioms, was also reported in an effort to justify the presence of some of the challenges and associated specifications. Axioms are "propositions which are necessary to take for granted" (Webster online).

Concepts: Product Ideas for Improving EDE at KIT

With the specifications clearly identified, the IDEA-KIT task force moved on to developing concepts for problems (challenges) described above.

Initially, task force members were asked to brainstorm. They produced as many ideas as possible on an individual basis. Individual ideas were then combined and placed in random order to create the initial list. The team met and reviewed the list hoping to be inspired and to generate even more ideas.

Student Learning Materials	Faculty Cooperation	Communication
Student Motivation	Faculty Timesavers	Course Management Helpers
Student Reference Materials	Faculty Training	Creativity
Student Reports	Instruction Quality	Tool Purchases
Teaching Materials	Standardization	Topic Suggestions
Student Instruction	Themes	Winter Quarter Projects

Table 1 Organization of the major categories for improving EDE at KIT

This initial list of ideas was then organized into major categories. The organization helped in at least two ways. First, many items on the list were either exact duplicates or very closely related. By organizing the list, the similar ideas could either be combined or their differences could be articulated more clearly. Second, the list contained so many ideas that it was impossible to comprehend it as a whole. The organization breaks down the list into 18 major categories which are listed in Table 1.

Some of the major categories were further divided into subcategories. Clearly, the task force could not pursue all of these ideas.

Solutions: Product Selection and Implementation

First, adjustments to the IDEA-KIT had to be made as a result of KIT’s decision to shorten the class period from 75 minutes to 60 minutes. Each week, EDI and II meet for two consecutive class periods, so thirty minutes of class time were lost. The task force, therefore, needed to look for product ideas that still provided solutions to the challenges and would teach the EDP within a shorter class period.

Furthermore, KIT decided to make changes in class-scheduling. In this context, the new curriculum would have EDI taught in the fall term of the first year and EDII taught the winter term of the second year. As a result, the course objectives of EDI and II needed to be distinct but properly coupled in order to continue the engineering design learning process and overcome any knowledge retention problems associated with this three term gap in the sequence.

Finally, the nine-week term was altered to an eleven-week term, with exams held on the 10th week.

These changes introduced new constraints and modified some that had been identified by the Task Force during the design specification stage of the IDEA-KIT project. Design efforts by the Task Force were then directed toward products that would meet these new conditions.

According to those changes, the task force started by developing a set of objectives for both EDI and EDII. The task force recognized that the only way for the students to be properly taught the EDP was to have the course objectives for EDI take the students to a point where a seamless transition into EDII would occur. This would ensure the continuity and completion of the teaching of the EDP. To help achieve this, the task force designed a “Project Summary Document” for use in EDI and it is the source document for EDII students.

Next, the task force listed all the deliverable products for EDE in order of priority as shown in Table 2. Several products for improving EDE at KIT were selected for further development with the aim of implementing them in the new ED courses.

These courses have been prepared in both English and Japanese. The main deliverables are as follow:

Course Objectives for the New EDI and II

The *levels* that the students are expected to reach at the end of EDI and EDII as well as the extent of the educational *content* in both classes associated with individual learning outcomes have also been specified. These objectives have been listed and categorized, and inserted in the syllabus, which is distributed to all students at the start of each quarter.

	High Priority				Low Priority			
	Class Package Spring EDI Winter EDII	Objectives and Descriptions EDI and EDII	Course Packages New EDI & EDII	IDEA-KIT Website	Class Roll Database	Class Module Maintenance Program	Website Enhancements	Materials Winter Term
EDE web site for faculty				•				
Office Hours Rules			o					
Student web page				o				
Class Management Forms and Tools	•		•					
Class progress assessment Tools			o					
Complete Course Package	•		•					
Grading Spreadsheet			o					
Off-site visit manager			o					
Faculty Teams								
Floating Instructors	•							
Automated software for course management			o		o	o		
Student Assessment of Teachers	•		•					
Distinct education objectives		•						
ED 1 projects followed up on in ED 2		•						o
Assessment of individual contributions								
Description of Submissions	•		•					
Grading policy statement	o		o					
Student deliverable standards	•		•					
Student Evaluation Tools	o		o					
Student involvement in quality control								
Clearer statement of the design process			•					
Objectives and Standards	•		•	•				
Careful description of student deliverables	•		•					
ED Support tools				•	•			
Report formats			•					
Class presentations with teaching notes			•					
Design Examples for Use in Class			o					
ED Tools modules			•	•	•			
Project Theme Submission Procedure			•					
Theme Standards			•					

Table 2 Priority of the delivered products

Course Packages for the New EDI and II

A complete course package has been developed for the teaching of the new EDI and II. These packages consist of manuals for both the instructors and students, providing with the basic information necessary to successfully complete the class. Furthermore, these manuals were intended to provide structure to the in-class and out-of-class activities, while the learning of the design problem itself would be open-ended and unstructured.

Instructor Manual: This includes:

- weekly class plans that give a recommended outline for each class meeting, along with slides, forms, and any other materials for the class.
- materials to help evaluate student work in the design sequence, such as oral presentation evaluation form, a peer evaluation form, and a recommended practice for keeping track of how each student contributes to class each week.

Student Manual: This includes:

- activity sheets that provide clear instructions for what the students are to accomplish in class each week;
- assignment sheets that provide clear descriptions of what the students are to accomplish outside of class;
- reference materials that provide additional information about the design process or specific design tools;
- supplemental materials that consist of special forms, template files to be used by the students for their assignments.

IDEA-KIT Website

One very convenient way to distribute materials that have been developed is through the World Wide Web. A website has been developed for dispatching these materials.

A major challenge in developing the website was finding a way to effectively create a

bilingual website. A bilingual site was needed to support the English-speaking faculty members and to allow Japanese faculty members access to the documents that were originally developed in English.

Commercially available web development tool "Front Page" has been used with the help of an additional customized program for automatic linking between the different languages. The completed site has proven to be fast and easy to use and maintain.

Conclusions

The task force has successfully completed the IDEA-KIT project's mission. The design process and team approach that were used proved to be an effective strategy to identify the problems and needs in EDE at KIT. Accordingly, course materials have been developed with the aim at bringing a new structure and a good consistency to the ED courses.

This new structure was tested by all the instructors in EDI during the autumn quarter of 1999. Results indicate that the provided structure was well received by both students and faculty, and that the overall quality of teaching and learning experience was enhanced. As for EDII, the course materials have just been completed and will be ready for use during the winter term of 2000.

However, total success will depend upon properly training the faculty in using these materials, providing faculty with good sources of assistance as they teach, while fostering an environment where information and experiences can be shared.

For sake of brevity, we will not provide the list

of objectives, details of course materials and the statistical results from students' evaluations. These documents will be published in the near future.

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