

Introducing student-centred teaching strategies to improve teaching and learning in *Theory of Machines and Mechanism*

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Introduction

The reform of the structure of higher education has led to stronger competition in the educational market in China. How to improve the quality of education is not only the concern of the administration system of higher education, but also the issue for each higher educational institution in the country to survive and develop. The Faculty of Mechanical Science and Engineering (FMSE) of Huazhong University of Science and Technology (HUST) is a reputed institute in the training field of mechanical engineering in China and has done many explorations to innovate the curriculum systems for undergraduate programs, to improve students' training. However, courses, as an important part of discipline, have not yet changed much to accommodate the change of external environment of the education system over the last twenty years. Since lectures still are mainly used to carry out courses in universities everywhere, and since lectures represent teacher-centred teaching style, it is safe to say that teacher-centred teaching still dominates the campuses of universities all over the world. This article discusses how to introduce student-centred teaching and learning strategies (SCTLS) into the course *Theory of Machines and Mechanism*, based on the author's teaching experience. A revised teaching model based on SCTLS is established and a practical example of problem-based learning (PBL), as one of important method of SCTLS, is given to demonstrate how to use SCTLS in the course.

Some meaningful change in the current course teaching

The *Theory of Machines and Mechanisms* is a basic course of disciplines for all students in specialties of mechanical-relevant engineering. The content of the course includes describing methods of mechanisms, typical mechanisms' analysis, synthesis of mechanisms and kinetic and dynamic design of machines. Altogether there are 50 hours of lectures, 6 hours of workshop practice and two weeks of course project.

As a part of a reform of curriculums, FMSE of HUST has modified the course in the following ways:

1. shortened lecture hours from 90 hours to the current 50 hours;
2. introduced a revised textbook with new context, closely related to contemporary engineering research and applications;
3. applied computer aided instruction (CAI) to improve teaching efficiency;
4. developed courseware to demonstrate the character of mechanisms and to simulate the principles of machines and their functional processes;
5. constructed many practical projects for students to choose for their course projects, and allowed students to construct projects from the real world based on their own experience; and
6. allowed students to work in teams or to work individually.

All the changes above have been positive and have significantly improved teaching and learning against the background of the development of society, based on active criticisms both from students and educational authorities. However, these changes are not enough because some important features of student-centred strategies have not been achieved. In particular the course used traditional teaching strategies, which do not encourage problem solving ability and creativity. It is vital and necessary to further and deeply reform the structure and teaching manner of the course.

Aims of introducing student-centred teaching and learning strategies into the course

SCTLS are a useful method to change the traditional course teaching to adapt to changes and trends in teaching theories and practices. The contemporary research of

education theory has widely and deeply investigated many aspects of how students learn and how teachers should teach them more effectively. Many valuable conclusions have been achieved and SCTLS has been identified as an important and powerful method of improving course teaching quality^{1,2}. Application of the principles of SCTLS will be made with following aims:

1. Increasing students' interest in specialties of mechanical engineering

SCTLS will make teaching more interesting and learning more motivated. The most frustrating thing for a teacher is that students dislike learning a course. When that happens, the best teacher can do nothing for students' learning. Unfortunately, a big proportion of students majoring in mechanical engineering are not interested in their specialties since manufacturing industry, in which most students will be engaged for their future professional careers, is a typical low profit margin economic sector, which means that most students could not expect high income in their future careers. The only reason for some students to major in mechanical engineering is that they currently have limited opportunities in higher education in China. However, when graduates become very successful engineers, the situation will totally change. Therefore, if the institute can provide excellent training programs in mechanical engineering that are interesting to learn, more talented students will enrol, and in the long run, when more education opportunities for the diversity of subjects are available to students, less and less students majoring in mechanical engineering would be avoided.

2. Improving the quality of teaching by incorporating contemporary research in education theory

How to improve teaching quality is always an issue for teachers. The correct and shortest way to achieve this is to incorporate research outcomes of education theories. Theories and practice of SCTLS have proved themselves a correct way to improve teaching and learning.

3. Enhancing students' abilities and skills

SCTLS focus on students' abilities and skills. It is commonly recognized nowadays that education should nurture students' abilities and skills, such as critical thinking, problem solving, logic and reasoning and creativity, rather than merely shifting knowledge between teachers and students, because knowledge is not static, but changes even through to basic principles. If current teacher-centred strategies for courses are not changed, students' abilities and skills will not be improved.

4. Developing students' self-directed and lifelong learning skills

SCTLS serves self-directed and lifelong learning skills, which is more valuable and effective teaching style for students than the teacher-centred one, considering the rapid pace of the world's change. With the development of science and technology, knowledge is increasingly revised and people have greater and greater access to information. This situation has strongly pushed education systems to accommodating changes, but the change was not occurred in the basic element, courses.

Important principles of student-centred teaching and learning strategies

The concepts of SCTLS are widely accepted and derive from research launched by American institutes of higher education since the 1970s, mainly to address the problem of gradually increasing loss of students in science-related disciplines. Such actions triggered a campaign all over the world to reflect on traditional teaching strategies in almost all subjects, and led to the formation of systemic theories of SCTLS in the 1990s. Some concepts of SCTLS are given below and a brief analysis is presented.

Make students more motivated by PBL because it leads to deep level processing of knowledge

PBL can stimulate the interest and intrinsic motivation of students towards learning, which leads to deep level processing of knowledge. Learning is integrated and self-directed, and occurs in the context in which the knowledge and skills will be used. Evidence shows that the first Chinese teacher and great philosopher, Confucius, taught his students 2,500 years ago in a similar way, the result being that more than seventy of his students became famous scholars in many fields, such as politics, philosophy, economics, the military and education in the history of Chinese. His teaching focused on training students' abilities and skills by the teaching methods of learning from teacher, reflection by students on what they have learned, the exposing of students to the real world, and consultation with administrators in many nations to use knowledge and to enhance students' skills. In that time, textbooks were not yet available. Confucius and his students are the first group of people to start to collect, analyse, compile and synthesize the literatures scattered among people. In this sense, teaching and learning is the process of creating knowledge. One of their important contributions is to have established systemic and perfect moral and social systems in Chinese history, which have deeply influenced the Chinese. It can be seen that the teaching philosophy of Confucius focused on students' abilities and skills and is one of SCTLS.

Expose students to a 'real world context' so that they can see the importance and the relevance of the material

'Real world context' answers the question of what sort of problems should be used in PBL. Confucius could open the first school in the Chinese history only because his students came to him to explore the world's unknowns rather than to simply learn what he knew. One of his famous sayings, 'You can learn from at least one if any two people are with you', reflects in one aspect that their learning were based on discussion of problems. This situation made his students good at studying and eager to learn. In this way, 'real world context' made his students more motivated and made the outcome of teaching abilities and skills of students.

Make the lecture more interactive because learning is both a social and an intellectual construct.

Lectures are one-way communication, in which student are given roles as an audience. This characteristic is a big

obstacle for students to learn effectively because learning is both a social and an intellectual construct. The only records of Confucius's teaching class that survived today indicate that he gave his courses by way of conversation with his students, which is a two-way communication. At this moment lectures are still large parts of most courses and the size of classes is generally big, so how to make the lecture more interactive is a major concern in considering the modification of teaching. A practicable technique to push students to be active learners in the lecture class is to use the method 'Predict, Observe and Explain' (POE). The effectiveness of this method has been illustrated by Stewart (2003)⁴.

Remodeling of the course

Currently the course is delivered mainly by lectures. To complete the transition from teacher-centred teaching strategies to SCTLS, many aspects of traditional teaching philosophies and processes should be modified. A new course model by SCTLS is established below by modifying course structure and teaching methods within lectures.

Combine course project and course lectures as a whole

The course project used to be launched after the completion of course lectures as the application part to enhance students' learning. Obviously such a course structure mainly focuses on assimilation of knowledge rather than development of abilities and skills. When PBL is engaged in the course, the course project changes its role to that of presenting 'problems' for PBL.

Introduce PBL into lecture classes

When PBL is used, lectures still retain their importance for course learning, but the focus is changed, switching from transmission of knowledge between teacher and student into a situation where the teacher seeks out common difficulties among students in their problem solving and gives additional support via lectures. So the teaching mode of traditional lectures changes according to the problem solving process. The following is a typical mode which could be used for course lectures:

Proposing practice engineering projects → group discussion → mini-lecture → problem solving → presentation by students

Reorganize the teaching materials to accommodate PBL

Traditionally, a textbook is a road map both for teaching and learning. In PBL, it will become only one of the reference materials, since any real world problems should be very complicated and widely spread out in the fields of knowledge. However, this aspect of PBL may bring trouble to teachers: they need to decide what they should teach and even what they can teach without the guide of a textbook. Such controversial problems may be overcome by several strategies. Firstly, students can be led to choose 'problems' for PBL, which can be solved or partly solved by current knowledge in the subject according to the judgments of

teachers, since teachers should be qualified in their discipline specialties. Secondly, teachers can prepare dynamic teaching materials for lectures according to the real situations students face in their problem solving. Finally, much of the content of textbooks can still be used in PBL style lectures because textbooks contain concept maps of a discipline, and are helpful for students to understand the knowledge that should form the basis of problem solving. Therefore, the teaching materials should be reorganized according to the situations that students confront in their 'problems' in PBL and the textbook is diminished as an important reference book for teachers and students.

Develop web-based teaching to support students' PBL

The intranet of a campus has become a more important teaching resource, which not only gives students easy access to information needed for problem solving, but also provides a useful teaching tool for the teacher to deliver assignments, to assess students, and especially for PBL, to support students individually and in real time. Furthermore, most courseware already developed for computer aided instruction could be put on the Internet for students' self-directed learning. This will greatly improve the condition of the whole curriculum of specialty.

Have the regular duty tutors organise tutorial classes and encourage students to work together

Tutorial class is an effective teaching measure to develop students' self-directed learning, teamwork and interpersonal skills. In traditional course teaching, tutors take a role to help individual students by answering their questions or explaining confusing concepts after lectures. However, in tutorial classes, tutors reverse their roles by asking questions to encourage students to think and work together to find out potential solutions to the problem by pooling their resources.

Make course projects closer to the practice of engineering and focus on problem solving

Namely how to fulfil the design tasks, such as the optimal performance, lowest cost, improved safety and reduced consumption of original materials and energy.

An example of PBL for the course teaching

1. Project: Improving the design of a printing machine with a flat bench
Problems with existing model: printing quality deteriorated after long-term running, i.e. characters printed are blurred or the density of ink is variable.

Task A. Give practical and effective instructions for maintenance of the machine

Task B. Renew the design of the old model or develop a new model to improve the performance and to avoid the existed problems

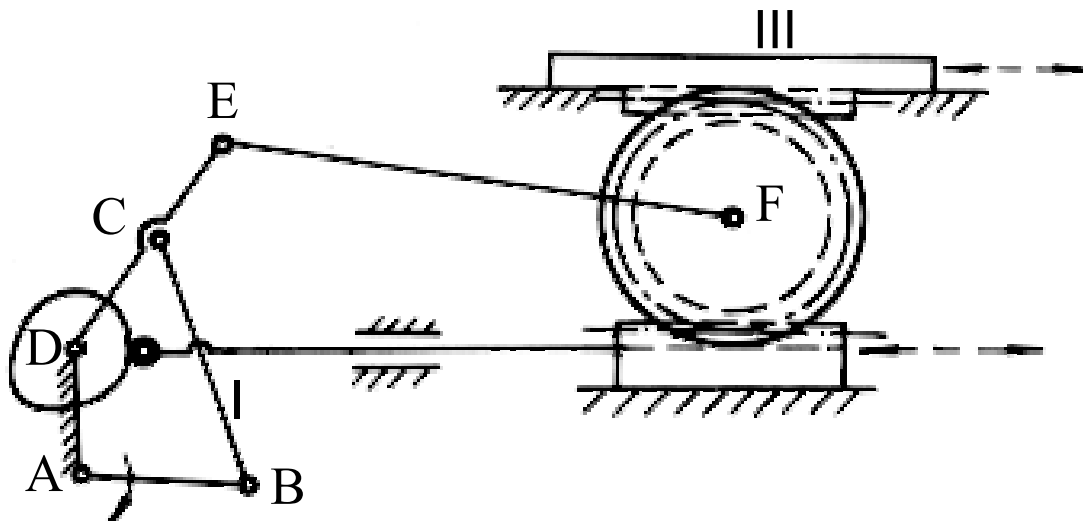


Figure 1. Illustration of the functional principle of the machine

2. Flowchart to develop the project (Figure 2)

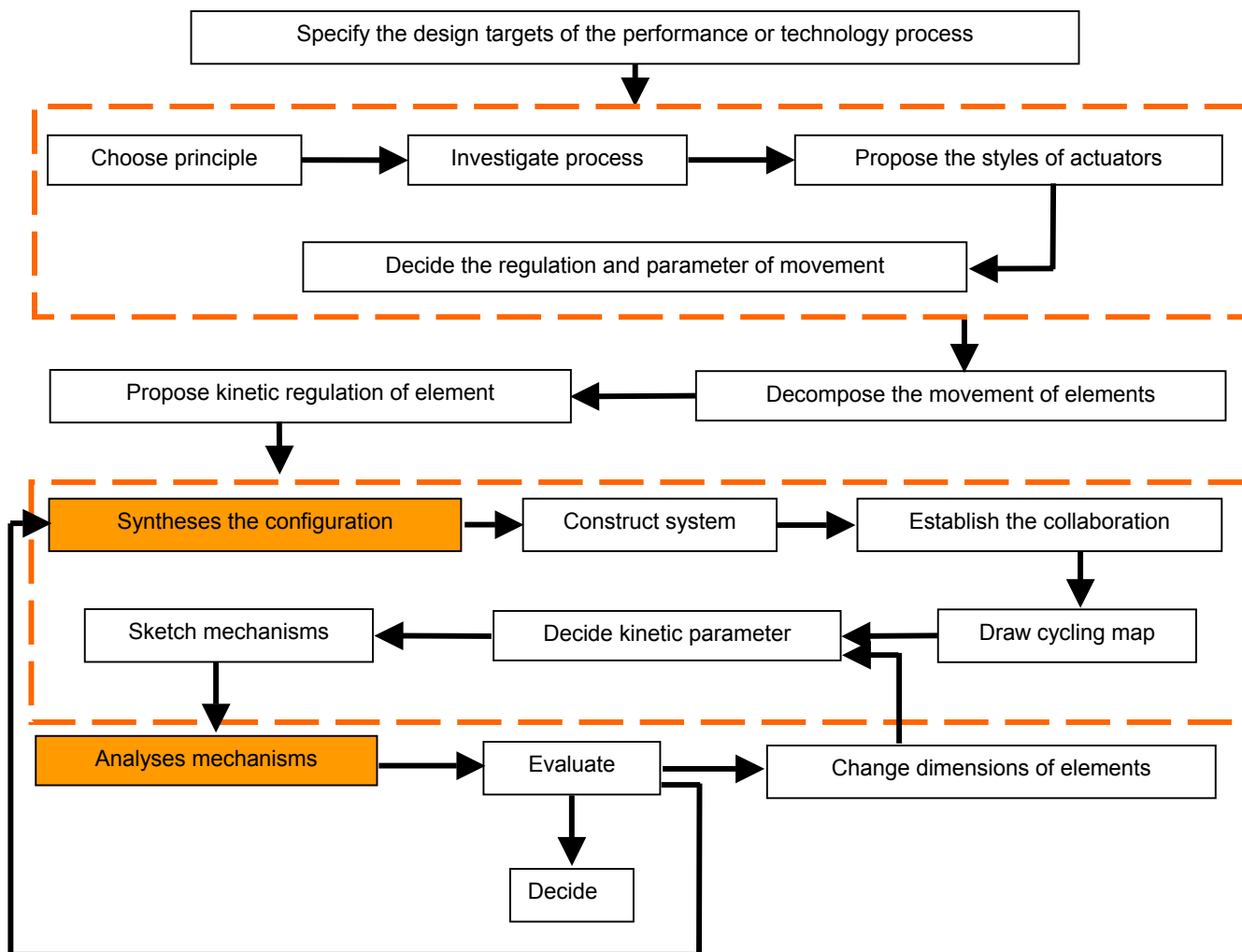


Figure 2. Flowchart for design of kinetic sketch of mechanisms

3. Acquisition of a well-structured knowledge base in PBL
 In PBL, different learners confront different problems in their projects and must learn different points of knowledge

based those projects. So the introduction of suitable problems is vital for acquisition of well-structured knowledge base required by curriculum disciplines.

Currently, most teaching hours of the course are spent on teaching theories of analysis and synthesis of typical mechanisms. The above model involves three typical mechanisms, which are the linkage, gear and cam mechanisms shown in Figure 1. As can be seen in Figure 2, the application of the knowledge of analysis and synthesis mechanisms is an important process in project development. Therefore, in the process of project development, learners will not only acquire a well-structured knowledge base, but also develop their diverse abilities and skills, which will be more valuable than the former. In fact, while the knowledge is believed to be very powerful to solve real world problems, many other projects for PBL will also lead students to acquire the knowledge base demanded by the course design, if the problems are suitably well-devised.

In the meantime, lectures will still retain their importance for students to acquire the well-structured knowledge base in the discipline area in PBL but lectures will become more flexible as regards delivering time and content, which will concentrate on common problems and difficulties in the process of students' project development. In this way great freedom is reserved for students' self-directed learning.

Challenge and prospect

Any coin has two sides. While many advantages of SCTLS have been presented above, it will also bring many challenges for education institutions, teachers and students.

For the education institutions, SCTLS will exhaust more teaching resources per student, for instance, more teaching staff are requested, more intranet facilities are needed, more classrooms and tutorial workshops are needed to accommodate students for discussing in groups or for developing their projects, and even more library resources are required. It will, no doubt, increase education cost and finally limit the numbers of students able to enrol in higher education.

For teachers, SCTLS will not only require higher qualifications but also will load more work on them than before. Firstly, any practice engineering projects present a huge challenge in the different aspects of knowledge for the teachers themselves as well as for students. Secondly, the extra workload will be a problem for teaching staff. Teachers will spend more time to research different projects in advance for different student groups and then to give the required support to students. At the same time, teachers will need to respond to diverse questions from individual students. Finally, teachers will need to follow up students to confirm that they are enjoying their projects and working on the projects in a correct way. This makes the teaching process difficult.

Last but not least, students have accommodated to spoon-feeding teaching in each education stage. Strong challenges may threaten some students' confidence to confront

problems in the projects; some of them could become very relaxed since the projects run for a long term; and some maybe 'cheat' by copying their peers' projects.

Summary

In conclusion, SCTLS reflects the trends and changes of contemporary education. Weighing the 'pros and cons', it is worthy to apply in the course *Theory of Machines and Mechanisms*. SCTLS could be introduced into the course step by step. Teachers should work together to trial them and the administration system should encourage this effort with necessary financial support. If all such efforts are exerted, the teaching quality of the course could be upgraded to a new level.

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