AC 2011-225: THE STUDIES OF EFFECTIVE TEACHING AND LEARNING METHODS IN CHINESE ENGINEERING EDUCATION

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The Studies of Effective Teaching and Learning Methods in Chinese Engineering Education

Abstract

Research studies discover a number of teaching and learning methods and these methods can be used to develop student's ability in critical thinking, logic reasoning, and problem solving. Student's learning outcomes are greatly impacted by these teaching and learning methods. It is hypothesized that properly selected teaching and learning methods can be applied in student's learning and knowledge development to help students with different culture backgrounds yield better learning outcomes.

This research study selects three teaching and learning methods for an experiment in a software engineering class. These methods are tightening connections between learning objectives and outcomes, a repetitive learning model to improve student learning results, and a new measurement for student team project. A hypothesis testing is designed to verify effectiveness of these methods in developing student's learning outcomes.

An experiment was conducted in two software engineering project management classes with a group of seventy Chinese engineering students. Main purpose of the experiment is to test a hypothesis - whether or not the three newly modified teaching and learning methods can significantly improve student's learning outcomes. Sample data is collected from the experiment and is then analyzed by proper statistical methods. Statistical analysis of a small sample of data helps accept the original hypothesis. Due to the limitation of study and particularly small sample size a proposal is made that the same experiment will continue in a larger student population.

1. Introduction

Research studies previously conducted by the author and other researchers find that today's successful and innovative educational approaches must focus on critical thinking, logic reasoning, and problem solving.[1,15] Higher education institutions in the US have made enormous efforts to use newly designed curricula and adopt new techniques in teaching and learning in order to significantly improve student's learning outcomes and educate students to become well informed critical thinkers and deeply motivated problem solvers who can think critically, analyze problems, and discover innovative solutions. This effort also helps meet ever changing demands from rapidly changing business and working environment in this global economy.

To achieve the same goals Chinese engineering education must discover appropriate curriculum delivery methods with focus on critical thinking and problem solving. This research identifies, develops, implements and tests three new or modified teaching and learning methods. The methods in this experiment are tightening connections between clear objectives in teaching and student learning outcomes, a repetitive learning model to improve student learning results for two different types of students, and a new measurement for student team project. Validation and improvement of these new methods then becomes main tasks in this research.

2. Student's Needs Require Innovative Teaching and Learning Models and Methodologies

Research studies find that traditional learning model only focuses on teaching, not learning outcomes from teaching.[1] Research studies also discover that inefficiency in teaching is often caused by misunderstanding or ignoring the needs from students, higher education and this challenging global economy.

This research study summarizes student's main needs:
- fun and relevant topics
- student focused lessons
- learning from each other
- student's involvement in knowledge development

Additional needs with a focus on new global economy include:
- subject matter focused
- learning through experience
- focuses on language within the cultural context
- fast and effective
- key skill development

Unlike in traditional models students must be the center in learning and knowledge development in new teaching and learning model. Developing new teaching and learning methodologies must first understand what students need, student learning process, and how to achieve effective learning results. A new set of modified teaching and learning models and methodologies are identified and developed to ensure accountability, learning effectiveness, and quality in teaching in a positive learning environment. Experiment results must support that there is a positive correlation between the new models and methodologies and student learning outcomes.

3. Strong Connections Between Learning Objectives and Outcomes

Developing, formulating, and writing objectives is a key to the success of any education. Without clear objective, it is impossible to reach any goal in education. Use of objectives has become commonplace in higher education. Higher education often uses instructional or behavioral objectives in teaching and learning. In order to affirm the value of objectives it is important to incorporate objectives within the curriculum and specific units of study and make connections between objectives and learning outcomes.[3,4]

Instructors often use a standard protocol to develop objectives for their students. Although objectives are not difficult to write, the challenge is how to write instructional objectives for students that clearly state what students are expected to do by following instructions.[1,5] If goals are too general or not specific, it is difficult for both instructors and students to follow. It is almost impossible to measure student's learning outcomes by any vague standard and procedure. Moreover, inappropriate or inconsistent objectives for a course or a curriculum may mislead instructor's teaching, student's learning as well as the measurement.[5] Objectives must be specific, observable, and more importantly, measurable to student's learning outcomes in order to be used as part of pre-determined evaluation tools to measure student's learning outcomes.[3]

This research discovers benefits to incorporate objectives within any coursework are obvious and student learning improvements can be significant. Objectives emphasize major points and reduce non-essential material. Objectives simplify note taking and cue students to emphasize major points. Objectives assist students in organizing and studying content material. Objectives assist students in studying more efficiently and guide students directly to what are expected from them and help them concentrate on important information only.

More importantly, when examination items try to mirror objectives, students can use the objectives to anticipate test item. Clear and tight connections between objectives and learning outcomes require greater understanding of setting up goals to connect learning outcomes and use of proper measurement on whether or not every single goal has been achieved.

The action verb in objectives is an essential element in an objective. The action verb states precisely what students will do by following instruction at three different levels.
- recall – knowledge and comprehension
- interpretation – application and analysis
- problem-solving – synthesis and evaluation

The recall of an objective is at a basic level and it involves recall or description of information. Interpretation of an objective is a higher level of learning and involves application and examination of knowledge. Problem-solving skills test the highest level of learning and involve construction and assessment of knowledge, which is a foundation to improve student's ability in critical thinking and problem solving.

To make a successful objective also requires a special focus on the component - intended audience or students in an objective:
- action verb
- conditions
- standard
- intended audience or students.

This solution is to include students as a part of objective and to integrate students into objectives in their learning process. This solution helps make strong connections between objectives and evaluation and measurement of student learning outcomes. The same solution integrates a set of concept mapping techniques below to create milestones for measurement and check-up evaluation procedure at each milestone in student learning process.

Concept mapping techniques below are used in the process to define and develop objective, process, expected result, scoring mechanism, and score analysis.
- multiple uses for concept maps
- different types of maps: spokes, trees, center-focus and visual metaphor
- the appeal of concept maps to visual learners
- where to determine checkpoints in concept mapping
- drawing concepts maps
- using concept maps to increase engagement and foster creative connections
- proper model of concept map works best in different learning environment

It is obvious that concept mapping provides a powerful way to help students organize, represent, understand knowledge and substantially increase student understanding of difficult topics and make their efforts toward their learning goals. It also helps instructors broaden their teaching repertoire while showing students how to learn in authentic and active ways to start from objectives and move toward their learning goals.

Concept mapping could be a long process with many pieces of connections in it, but an effective tool to make such connections in student learning. By using a concept map, students will have a visual tool to depict a set of ideas by linking them and explaining the connections. Properly using concept mapping can make it easy to measure student learning outcomes at every connection point in concept maps. Concept mapping may be applied to make better sense of reading, document learning or thinking, or brainstorm a project. So it is particularly useful in measuring student performance in student team projects.

4. Student Learning Methodologies in a Repetition Model

Teaching can be defined as a set of processes used by instructors for the purpose of making learning happen.[2,4] The processes consist of transferring knowledge and bringing about positive changes in a learner. An improvement on a common three stage learning model is to integrate additional process steps into a repetitive knowledge transfer and absorb process loop.

Motivation Stage
Learners are stimulated to utilize learning resources to receive knowledge transfers

Acquisition Stage
Transferred knowledge enters in learner's short term or long term memory

Performance Stage
A portion of knowledge in learner's short or long term memory cause permanent change in learner's behavior
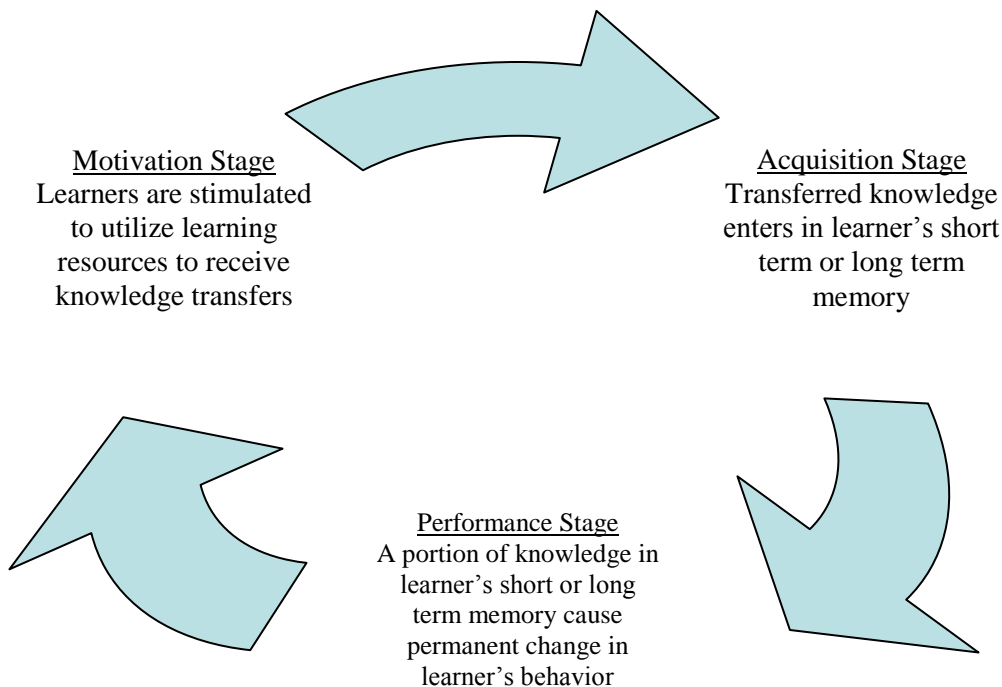
Figure 1: Three Stage Learning Model

Learning happens in a format of combination of an internal and an external process. An external process occurs through interactions between an instructor and learners. Such interactions may occur among learners too. An external process creates partial or temporary changes in a learner's memory if proper teaching methodologies are adopted in knowledge transfer. An internal process

occurs in the learner's memory and cause a relatively permanent change in the behavior of a learner.

Research reveals that learning usually takes place in three stages: the motivation stage, the acquisition stage, and the performance stage. [13]

In the motivation stage a leaner receives a stimulus to learn. This provides the drive for the learning process. The learner selects information from the environment, which is obtained by the sensory receptors.

In the acquisition stage the information is acquired and processed in the following manner: It enters the short term memory from which it can be retrieved and exploited within a very short time. But the capacity of the short term memory is very limited. The acquired information is then stored in the long term memory or is lost.

In the performance stage a learner provides the evidence of results from the learning process.

Research studies find that student's learning outcomes largely depend on their knowledge receiving process. Knowledge receiving is more complicated than a simple lecture delivery because students may come from different backgrounds which determine that they may have different levels of motivations, a variety of personalities, and unique learning experience. Based on their preferences to receive knowledge learners can be classified into two main groups: active learner and passive learner.[13]

As a result their learning methods can be quite different from each other. Most common learning model among learners is that their learning process is not a simply top-down process or is not one simple cycle of process. This research finds that the repetition type of process shown in Figure 2 fits into the learning model very well and may yield better results.

Another issue is that resources are not used efficiently in most of learning process. These resources include:
- human resources (lecturers, learners, administrators and support personnel);
- physical resources (classrooms, library, laboratory, and workshops);
- material resources (teaching material, audiovisual materials and others) financial materials (operational allowances, scholarships, training grants and others); and the political and social context (democracy versus dictatorship, peace versus war).

A process circle in Figure 2 tries to make full use of all the resources available while implementing teaching process and procedure. The enhanced model forces this process to eliminate any possible confusion in knowledge transfer, creating more chances to acquire additional knowledge, and store digested knowledge permanently in long term memory.

This new repetitive learning model is specifically suitable to a student team environment where most of students are non-active learners. The additional benefits in such environment are:
- Teaching methods focus on bringing student team together
- Knowledge transfer happens among two different types of student via team work
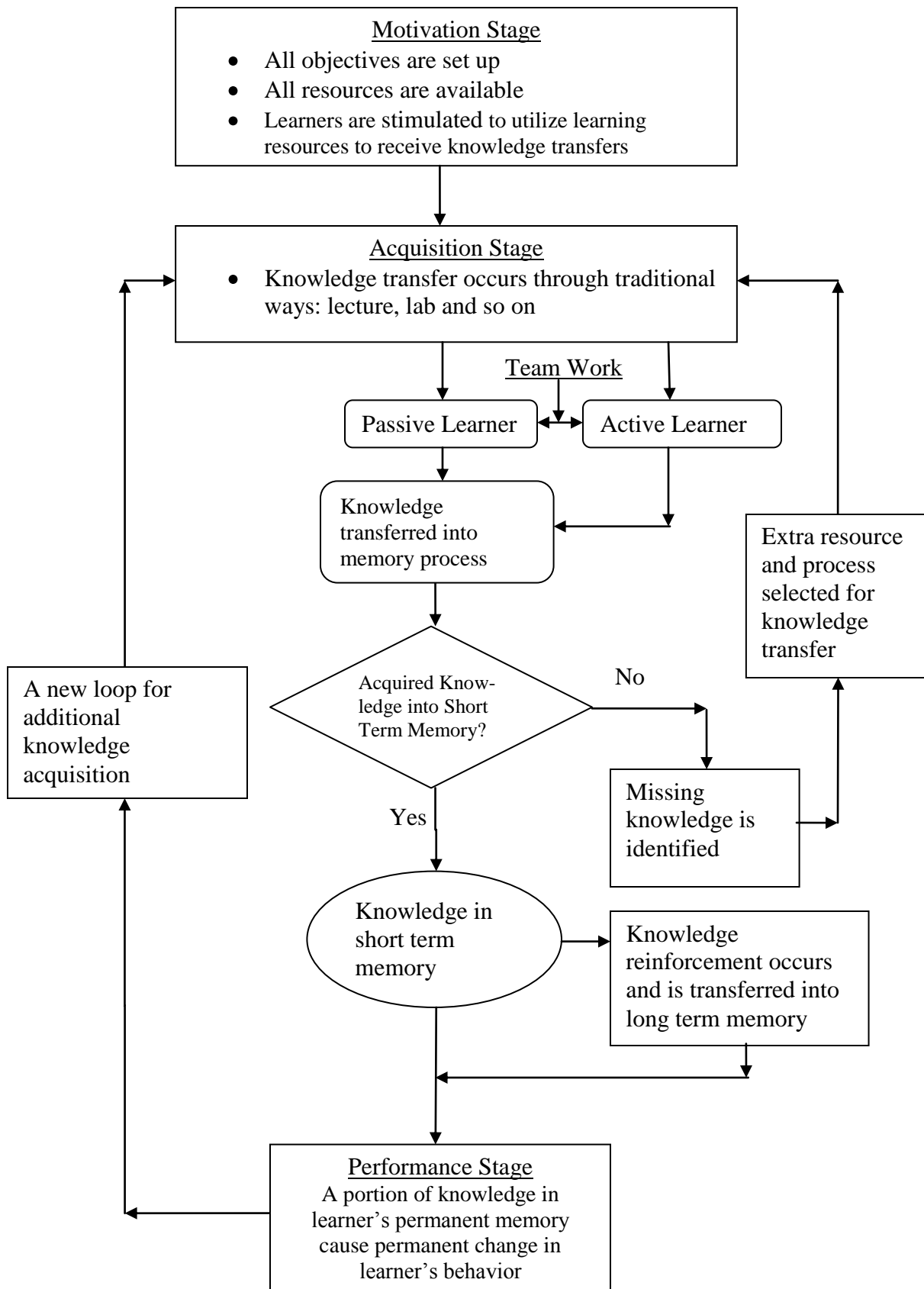
Figure 2: Common student's learning process model

5. An Altered Approach To Create A Community and New Evaluation For Student Learning

Chinese engineering programs have tremendous potential, but increasingly, students and instructors are experiencing frustrations on a number of issues. One of the frustrations commonly existing in Chinese engineering programs is that students often miss a sense of community. In other words, there is little interaction among students in student learning process. This issue may have existed for a long time and did not get any attention. As a result, it becomes a difficult topic that no one wants to address.

A classroom is supposed to foster a community. If students often feel isolated without any sense of connections in a community, there may be negatively impacts on student learning.[10] This problem is real, but it is not insurmountable. Any learning system relies on three poles: knowledge, the learner, and learning situation. Learning is influenced by other learners as well as their way to process information and absorb knowledge. This is also determined by relationship between an instructor and a learner as well as relationship among learners.

The solution lies in creating a learner-centered community that encourages students to assume more of the learning responsibility. Now roles of an instructor and a learner vary in this relationship. An instructor is no longer a mere transmitter of knowledge. In this learning environment a learner is not entirely dependent on what the instructor says or does. A learner has just become an educator rather a recipient. The learner is assisted in becoming autonomous and being able to plan his/her learning. On the other hand, a learner can play more active role in another learner's learning as an integrative force for essential teamwork in any project development where student teams serve the role effectively under the guidance of their instructor.[5, 6]

Although instructors establish their invisible presence in their classrooms in this new learning environment, they still play an important role of a facilitator to guide learning process and identify and implement strategies for establishing an instructor's presence. They combine learner-centered, interactive instructional activities with targeted instructor feedback to enhance student achievement and learning outcome. They develop assignments and grading strategies to increase student interactions. Team work provides tangible working solutions that students can use to modify their approach and create active learning.[9]

Instructor's less involvement in student learning and particularly evaluation may create difficulties to achieve effective teaching and learning. Not only should instructors be properly prepared; there is also a new need to require learners with adequate participation, effective communication, fair contribution, and willing to help others in this teaching and learning model.

Team work is a way to work with other students with different personalities, strengths, and so on. It is reasonable that a team member plays multiple roles in a team effort and may likely be assigned to different workloads based on their knowledge, strength, and experience.[9,10] Most of team projects or assignments have to be divided, but cannot be equally divided. Everyone receives the same credit for success or same penalty due to failure no matter how much their responsibility and contributions are. The benefits of team work are to work with people with different personalities and develop student's interpersonal relationship management, a key skill

to motivate people and receive support. Students learn how to create an environment and compel to them to work and think individually. Participants in a team can help leverage unique insights, foster collaboration, and build momentum for change. They may generate productive discussions and thoughtful reflection, share guidelines for continuing the conversation after the event, implement the strategies discussed, and create a feedback loop for sharing best practices and challenges.[8,9] Students must adapt their own personal skills to meet this new dynamic. Student team work connects students to other members of their class, thereby reducing their reliance on instructors. At the same time students enjoy a much more fulfilling educational experience and the course evaluations will reflect it.

In fact individual workload can be equally divided in some of student team activities. Contributions to those team activities and individual student contribution and performance can be measured:
- Reporting
- Presentation

However, in other team activities students may be forced to choose different roles in team activities and make their contributions in a variety of ways. Their contributions cannot be measured merely by equal share and contribution as it is impossible to divide those assignments into equal shares and there is no single standard to measure their performances in:
- Leadership and Project Management
- Discussion
- Meeting
- Communication

As a result, no one in a team is held accountable for entire team project result and learning results of others in a team. Therefore, properly choosing team activities and defining rules of measurements on every individual's contribution can have impacts on student learning outcomes. This choice and rules for measurements are usually made by instructors.

To be specific on the measurement instructors must create a fair evaluation procedure and much more sophisticated grading system. A fair evaluation procedure and grading system can encourage student team members to maximize their efforts and contributions and eventually benefit other team member's learning outcomes.[14]

A new type of evaluation and grading process needs to be designed and developed by instructors for team work performance and team member accountability.[11] The evaluation specially measures student's ability in Helping, Listening, Participating, Persuading, Respecting, and Sharing where student's efforts cannot be divided into equal shares.

In the evaluation and grading process the best judger to determine a student team member's performance is not instructors, rather students themselves because students are deeply involved in entire team work process and they are the best observers and judgers.[12] An example of student team work evaluation form in Table 1 is an example of new evaluation process and is designed for students to judge other student's performances in team activities different from project report and presentation.

Skills	Criteria				Points
	1	3	4	5	
Helping Student offered assistance to others.	*None* of the Time	*Some* of the Time	*Most* of the Time	*All* of the Time	_____
Listening Student worked from others ideas.	*None* of the Time	*Some* of the Time	*Most* of the Time	*All* of the Time	_____
Participating: Student contributed to the Learning Team Activities.	*None* of the Time	*Some* of the Time	*Most* of the Time	*All* of the Time	_____
Persuading: Student exchanged, defended, and rethought ideas from teams.	*None* of the Time	*Some* of the Time	*Most* of the Time	*All* of the Time	_____
Respecting: Student encouraged and supported the ideas and efforts of others.	*None* of the Time	*Some* of the Time	*Most* of the Time	*All* of the Time	_____
Sharing: Student offered ideas and reported their findings to each other.	*None* of the Time	*Some* of the Time	*Most* of the Time	*All* of the Time	_____
				Total Points	_____

Table 1: Student Team Performance Evaluation Table

6. Research Data Analysis

A number of surveys are conducted at the end of each course. All surveys are questionnaires with specifically designed questions with 5 predetermined answers. Data collected from the surveys is either categorical or numerical. Categorical type of data is then converted into numerical type accordingly. Each criteria or achievement in a survey indicates extent of agreement or disagreement with the statements on a five-point Likert Scaling (1= Disagree and 5 = Agree).

The first survey is designed to evaluate software engineering student's viewpoints on how the newly designed objectives impact their achievements in a software project management course by comparing their past experience in traditional teaching model. One of questions in the survey is "Do New Objectives and Concept Mapping Improve Student Learning Outcomes?" Based on student's personal experience in this class compared to other classes in the past they can only choose one answer from five possible answers: "Agree", "Somewhat Agree", "Not Sure",

"Somewhat Disagree", and "Disagree". The total of each possible answer is calculated and is then converted to a percentage.
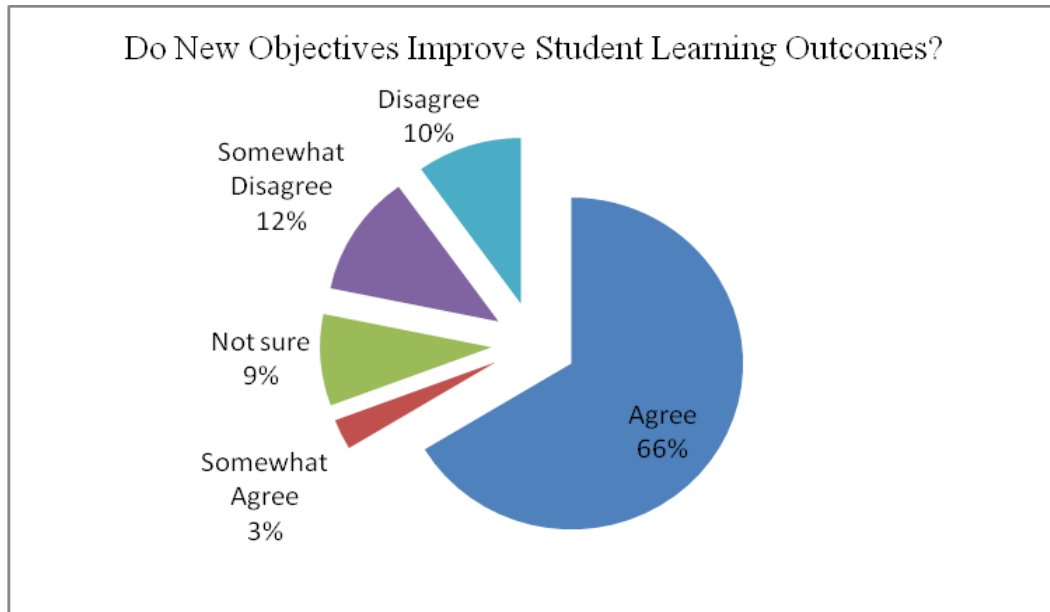

Figure 2: Survey Results on Better Connections between New Objectives and Learning Outcomes

One issue found from previous research is most of Chinese engineering students are passive learners and get used to following plan and instructions in their learning. They do not realize that coming into a university presents a different scenario of their learning. Some of the students are not ready for such dramatic changes in new learning environment where there is less involvement by instructors and more emphasis on individual initiatives and efforts. Concept mapping helps them use new objectives and connections to guide their own learning without instructor's involvement.

Statistical analysis on data from the first survey shows that nearly 2/3 students would agree that new objectives and concept mapping help their learning in this new model compared to traditional models. New objectives with students in the center make a closer connection to their learning outcomes. Another finding is 1/3 students have different opinions. This may indicate that more work needs to be done to educate students the importance of this change, how to work this change, and how to benefit from this change.

The second survey is conducted to compare students' grades between the environment with newly design repetitive model and without the model. Average student's scores are collected from two different classes in two different years. All the four main student learning measurements, Exercise, Report, Presentation, and Quiz, show slight increases from year 2009 to 2010 even though some of these increases are not significant. This may be caused by average numbers in 2009 are already high enough so that there is not much room to show any significant increase. In the future new grading criteria may need to be modified to see whether or not the impact of a change is significant.
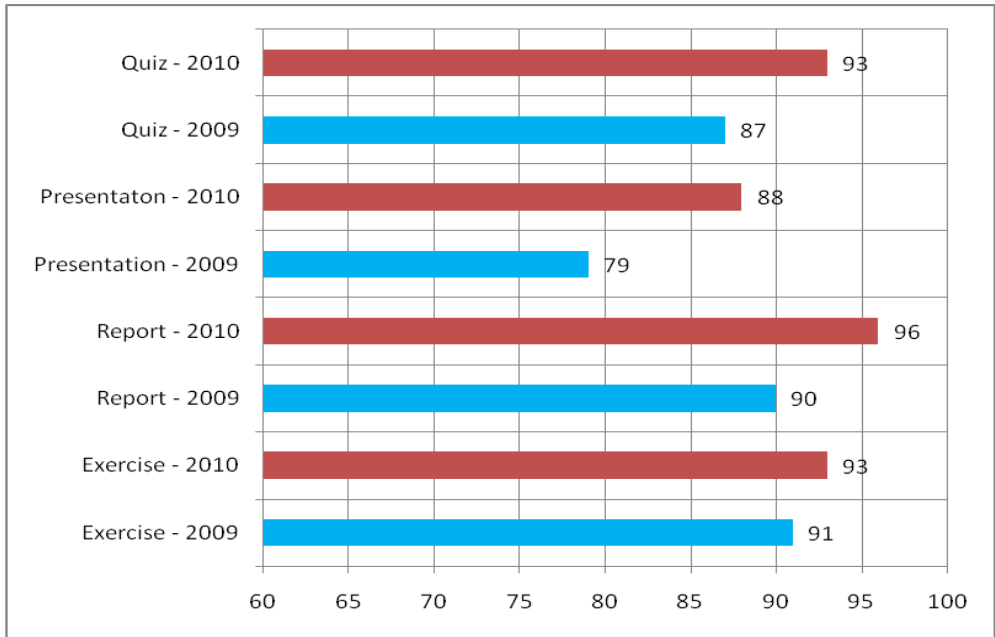
Figure 3: Survey Results on New Repetitive Learning Model

The third survey is conducted to collect student's opinions on new team work evaluation process comparing to no measurement for team work performance. One of questions in the survey is "Does New Team Work Evaluation Reflect Student's Performance?" Based on student's personal experience they can only choose one answer from five possible answers: "Agree", "Somewhat Agree", "Not Sure", "Somewhat Disagree", and "Disagree". The total in each possible answer is calculated and is then converted to a percentage.
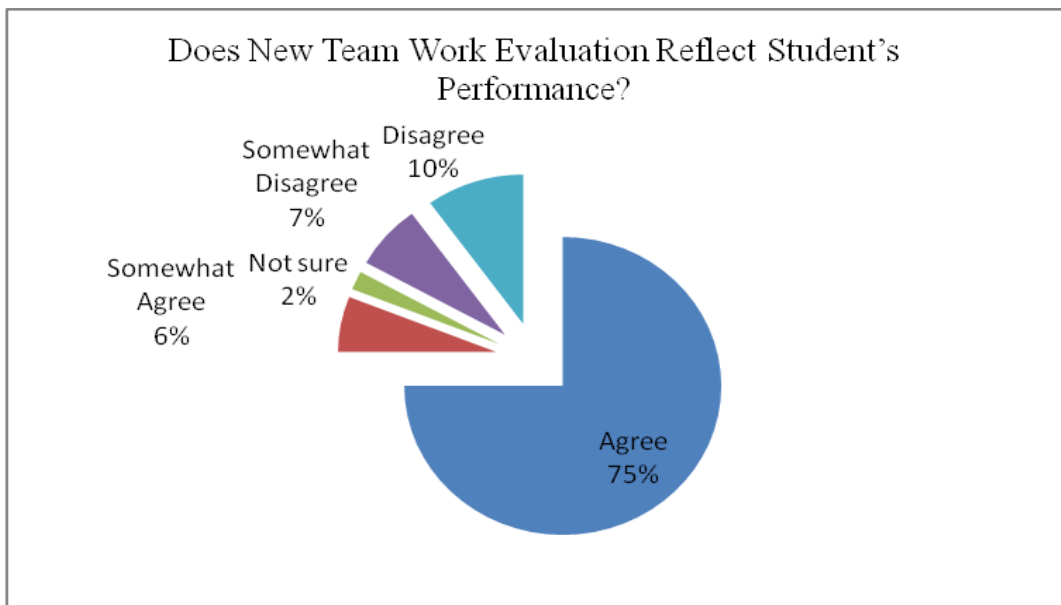

Figure 4: Survey Results on New Student Team Effort Evaluation

Most students agree that team projects and business cases from work places are vital in developing student's ability to convey their ideas and thoughts to others in problem solving process. Observing each other's work helps students develop their own knowledge and skills by learning from other's progresses. Real life experience and examples particularly enhance teaching scientific and practical communications to bridge the gap between the university novice and the seasoned professional.

To hold every team member accountable and fairly grade every team member's performance, efforts and contributions is a key to the success of team work. Student's involvement in team assignments impacts student learning outcomes. Fairly grading student's individual efforts in team work will ensure recognition of each student's own contributions to any team assignment. About 75% of students in the survey have confirmed this hypothesis. The main issue left is that about 10% of students disagree with this new change. Their main concern is fairness of the evaluation process and limited coverage and power of evaluation tools. Future improvements and new focus are fairness in evaluation process and effectiveness of measurement tools.

In summary, as long as proper changes and improvements are developed and implemented in student team assignments, students will be able to achieve most of their learning goals through their team activities. Student team project activities particularly create such unique atmosphere to allow students to share their knowledge and experience in other team member's learning process. Student's efforts to share their knowledge will be fairly recognized and graded in a student team evaluation process. How to encourage every student to make a full effort and maximize individual contributions in team activities remains a center of future study and additional efforts on evaluation process are to be made in order to continue improving new teaching and learning model and methodologies.

7. Limitations of the Study

This experiment is mainly to test the enhanced course framework with new focus on student's learning environment and methodologies in one engineering course. Raw data is collected from a small sample of one instructor and seventy software engineering students participated in this experiment. Although preliminary results from data analysis support original hypothesis and indicate that most of goals have been achieved, it is still difficult to predict complete and accurate outcomes for a large engineering student population to further support the hypothesis and findings from the experiment at this moment. Thus, the same experiments on a larger engineering student population are necessary in order to obtain more reliable test results for future engineering curriculum development. Modified surveys for the experiments are vital to provide additional data for statistical analysis to verify hypothesis and reach conclusions.

8. Conclusion

This research experiments three student learning models and methodologies focused on development of student learning outcomes in a software project management course. Preliminary results from the student course work, classroom activities, discussions, meetings, presentations, tests, team project reports, and student team peer evaluation provide strong evidences to support original hypothesis. Three new enhancements to student learning are effective and successful in

improving student learning outcomes. The lesson learned from the experiment has laid out a solid foundation for future improvements and experiments with a large student sample size.

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