INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN
ICED 05 MELBOURNE, AUGUST 15-18, 2005

# A METHODOLOGY FOR CURRICULUM PLANNING AND EVALUATION OF THE DESIGN-ORIENTED COURSE "MECHANISM" BASED ON STUDENTS' OUTCOMES

Shyi-Jeng Tsai, Pei-fen Chang, Jiunn-Chi Wu

*Keyword: ABET EC-2004, mechanism, learning outcomes, mechatronic platform*

## 1. Introduction

Our worry about the Taiwanese students' competence, especially the design abilities, to face the challenge of global competition is gradually stronger. One of the attempts for engineering education reform in Taiwan is introducing the concept of outcomes-based curriculum planning in universities. Through a joint research group from the National Central University, and Yuan Ze University, we aimed thus to develop a methodology based on ABET EC-2000 outcomes criteria under a three-year integrated project. The undergraduate course "*Mechanism*" is chosen as one of pilot courses to experiment the feasibility of the outcome-based course planning as well as to redesign our current course planning in consistency with the learning outcome and engineering criteria. According to the developed approach, we developed therefore teaching strategies, actions as well as assessment methods based on the course objectives and the corresponded leaning outcomes of students.

## 2. Outcomes-based curriculum planning in Taiwan

Outcomes-based curriculum planning is a continuous improvement model following "*plan-act-do-check*" approach. Since the ABET EC-2000 [1] has been proposed, engineering educators in the United States are forced to focus on how to implement the Criterion 3 (A-K) into their academic program as to strength their accreditation process. Recently in Taiwan, the accreditation for engineering education is just initiated by the IEET (Institute of Engineering Education, Taiwan) [2]. And there is loose linking between the engineering criteria and outcome-based assessment to the academic program in almost every engineering institution in Taiwan. Most of engineering courses offered in the undergraduate institutions in Taiwan only emphasize on the contents of knowledge part and neglect the essence of student learning outcome. Our study will be one of the few engineering curriculum reform in Taiwan to realize the importance of outcome-based learning and put it into action.

## 3. Features of the course "Mechanisms"

In curriculum of mechanical engineering, the course "Mechanism", or known as another name "Kinematics", is a traditional course in comparison with the other courses on newly developed technologies, such as "Biomechanics", "MEMS" or "Nano-technologies" and so

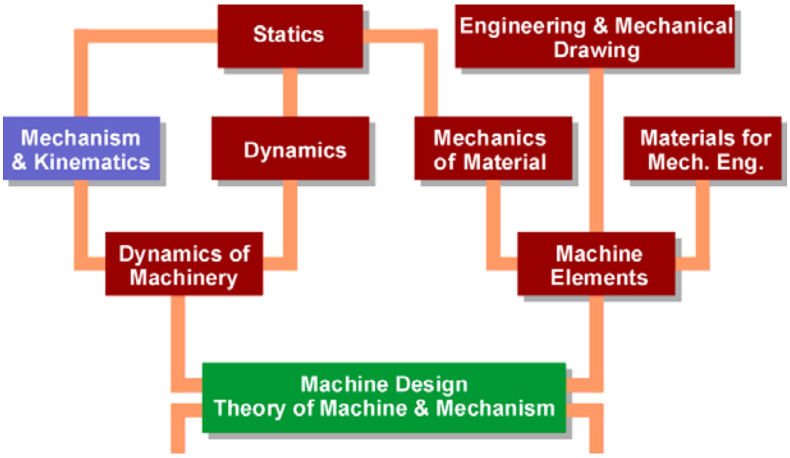


Figure 1. Related courses of Machine Design [3]

on. In general, the course "Mechanism" belongs to the "machine design" or "mechanism and machine theory" course series, as **Figure 1** illustrated. At the department of mechanical engineering, National Central University, Taiwan, "Mechanism" is a compulsory course for sophomore with three credits. The course contents generally include two main parts, "structure of mechanism" and "kinematic analysis", and are divided into the main topics: the composition of mechanisms, mobility analysis, kinematic analysis of linkage mechanisms, cam mechanisms and gear mechanisms.

Although the contents of this course at universities are mostly oriented in kinematical analysis, many solution principles by designing engineering products, especially the mechanical devices, are developed from the basic principle structures of mechanisms [4]. From a course attribute point of view, the course "Mechanism" may have two significant features:

- It is an analysis oriented and needs mathematics as a tool, just like the engineering science course "Mechanics".
- It has a close relation to the "engineering design" courses, e.g. "Machine Elements", and uses also graphics as a media for problem thinking and concept representation.

Our experiences on teaching engineering design in the past years shows that there is a somewhat great gap between the both courses "Mechanisms" and "Engineering Design". Consequently the undergraduate students have difficulties in applying the domain knowledge of mechanisms to the development of solutions while in processing their design projects. From the previous study [5] we summarize the difficulties of the mechanical engineering students in Taiwan by learning such a non-pure science course as follows.

1. The course contents are much more abstract, even though the objects discussed in the course (e.g. gear or linkage mechanism) are very concrete. Especially the representation of mechanism through symbols is meaningless to most students if they cannot establish the mapping relation between abstract symbols and realistic mechanisms in mind.
2. There is no close relation between the individual course contents of "Mechanism". It is not necessary, for example, the chapter "Cam Mechanism" and "Gear Mechanism" in a given order to teach. As a result, the students are not capable of integrating the diverse knowledge acquired from the course to solve the practical kinematic problems by capstone design.

3. Only by the chapter "cam mechanism", the students can acquire design ability to construct the cam profile, while the other contents are almost analysis oriented. Due to too many teaching materials on analysis-oriented contents, the ability how to apply the acquired knowledge to the design task is often ignored. Consequently the students have no ideas about how to apply the acquired kinematic or mechanism knowledge to their design task.

# 4. Method for curriculum planning

Although reviewing institution's mission statement is in general the starting point of the outcomes-based curriculum planning, this is not available in our study. Therefore we skipped the first step and adopted a modified approach: (1) defining course objectives and learning outcomes, (2) comparison of cognitive level and outcomes attributes, (3) developing corresponding teaching strategies, and (4) developing assessment methods.

## 4.1 Defining course objectives and learning outcomes

The first step of curriculum planning is to identify the objectives of the course clearly. At this stage a clear statement should be described what faculty wants to accomplish by the end of the course and what will the students know and be able to do when they have completed the course.

Due to the engineering education reform ("*education pull*") as well as due to the needs by industry and also new development of technologies ("*technology push*"), the teaching objectives and the strategies of the course "Mechanism" must be modified to meet the new requirements. From viewpoint of learning type, we classified the student learning outcomes into three groups: "knowledge", "tool" and "methodology" [6]. Based on this classification, the new objectives are derived through intensive discussion with the department faculty and also through receiving feedback from students. They are summarized as follows:

- They can learn a variety of knowledge of mechanisms and know how to use those mechanisms to solve the problems of transmission and transformation of motion.
- They can use and apply different methods to analyze, to plan and to calculate the motion of mechanisms.
- They are capable of establishing the motion logic of mechanism and also of constructing an integrated mechatronic mechanism through teamwork.

From above objectives, we have drawn up expected learning outcomes and corresponding attributes by using the framework developed by Besterfield-Sacre et al. [7]. In this framework each ABET outcome (a-k) has been specified based on Bloom's taxonomy and expanded into a set of attributes [8]. A portion of our planning is shown in **Table 1** [9, 10, 11]. The index in Table indicates not only the initial EC-2000 criterion a-k, but also outcome elements and Bloom's cognitive category.

## 4.2 Comparison of cognitive level and outcomes attributes

After the course objectives and the learning outcomes are defined, it is also important to compare and to identify what cognitive level of various outcomes has reached. In order to visualize the differences of the learning outcomes and the complexity of understanding that students are expected to demonstrate, we construct a two-dimension matrix as a learning objectives profile for further attribute analysis of the course. From the profile shown in **Figure 2**, it can be seen that the learning outcomes of the course "Mechanisms" are fairly well distributed among ABET criteria *A*, *C*, *D*, *E*, *G*, and *K* [1][1] with most components represented at the "*Application*" cognitive category. In addition to this, students will be also expected to acquire some outcomes with the levels "*Comprehension*", "*Analysis*" or "*Synthesis*".

## 4.3 Developing corresponding teaching strategies

From a psychological point of view the knowledge that we impart to the students in universities can be distinguished between "*declarative knowledge*" and "*procedural knowledge*" [12]. The knowledge about "*how to design*" belongs essentially to the last. It is difficult, however, to teach the students to acquire design abilities from the course "mechanism", if there is no suitable teaching strategy developed and applied. Since procedural knowledge is best taught by demonstration and best learned through practice [12], we emphasize some measures, apart from conventional teaching strategies, to enhance the students' design skills. One of them is to use simulation software both in the lecture and the exercise (or homework) to improve the abilities to establish the "conceptual model" of mechanisms, and the others are to hold the hands-on activities (e.g. after-class activities and a contest) with aid of "Fischertechnik©" kits. Those teaching strategies will be further described in detail in section 5.

Table 1. Course planning, a portion [9, 10, 11]

| **Course Objective 1**：*Provide students with opportunities to learn the knowledge of different mechanisms and how to apply these mechanism to solve the problem of motion transformation.* | | | |
|---|---|---|---|
| **Strategies and Actions** | **Outcomes** | **ABET Attribute Index** | **Assessment Methods/Metrics** |
| **Lecture:** Lectures will present key concepts, fundamentals, and illustrated examples with aid of and animation of software "SAM" (for analysis and simulation of mechanism) to enhance understanding of students for motion of mechanism. For some complicated mechanisms, realistic models will be presented on site to show the motion and composition of mechanisms to students. | 1. Students will recognize the composition and related components of linkage, cam and gear mechanisms;<br>2. Students can understand the kinematic principle of different mechanisms;<br>3. Students can choose suitable mechanisms for different requirements.<br>4. Students will demonstrate their abilities to analyze and calculate the degree of freedom of mechanism. | A2.3<br>E3.3 | **Questionnaire** will be given to students to gain their perceptions about the course objectives.<br>**Quiz** will be given to students after the lecture to gain feedback from students on understanding of the lecture contents.<br>**Locally developed examinations** will be used to verify the learning outcomes in each stage of the course. |
| ⋮ | ⋮ | ⋮ | ⋮ |

Note: The meanings of index **A2.3**: the character "**A**" represents ABET criterion a-k. The first number "2" represents outcome elements defined by [8]. The second number "1" represents cognitive level (see Figure 2).

[1)] The related ABET outcome criterion are defined as follows: **A**: *an ability to apply knowledge of mathematics, science, and engineering*; **C**: *an ability to design a system, component, or process to meet desired needs*; **D**: *an ability to function on multi-disciplinary teams*; **E**: *an ability to identify, formulate, and solve engineering problems*; **G**: *an ability to communicate effectively*; and **K**: *an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice*

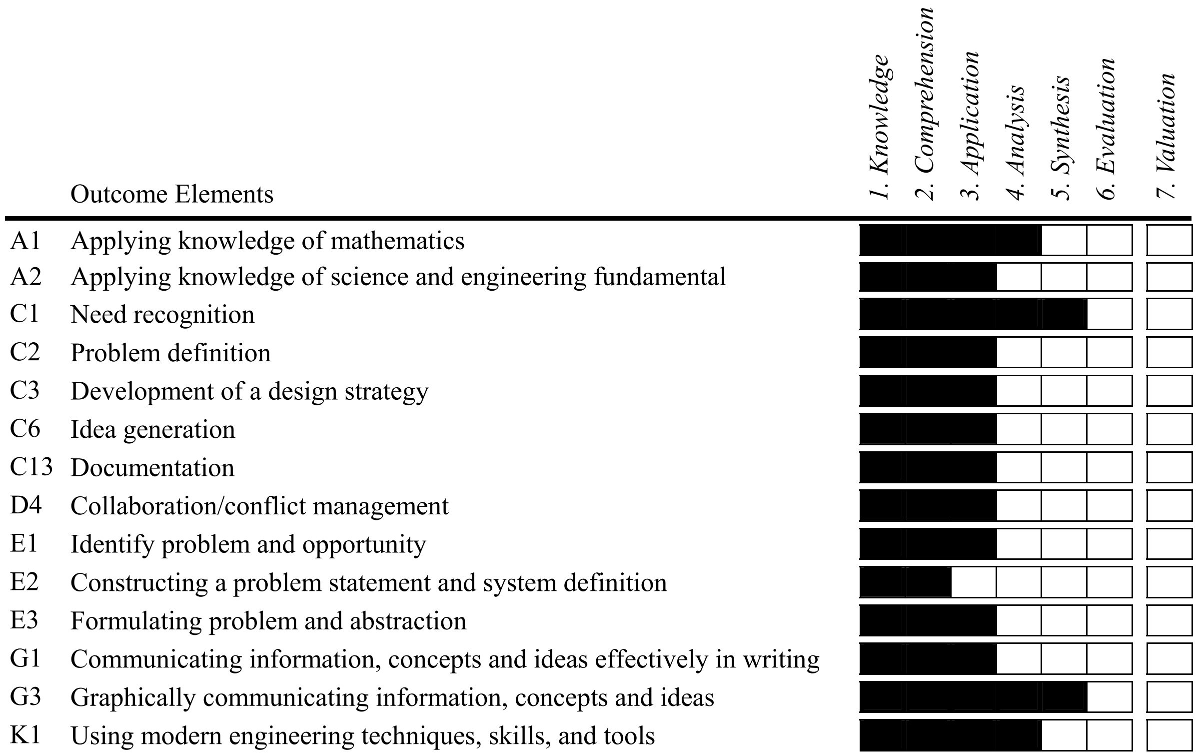


Figure 2. Learning profile for the course Mechanism

Table 2. Questionnaire, a portion [11]

| Questions | | 1*) | 2*) | 3*) | 4*) | 5*) |
|---|---|---|---|---|---|---|
| **I. Basic Abilities**: After this course, | | | | | | |
| 1. | I can apply the theory of calculus, linear algebra and geometry to analyze the motion problems of mechanisms. | | | | | |
| 2. | I can apply the knowledge of mechanism to predict and analyze the motion of mechanisms and machine systems. | | | | | |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

*) The number denotes the measuring states: 1 for "*strongly disagree*", 2 for "*disagree*", 3 for "*uncertain*", 4 for "*agree*", and 5 for "*strongly agree*".

## 4.4 Developing assessment methods

Based on the developed teaching strategies and actions, we devised some corresponding assessment methods. Some usually applied assessment methods, such as quiz and exam, were facilitated as summative evaluation. Although these methods are traditional instruments, they still provide multiple measurable performances of students. The unique and new assessment developed in our study is the questionnaire. It is an important assessment tool to evaluate students' confidence in acquisition of the specified core competences from the course.

The statements of the questions in the questionnaire are derived from the outcome attributes (see Table 1) and grouped together according to different teaching actions such as (I) basic abilities for lecture and tutoring exercise, (II) open-ended homework, and (III) after-class activity with Fischertechnik. **Table 2** shows a portion of the questionnaire, and only two questions are listed in here. A total of 23 questions are generated and can be found in [11].

In order to examine the appropriate phrasing and any misinterpretation so as to have valid and effective instrument, the context of questions is reviewed by a focus group, which is formed by faculties and students. Analysis of the survey data based on the questionnaire result will be further discussed in section 6.

# 5. Teaching strategies with hands-on oriented activities

As mentioned in section 4.3, we emphasized the role of simulation software as well as the importance of hands-on oriented activities in the course for enhancement of the students' design abilities. In the following we will illustrate our teaching strategies and actions how to reach to the specified course objectives.

## 5.1 Demonstration and exercise with simulation software

From viewpoint of engineering design, establishment of "*conceptual model*" of various mechanisms is much more important than acquisition of the ability for kinematic analysis. The "*conceptual model*" is so understood that if a designer has formed a "*conceptual model*" of a device, s/he can mentally simulate its operation while looking at its sketch or picture [12]. For example, when observing a symbolic graph of a four-bar linkage (e.g. crank-rocker), we can identify the rotation direction of the output link with given rotation direction of the input link, because we have already a "*conceptual model*" in mind. This "conceptual model" is critical for designer to search and to select suitable mechanism in her/his task. Based on the concept of "conceptual model", we use simulation software to demonstrate the animation of mechanisms in the class to improve the competence of understanding motion of mechanisms.

By searching suitable simulation and analysis software for mechanisms, we have concluded following requirements,

- <u>Simple, easy operation and clear interface</u>, because there is no more time left for the course to teach the students to operate complicated software.
- <u>Including the main topics of the course on kinematic analysis.</u> At least linkage mechanism and gear mechanism must be included in the software.

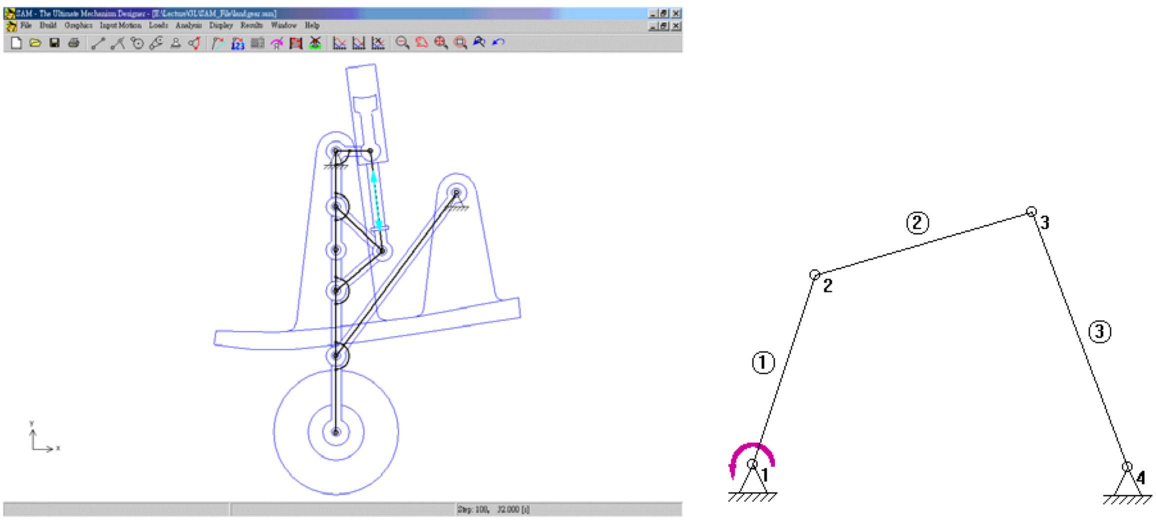


Figure 3. Interface and modeling representation of the software SAM

- Inexpensive purchase price and available student's version. It is important that every student can use this software for homework and self-study after class.

Among commercial software we chose the application program SAM (**S**imulation and **A**nalysis for **M**echanism) from Holland [13] for use in the course. This software is applied not only to demonstrate the examples in the textbook through animation in the class, but also as a tool for the students to solve the kinematic analysis problems for homework. The main advantage of the software SAM is its simple interface design (see **Figure 3**), in which the mechanism modeling is represented through the commonly used mechanical symbols, so that there is no transformation problem left for the students to understand the meaning of the symbols taught in the class.

## 5.2 Enhancing design skill through the after-class activity

In order to improve the design ability of students, we put more efforts to another hands-on oriented activity, using Fischertechnik© kits as a mechatronic platform. Due to the limited resources, for example the amount of "Fischertechnik" kits (20 kits) and the tutors (only one per class), all the participants in this activity are volunteers. The Fischertechnik kit, shown in **Figure 4**, consists of fundamental building blocks, sensors, various mechanism parts (shafts, gears etc.), electric and pneumatic components, and other accessories etc. All parts were purchased as spare parts from the maker based on our requirements of activity planning.

**Table 3** shows the topics and the objectives of this after-class activity, in which students must construct with Fischertechnik© not only conventional mechanisms, such as linkage, gear, belt mechanism, but also the mechanisms for mechatronic and pneumatic application. Through each hands-on oriented exercise, the students can learn how to build mechanisms to meet the specific requirements of motion and function and also can experience how these mechanisms work in reality. The ability to integrate domain knowledge to solve mechatronic/pneumatic problem can be also acquired in the integrated exercises. For example, by the unit "automatic door" the students must construct an automatic door by using pneumatic and electronic control components to meet the following requirements (final product see **Figure 5**):

- The door will be opened, if the button near the door is pressed.
- The door will be closed automatically, if one left a certain area near the door.
- The door will not be closed any more, if one stay in a certain area in near of the door.

Figure 4. The Fischertechnik kit, developed by ourselves

Table 3. Contents of after-class activity with Fischertechnik©

| No. | Topics | Objectives |
|---|---|---|
| 0 | Fundamentals on Fischertechnik Modules | To learn the experience and the skill how to use FT-Modules to construct mechanism |
| 1 | Linkage Mechanism | To learn and verify Grashof's Law through construction of mechanism |
| 2 | Cam Mechanism | To learn basic structure and motion type of cam mechanism; build some common cam mechanisms |
| 3 | Chain and Belt Mechanism | To learn the motion relation of the chain/belt mechanism |
| 4 | Gear Mechanism | To learn the different types of gear mechanisms and how to apply them to the specific problem for power transmission |
| 5 | Electric Control Modules | To learn how to use the different types of sensors and the flip-flop controller to solve the problem of motion control |
| 6 | Fundamental of Pneumatics | To learn the basic pneumatic components and how to construct a pneumatic system to fulfill the motion requirements |
| 7 | Integrated Exercise: Automatic Door | Use pneumatic components and electrical controller/sensor to construct a door with automatic opening and closing functions |
| 8 | Integrated Exercise: RF-Remote Controlled Car | Build a car that can run along a defined route through RF-remote controller |

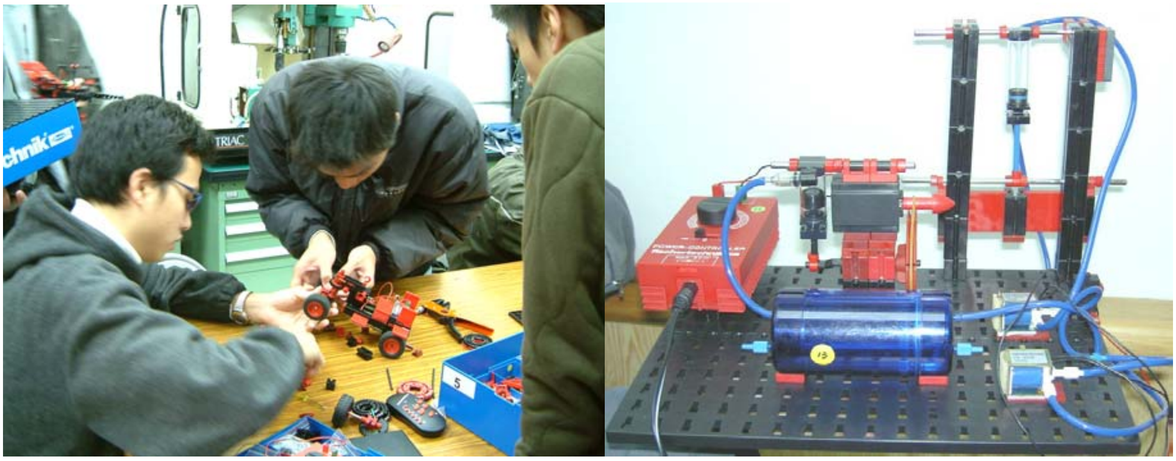

Figure 5. Students by after-class activity (left) and their prototype for automatic door (right).

## 5.3 Learning teamwork through the contest

A contest can (1) motivate the students, (2) impart a good sense of reality, (3) train to work in simulated but realistic industry-like settings of limited resources, time pressure, and high competitiveness, and (4) teach the importance of co-operation and teamwork [14]. Based on these arguments we hold therefore a contest at the end of the after-class activity. We emphasize two learning outcomes that the students should learn at least in the contest:

1. How to design and construct a mechanism step by step and how to choose the suitable methods to solve the kinemaic or other problems;
2. How a team operates in collaboration with each other during the preparation of contest.

In order to motivate the students, the theme and the rules of the contest were discussed and specified by the students. The themes of the contests held in the past four years are:

- 2001: Castle Attacking,
- 2002: Obstacle Car-Race,
- 2003: Walking Machine Fighting,
- 2004: Soccer Robot.

Because the task for the contest is open-ended and needs to apply knowledge of mechanisms or mechantronics to solve problems, the rules specified by the students needs thus to make some adaptation to restrict the difficulties, so that the contest is feasible for them. The following example will show our experiences.

## 5.4 Example: walking machine fighting contest

*1. Task description*: Each team builds two kinds of robots to fight for the competitor's flag and to defend one's own flag respectively.

*2. Participants*: All the participants in the after-class activity, namely 60 students totally from three classes.

*3. Some important rules*:

- The playing time for each half is limited in 20 min.
- The dimension of the playing area is 2.4 m×3.0m, as **Figure 6** (left) shown.
- Only the attack robot, i.e. the "walking machine", that has feet or non-circular wheels as power source for moving, can grasp the flag in the contest.
- The other robots, just playing the role of guard, can be constructed like conventional cars with circular wheels.
- Each team gets one score when the "attack robot" grasps the flag from the flag zone of the competitor and brings it back to one's own flag zone.
- The flag zone is a restricted area, where only the "attack robot" can enter to grasp the flag. The others who get in this area will be sent off.

*4. Some significant experiences:*

- It is difficult for teachers to play a suitable role in such a contest. For example, the original idea generated by the students was that each team built two giant working robots for fighting competition, though they had no ideas about how to realize this challenging task, even this is out of their abilities. Through discussion with all the participants, the rule for the contest was thus anew specified as mentioned above.
- The performances of students by the contest, especially their creativity, are mostly beyond our imagination. An interesting result from our observation was: "*Creative robot does not necessarily win the contest. Diligent students usually win*." The students learn indeed not only the specified outcomes, but also how to debug effectively their design through trial-and-error under time pressure. One of their robots is shown in **Figure 6** (right).
- Some rules increase difficulties for the contest; however, they can also motivate the students to challenge problems while in preparation. The rule, for example, that each robot must be built by three participants, can force the students to learn more issues about the teamwork.

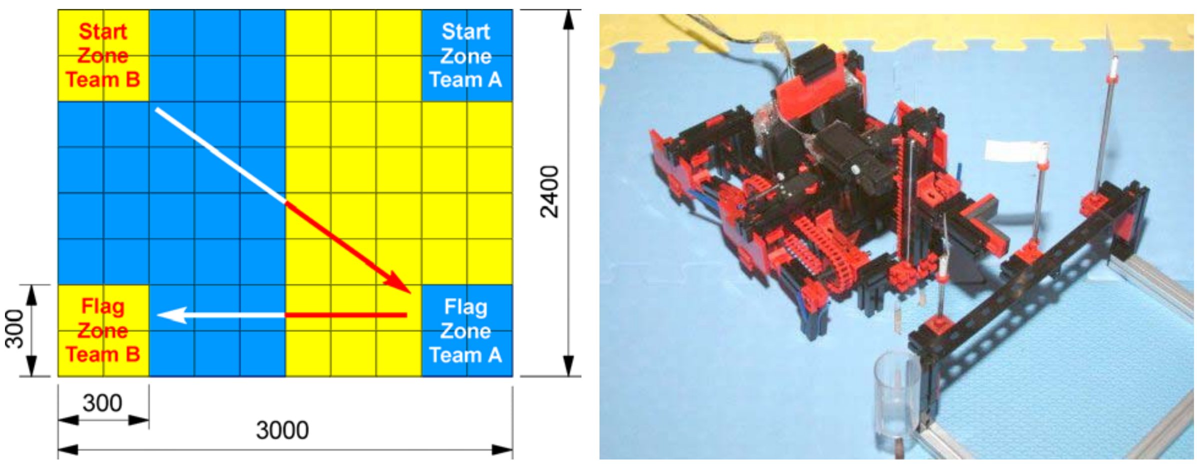

Figure 6. left: course of the contest 2003, right: Students' "walking robots" for contest

# 6. Evaluation of the teaching strategies

## 6.1 Survey result of the questionnaire

The questionnaires were given to the students at the last meeting of the class in the fall semester 2004. The results of the survey are shown in **Figure 7**, each for the lecture and the homework as well as for the after-class activity respectively. For the lecture and the homework, the figures demonstrate that within 40 valid surveys the response of "agree" occupies the highest percentage (45%), and the response of "uncertain" follows in rank (41%). Similar results can be also found in the survey for the after-class activity, although the responses of "disagree" and "strongly disagree" occupies only less than 2% within 16 valid surveys. As these results indicating, most of the students are aware that they have acquired the core competencies stated in the questionnaire.

Further result from analysis of survey data is illustrated in **Figure 8**, in which the level of the students' confidence in acquisition of the core competences from both types of teach actions, according to ABET outcomes, can be clearly identified. As indicated in Figure 8a, most of the students "strongly agreed" or "agreed" that they are capable to acquire the core competences *A* (54%) and *G* (55%) from the lecture and the homework. This means more than the half students by the survey have good level of confidence in acquisition of competency to visualize and analyze the kinematic problems graphically. The reason may be explained that the simulation software plays indeed a significant role by teaching the graphic representation of mechanisms.

On the other hand, most of the students "strongly agreed" or "agreed" that from the after-class activity they could acquire the core competences *C* (85%) and *D* (55%), as shown in Fig. 8b. Through further study we can recognize that their positive responses come from learning collaboration through teamwork. The acquisition of outcome E and K, however from their viewpoint, is weaker. This means that we must change the contents of the after-class activity, and emphasize the logical control with LLWin® in an integral exercise unit.

While studying the interrelation between the corresponding outcomes, we found a correlation between the outcomes. **Table 4a** and **4b** show the correlation coefficients based on the survey data from the lecture and the after-class activity, respectively. From the results we may find that:

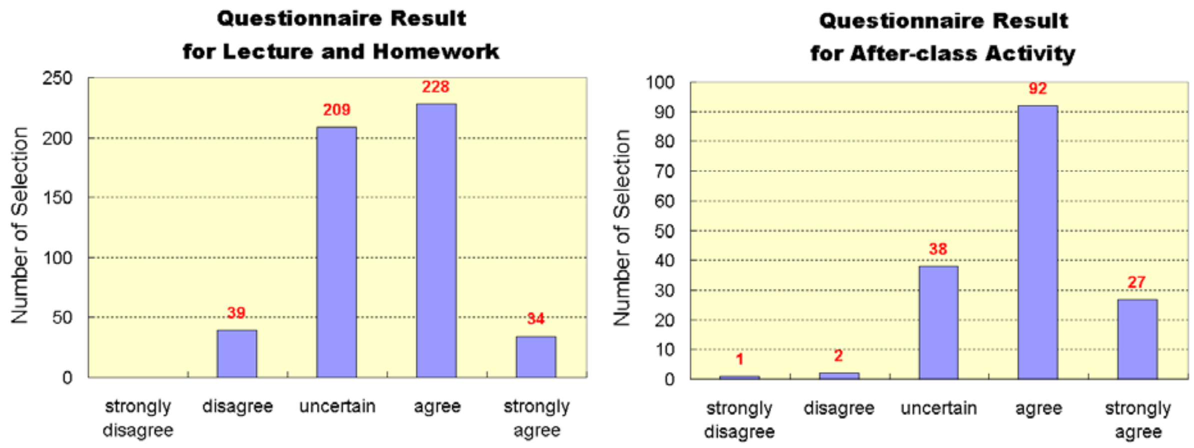


Figure 7. Survey result of the questionnaire: (a) for lecture and homework (b) after-class activity.

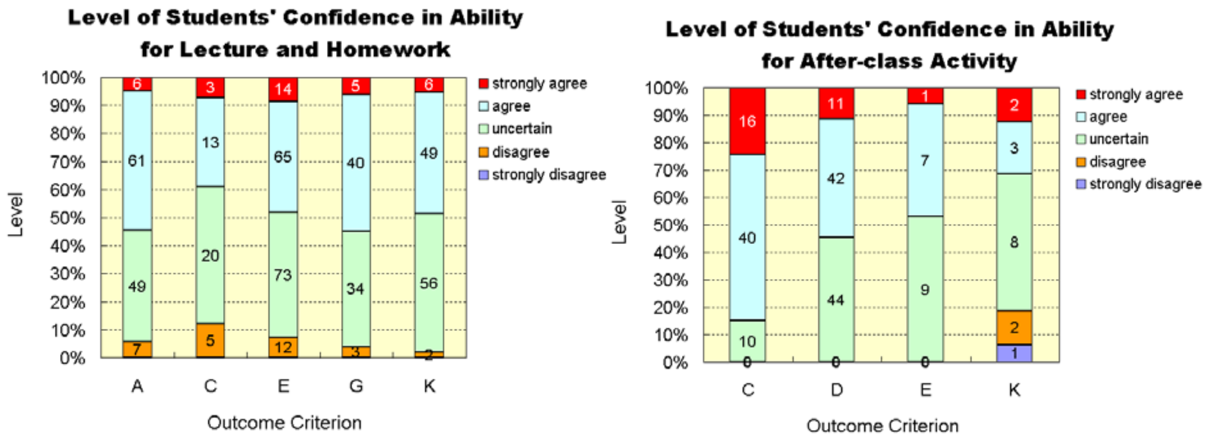


Figure 8. Level of students' confidence in outcomes: (a) by lecture and homework (b) by after-class activity.

Table 4a. Correlation between different outcomes acquired from after-class activity

| | Outcome C | Outcome D | Outcome E | Outcome K |
|---|---|---|---|---|
| Outcome C | 1 | 0.919(**) | 0.847(**) | 0.700(**) |
| Outcome D | -- | 1 | 0.777(**) | 0.743(**) |
| Outcome E | -- | -- | 1 | 0.731(**) |
| Outcome K | -- | -- | -- | 1 |

Note: **: P<0.01

Table 4b. Correlation between different outcomes acquired from lecture and homework

| | Outcome A | Outcome C | Outcome E | Outcome G | Outcome K |
|---|---|---|---|---|---|
| Outcome A | 1 | 0.265 | 0.259(**) | 0.326(**) | 0.209(**) |
| Outcome C | -- | 1 | 0.431(**) | 0.072 | 0.599(**) |
| Outcome E | -- | -- | 1 | 0.234(*) | 0.456(**) |
| Outcome G | -- | -- | -- | 1 | 0.243(*) |
| Outcome K | -- | -- | -- | -- | 1 |

Note: **: P<0.01; *: P<0.05

- Among the outcomes acquired from the after-class activity, each outcome has a significant correlation with another.
- Among the outcomes acquired from the lecture and open-ended homework: (a) outcome E has a significant correlation with A and C; (b) outcome G has a significant correlation with A and E; and (c) outcome K has a significant correlation with A, C, E and G.

From the facts mentioned above, it is interesting to recognize that the outcome *K* acquired in the course has a close correlation with the other outcomes defined in the curriculum planning. This means our teaching strategy, using the simulation software SAM to improve the students' "conceptual model" as an aid for learning the course "Mechanisms", is successful.

## 6.2 The learning effect of hands-on oriented activities

The after-class activity using "Fischertechnik" kits is an experimenting teaching action to motivate the students by learning abstract contents of the course and to improve their design abilities to apply the acquired knowledge in the course. It is hence interesting to know which role the after-class activity plays indeed for acquisition of core competencies in the course. For the purpose of comparison we divided the students into three different groups as follows:

1. Group A: those who participated in the after-class activity "Fischertechnik" (20 persons);
2. Group B: those who did not participate in the after-class activity, and first took the course (35 persons);
3. Group C: those who did not participate in the after-class activity, but took the course for second time or more (13 persons).

The comprehensive performance of the students for comparison was evaluated from the final and the midterm examination, the tutoring exercise and the open-ended homework. From the histogram of grades of all three groups, as illustrated in **Figure 9**, we discovered some facts to evaluate the effect of after-class activity on the students' learning outcomes:

- The students from group A have a better performance than those from group B and C, whereby the average grade by group A is equal to 67, by group B 60 and by group C 49.

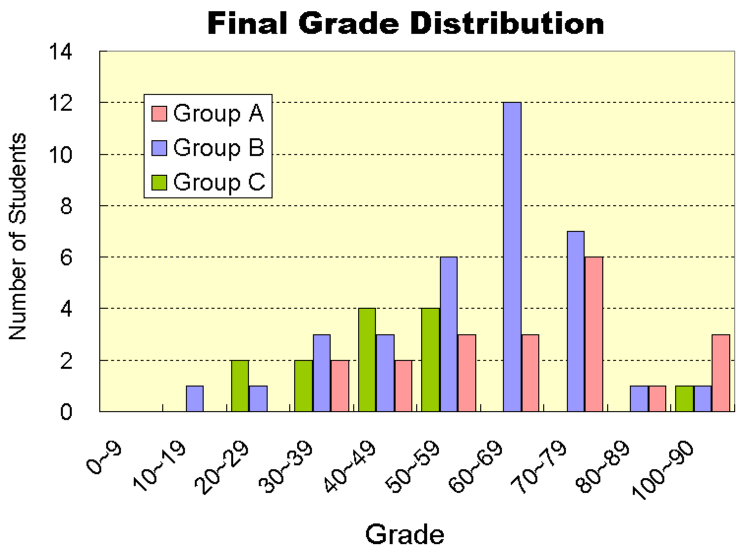


Figure 9. Histogram for comparison with semester grading

- The grade of the students from group B meets our expectation (“normal performance”), however, the number of the students with “bad” grade is a bit more. Through our further review on their documents (examination paper, report, quiz etc.), we observed that those with the worst grade had also a worse grade in homework. The reasonable explanation is maybe that they lacked the motivation to work on the problems of mechanisms.
- The students from group C in the fall semester 2004 had worst performance that only one of them gained the credit; even he had an excellent grade. Through review we found that about 8 students did not hand in the assignments of homework regularly. Some of them were even often absent in the lecture.

These facts, mentioned above, give us a stark impression that the hands-on oriented after-class activity can indeed motivate the students to learn the abstract course content of “*Mechanism*”.

# 7. Conclusion

This paper presents a methodology for curriculum planning and evaluation of the mechanical engineering course “Mechanism” based on the learning outcomes proposed in ABET EC-2000. According to this approach, we developed new teaching strategies to improve the students’ design skills, not only kinematic analysis abilities. In addition to conventional teaching actions, two hands-on oriented activities, namely after-class exercises and a contest by using “Fischertechnik” kits as the learning platform, are offered to the students. Another teaching action is to use simulation software SAM both in the lecture and homework to help the students by understanding the abstract course contents. Besides the conventional assessments we have also devised a questionnaire for further evaluation of the level of students’ confidence in acquisition of the specified core competences. The survey results show the success of our efforts on the new, design oriented teaching actions, and also prove the feasibility of implementing outcome-based curriculum planning into our academic program.

**Acknowledgement**

The authors gratefully acknowledge the support provided by the National Science Council of Taiwan (R.O.C) under grant No. NSC92-2745-S-008-002.

**Reference**

[1] The Accreditation Board for Engineering and Technology, “Engineering Criteria 2000, Third Edition: Criteria for Accrediting programs in engineering in the United States”, The Accreditation Board for Engineering and Technology (ABET), Baltimore, Maryland, 2000.

[2] Institute of Engineering Education Taiwan (IEET) Accreditation Council, “Accreditation Criteria 2004”, Taipei, 2004, http://www.ieet.org.tw/.

[3] Yan, H.S., “Mechanism”, Tung-hua Book Co., Ltd., Taipei, 1997.

[4] Yan, H.S., “Creative Design of Mechanical Devices”, Springer-Verlag, Singapore, 1998.

[5] Yeh, T.L., Chen, F.C., Hsiau, S.S., Wu, J.C., Wang, N.C., Tsai, S.J., “Exploring the portfolio assessment on novice engineering students' creativity, design and implementation process - setback event based analysis”. ICEE (International

Conference on Engineering Education) 2004, Florida, October 2004

[6] Tsai, S.-J., “The experience on curriculum planning of “Mechanisms” with aid of hands-on exercises” Proceedings of 7th National Conference on the Design of Mechanisms and Machines. Tainan, Taiwan, 2004.11.20.

[7] Besterfield-Sacre, M. et al., “Define the outcomes: a framework for EC-2000”, *IEEE Transactions on Education,* Vol. 43, No.2, 2000, pp. 100-110.

[8] Besterfield-Sacre, M. et al., “EC 2000 Outcome Attributes: Definition and Use”, University of Pittsburgh, 2000.
http://www.engr.pitt.edu/~ec2000/ec2000_downloads.html

[9] McGourty, J. Departmental and Course Workbook: Defining Program and Course Objectives, Gateway Coalition Web Site: http://www/gatewaycoalition.org.

[10] Tsai, S.-J., Chang, P.-F., and Wu, J-C., “Outcome-based curriculum planning and evaluation of the course mechanism”. Proceedings of 21st National Conference on Mechanical Engineering, the Chinese Society of Mechanical Engineers, 2004.11.26-27, Kaohsiung, Taiwan, pp. 3433-3438.

[11] Tsai, S.-J., Chang, P.-F. and Wu, J.-C., “Development of Teaching Strategies and Assessment Methods for Course “Mechanisms” based on Students’ Outcomes”. will be presented in the 2005 American Society for Engineering Education Annual Conference & Exposition.

[12] Norman, D.A., “The psychology of everyday things”, MIT Press, London, 1998.

[13] ARTAS -- Engineering Software. http://www.artas.nl.

[14] van Breemen, E.J.J., “Contests make better engineers”. Proceedings of 11th International Conference on Engineering Design (ICED 97), Tampere, 1997, Vol. 3, pp. 519-522.

Shyi-Jeng Tsai, assistant Prof. Dr.-Ing.
National Central University
Department of Mechanical Engineering
No. 300, Jong-Da Road, Jong-Li
TAIWAN
Phone: +886-3-4267301,
Fax: +886-3-4254501,
e-mail: sjtsai@cc.ncu.edu.tw