Engineering Mathematics Teaching Strategy Based on Cooperative Learning[1]

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The basic idea of cooperative learning focuses on team reward, equal opportunities for success, cooperation within team and competition among teams, and emphasizes share of sense of achievement through joint efforts so as to realize specific learning objectives. The main strategies of engineering mathematics teaching based on cooperative learning are to establish favorable team and design reasonable team activity plan. During the period of team establishment, attention shall be given to team structure including such elements as team status, role, norm and authority. Team activity plan includes team activity series and team activity task. Team activity task shall be designed to be a chain of questions following a certain principle.

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0. INTRODUCTION

The Student-Teams-Achievement Divisions of Cooperative Learning (hereafter referred to as STAD) is developed by the Johns Hopkins University (He & Chao, 2005). The basic idea of STAD emphasized the team reward, equal opportunities for success, cooperation within team, and competition among teams. The purpose of STAD is to improve each student's academic achievement through cooperative learning within the team, provide a teaching method for most competitive classroom mode which is unfavorable to backward students' learning, and improve interpersonal relationship within

the team through dependent activities exchanging learning skills (Lin, 2001). The core of cooperative learning is cooperation. But it also emphasizes how to respect students, mobilize their learning interest, improve their learning motivation, organize teaching and reform teaching forms, improve learning methods and teaching environment, and especially develop their comprehensive quality (Qin, 2007). Cooperative learning is beneficial to enhance learning among learners, improve thinking capability of abstract generalization for higher cognitive competence, and to make thinking and understanding capability more abundant and comprehensive during interactive communication in the society.

Engineering mathematics teaching is a process where the diversified teaching is formed. Cooperative learning is very enlightening on the deepening of engineering mathematics teaching reform (Guo, 2006). This article discusses the main teaching strategies based on STAD, *i.e.*, the team establishment and team activity plan design.

1. BASIC ELEMENTS OF STAD

It is emphasized by STAD to realize specific learning objectives through joint efforts and share of senses of achievement. Johnson (2001, pp. 5–15) pointed out that following five elements must be available so as to realize such learning objectives, namely, team member's dependence on each other (every team member plays an important role in success of the team), promotion of face-to-face interaction and team skill improvement, team member's personal responsibility system for mastery of learning tasks, improvement of interpersonal and team communication skills and process of team activities. The main teaching strategy of realizing such five elements is to establish favorable team and design reasonable team activity plan.

2. STRATEGY OF TEAM ESTABLISHMENT

2.1. Design of Team Structure

The more stable mutual relation form is team structure. Team structure consists of such elements as status, role, norm and authority. The team with a favorable structure is the prerequisite for the success of engineering mathematics teaching method based on STAD. Following measure may be adopted in order to establish a team with a favorable structure.

2.1.1. A team leader with higher status and authority of leadership.

The leader of the team consisting of four to five members shall be assumed by a member with outstanding academic achievement and certain management capacity. The teacher grants certain rights to the team leader, such as right to assign learning tasks, right to determine team roles and right to make decisions. The team leader is made superior to other roles so as to establish certain authority of leadership.

2.1.2. Other team roles of certain status.

The team has other roles such as spokesman, recorder, contactor and supervisor. Generally, members with different individual learning characteristics and personal capability are willing to play different roles. If an individual member plays more than two roles or roles which other team members are not determined, efficiency of cooperative learning will be reduced. Therefore, it is necessary for the teacher to help the team to form a role system with certain norm.

2.1.3. Personalized team norm.

In order to prevent role unbalance, the team needs to form certain norm so as to ensure favorable operation of team learning. Designed to provide team members with action guide for coordination and cooperation, team norm shall include such contents as team purpose and team assignments. The principled norm the team must follow is that everybody has equal learning opportunity and right of learning participation, everybody is liable to improve the team's academic achievement and promote the team's successful learning, and everybody has the equal opportunity to assume various roles. Based on principled norm, each team shall prepare personalized norms including such contents as liabilities, rights, status of role and work of team members. The appropriate team norm can help team members form higher sense of identity in a short time, enhance the team's cohesion and improve the team's activity efficiency.

2.2. Preliminary Team Establishment

Learning team is the basic unit of cooperative learning. Grouping usually brings troubles to teachers as backward students are often pushed aside; however, teaching method based on STAD can provide all students, especially backward student, with an opportunity to make contributions to the team. Team score based on STAD (hereafter referred to as "Team score X") is the average value of the sum of progress score J_i which is obtained by each member in various activities ('i' indicates serial number of the member in each team, the same below), while personal progress score is the result of personal score of each member G_i minus basic score Q_i. Thus team establishment in

STAD is not too difficult and following steps are generally followed.

First, the teacher shall introduce the basic ideas and learning objectives of STAD in details, emphatically introduce the specific implementation methods such as grading method, arouse students' interest on and enthusiasm for STAD, mobilize backward students' enthusiasm for participation and allow students actively and efficiently assist in team establishment.

Second, the teacher shall determine the basic score of each student.

Mathematics score of the pretest (or mathematics score of the freshman in the entrance examination) is generally used as basic score. It is recommended to ask for students' opinions on determination of basic score. After a period of cooperative learning, the academic achievement of the student will vary and the basic score will be dynamically changed accordingly.

Third, the teacher shall group the students and form a team structure.

Grouping shall be conducted in accordance with the principle of "Homogenesis in Different Teams and Heterogeneity in the Same Team." Based on the basic score and in consideration of such characteristics as student gender and personality, students of the whole class will be grouped into several teams with each team consisting of four to five members, and the average value of basic scores of students in each team shall be basically the same. The teacher shall form a certain team structure after grouping.

Fourth, the teacher shall establish team database.

The main contents inclusive in team database consist of personal information of team members, number, role, norm, personal basic score, team score, and etc.

3. DESIGN STRATEGY OF TEAM ACTIVITY PLAN

The team activity based on STAD consists of team activity plan and team activity guidance. This article merely researches into design of team activity plan, *i.e.*, the sequential design of team activity and task design of team activity.

3.1. Sequential Design of Team Activity

First, preparatory work emphasizing on equal opportunities for success: The teacher must prepare auxiliary materials of team activities in advance, provide them to all students, and make all students have sufficient opportunities of independent learning and opportunities of achieving success.

1) Task sheet: task sheet provided to students before giving lessons mainly lists contents and requirements of independent learning outside the class.
2) Answer sheet (partial or all answers or hints on task sheet): a copy of answer sheet

shall be handed out to each team after a period of team learning and discussion (stimulate team members to cooperative with each through share of materials).

3) Question sheet (quick-response question): problems are provided to each team for quick response within the classroom (promote competition among teams).

4) Test paper (compulsory questions): provided to students for unit test (realize evaluation of learning process).

Second, instruction emphasizing on integrated development of students: The teacher shall not only teach learning contents and assign learning tasks, but also provide guidance on learning skills and put forward requirements for team learning. Highlighting important points of teaching and sticking to testing objectives, the teacher shall teach learning contents in a vivid and interesting manner. Unnecessary interruption or questioning shall be reduced during the process of teaching so as to improve efficiency.

Third, team learning and discussion emphasizing on cooperation within the team: Team learning and discussion generally fall into two forms, namely intra-curricular team learning and discussion and extracurricular team learning and discussion. Intra-curricular team learning and discussion shall not disturb other teams. Every student must make efforts to understand and master problems on the task sheet and conduct communication and discussion on an equal basis. Problems shall be firstly solved within the team. Students can merely consult with teachers on problems that can not be solved by team members. During the period of the intra-curricular discussion, the teacher shall observe the situations of team discussion. Generally, the teacher shall not speak out the observed situations immediately, but keep certain "sense of mystery". The teacher shall interrupt the team discussion and provide guidance when necessary. However, the teacher shall not frequently interrupt team discussion so as to prevent students from losing confidence. Extracurricular team discussion requires the team to record discussion.

Fourth, tests and quick responses emphasizing on competition among teams: Test will be arranged after completion of team learning. The test shall be independently completed by students and team work is prohibited. Test papers shall be marked by the teacher or other teams so as to calculate personal test marks in a timely manner. As a supplement to the test, the team's quick response is suitable for statement of mathematical concepts, comprehensive mathematical questions and open questions. The team spokesman first makes a report and then other team members supplement the report within the prescribed time. In case of wrong answers, mark will be deducted or not deducted in accordance with the preset question types. Other teams may continue to answer questions.

Fifth, score determination emphasizing on team reward: Personal progress score J_i shall be calculated in accordance with the personal test score and basic score and be ranked from higher to lower in accordance with the average progress score of each team, and then test score of each team A will be awarded. And the teacher shall award team's

quick response score B in accordance with the actual conditions of team's quick response on the spot, and award personal quick response score to members participating in response and other team members in accordance with the different weight. Upon completion of course study, teams will be ranked in accordance with the team score (sum of A and B). Team score X will be equally distributed to each team member and added to personal progress score J_i. The result will be the student's personal score Y_i. Lastly, the standard score of Y_i will be included into the student's course performance in accordance with certain weight.

3.2. Task Design of Team Activity

STAD must have common learning task and common learning objective. Only with common objective can they cooperate with each other. But STAD is not suitable for all tasks. STAD is an effective method only when students try to solve a more complicated task. Therefore, the task design of team activity is the core strategy of teaching method based on STAD.

Contents of team activity task require the elaborate selection and organization. The teacher shall select enlightening and moderately difficult learning contents in conformity with teaching objectives, and reasonably organize learning contents. Most of current teaching materials of college mathematics present "icy and beautiful" mathematical knowledge and methods in accordance with deductive method, while STAD teaching method reorganizes learning contents in accordance with problem situation, and makes students experience "hot" mathematical thinking below "icy and beautiful" mathematical knowledge and methods through supposition, induction, analogy, abstraction, reasoning, and etc. In order to create question situations, team activity task shall be designed into the form of a question chain. Generally, a question chain has three levels, namely, "what", "why" and "how": Generally, "what" and "how" test learning objectives in the form of test papers, and "why" tests learning objectives in the form of quick response to questions. Design of a question chain shall observe the following basic principles.

3.2.1. Question chain for concept learning shall reveal the process of concept formation.

The teacher shall elaborately create and design the situational questions of concept formation in accordance with students' psychological characteristics of concept acquisition, lead students to fully perceive, distinguish, suppose and verify, make students integrate previous knowledge with newly presented materials, transfer provided materials into their own cognitive contents, and obtain new concepts through analogies, induction, abstraction and continuation so as to realize the effectiveness of concept teaching. For instance, the teacher may design following question chain for teaching of "Definite

Integral Concept":

① What is the background of formation of definite integral concept?

② Suppose planar surface $M = \{(x, y) \mid y^2 \leq x, y \geq 0, x \leq 1\}$, then please put forward approximation method for calculating area of planar surface M with reference to circle area calculation with cyclotomic method;

③ Please narrate definite integral concept of function $f(x)$ between $[a,b]$ with your own mathematical language after understanding, and talk about mathematical thoughts and methods reflected by definite integral concept.

3.2.2. Question chain for proposition learning emphasizes the development of discovery capacity.

Mathematical proposition is the bearer of mathematical knowledge, and the discovery of propositions and proof of proposition conclusion is one of the most confused and attractive steps in mathematics learning. Therefore, during the period of proposition learning, the teacher must suppose the process where the mathematician discovered and proved the proposition, simulate such process in teaching, and lead students to make bold suppositions and develop students' capability of discovering problems. For instance, the teacher may design following question chain for "Differential Mean Value Theorem":

① On the continuous curve arc AB with the same function value of two endpoints, if there are tangent lines everywhere out of the vertical of X Axis except two endpoints, whether there is a point C on arc AB through which a tangent line is parallel to X Axis and arc AB?

② If the condition of "the same function value of two endpoints" in Question ① is omitted, whether such conclusion can stand?

③ If continuous curve arc is represented by a parametric equation, what will be the conclusion?

3.2.3. Problem chain for problem solving learning (including practical problem solving) shall fully reflect ideals of constructivism as well as thoughts and methods of mathematical modeling.

During the problem solving learning, students shall identify, retrieve available cognitive resources in accordance with special problems, multi-dimensionally and deeply analyze substantive characteristics and mathematical structure of problems, and make necessary representation, restatement or amendment of the problems. Students shall form reasonable suppositions on problem solving through induction of special situations or analogy or association of similar contextual factors, and then verify, disprove, amend and reconstruct suppositions.

During the period of such learning, the teacher shall encourage students to actively

construct mathematical cognitive structure, develop student's untiring pursuit of discovery process of mathematical truths and the innovative spirit, enhance their subject consciousness in learning, and highlight the development of their capability of mathematical application and mathematical modeling.

4. CONCLUSION

If learners are merely grouped into teams, the engineering mathematical teaching method based on STAD is not likely to achieve successful teaching effect. The reasonable team structure design and team activity design can ensure favorable teaching effect. What differs from teaching strategies of the traditional classroom is that the teacher shall not only design teaching contents, but also design methods, techniques and skills for instruction of STAD in accordance with characteristics of the students. The learning evaluation of students shall be transferred from total evaluation to diagnostic evaluation and formative evaluation. The teacher shall shift attention from how to make students unilaterally obey the teacher's management and complete the teacher's requirements, to how to keep normal operation of cooperative learning, how to resolve conflicts of opinions among students in a timely and appropriate manner and how to adjust dependent relationship among students, and etc.

REFERENCES

He, Lilai & Shao, Jingjin (2005). Introduction to STAD Cooperative Learning: Objectives, Modes, Implementation and Evaluation. *Foreign Education Research* **2005(1)**, 60–62.

Guo, Shulin (2006). Research into Cooperative Learning based on Engineering Mathematics. *Heilongjiang Researches on Higher Education* **2006(6)**, 162–164.

Johnson, David W. (2001). *Theory of Cooperative Learning and Skill* (Translated by Liu Chunhong). Beijing: China Machine Press.

Lin, Xiao-dong (2001). A Case Study of Classroom Change, Cognition and Instruction. *Reflective Adaptation of a Technology Artifact* **19(4)**, 395–440.

Qin, Guolin (2007). Basic Theory of Cooperative Learning and Its Referential Significance. *Heilongjiang Researches on Higher Education* **2007(9)**, 116–118.