A New Cooperative Learning Framework in Mathematic Courses

Seifedine Kadry and Rabih Roufayel

Abstract— It is widely known that mathematics plays a major role in handling real life problems related to members in a society and serves in shaping both private and public sectors of a given community. Many students have showed signs of discomfort when dealing with mathematics, becoming more and more dissatisfied as they confront challenges to engagements. Solving this dilemma requires to search and develop an effective and suitable learning methodology that serves as a guiding tool in modern teaching. Recently, a new educational technique strategy "Active Learning" was implemented in many educational industries. This strategy briefly describes as a wide range of learning activities engaged by students in a classroom other than listening passively to an instructor's lecture. It involves student's engagement in critical thinking thus expressing and passing over ideas in small groups that can be illustrated by receiving immediate feedback from the instructor. The term cooperative learning covers the subset of active-learning activities that students perform in groups of three or more, rather than alone or in pairs. This paper shows a new learning methodology in mathematics based on cooperation between students with different educational background level. The main idea behind this cooperative method is to increase class average and on the other hand, to decrease the variance and range between students' critical thinking and knowledge levels. The proposed methodology in this study shows the advantages of active learning and the power of student centered approach.

Index Terms—Active learning, Bloom's taxonomy, Cooperative learning, Dale's cone, LMS, Mathematics, Student-Centered approach, Probleb-Based learning.

1 Introduction

Over the past decade, the demand on teaching and learning methodologies had the best interests at heart among university faculties seeking both new active and cooperative learning approaches [1-4]. A vast amount of research testifies the profit of active learning and its positive outcomes [5-7]. Figure 1 and 2 give a clear idea about the history of Student-Centered approach including both Active and Cooperative learning methods [11]**.** However, the traditional teaching methods are still offered in a vast majority of educational institutions due to the mistrust in the new educational pedagogical practices. Cooperative learning has been criticized by many educators stating that this learning technique is considered to be an alternative approach rather than a vital enhancement of lectures [7-12]. In this study, we provide a survey for a wide variety of active learning techniques that helps in supplementing lectures rather than substituting them. Delivering information and knowledge basically relies on the art of lectures and their significant importance in illustrating ideas to students. However, using it as the only mode of teaching may present problems for both parties in class [12].

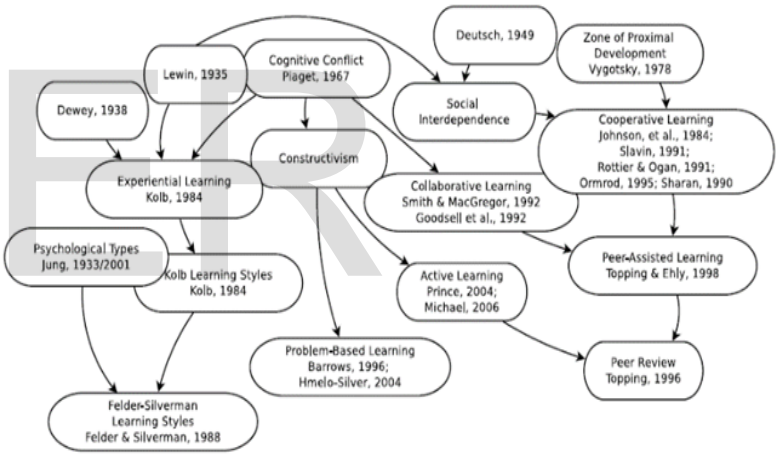

Fig. 1: History of Student centered approach

2 Active and Cooperative Learning

Active learning strategies engages students in a wide range of activities that involves critical thinking, sharing information with other members in a group with the ability to discuss ideas and explore personal values. All of these strategies can be done as an in-class activity that encourages students to engage in a large classroom rather than listening passively to the traditional lecture by the instructor [1]. These strategies teaches students to comprehend what they hear, to interact with group activities, to express new ideas through writing, to apply traditional course material to real life dilemma, and to solve new problems in a more realistic approach [14]. Moreover, active learning promotes deep and lasting learning rather than transferring of information from the notes of the lecturer to the notes of the student without passing through the minds of either as seen in traditional lecturing [8-9]. The term "cooperative learning" is considered to be a subset of active learning

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where students are organized into groups assigned to fulfill complex duties [1-7]. These duties range from complex exercises to projects and presentations that are demonstrated by speaking, sharing and doing assigned tasks with their partners within the same group.

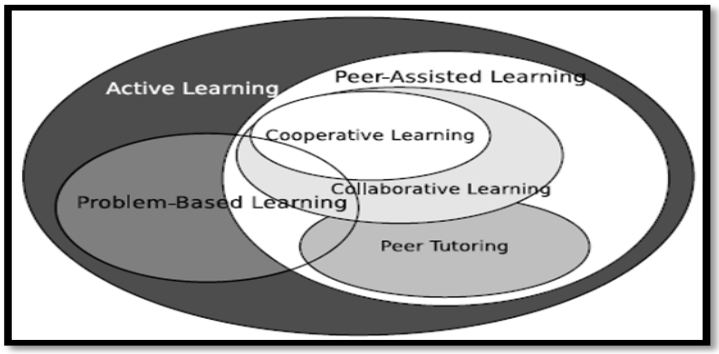

Fig. 2: Student-centered Techniques

Cooperative learning focuses on enhancing student retention of material and is considered of a well distance from the traditional learning. Every assigned group works on achieving a common goal rather than placing both students and instructors on an equal footing as seen in collaborative- learning strategies [3-13]. A learning activity could become cooperative when every student in class realizes that no group member can be successful unless the groups are successful.
Active learning techniques allows the instructor to spend a greater portion of time guiding students promote deep learning and engaging them to develop their understanding and skills and lesser portion of time in dictating information as seen in traditional lecturing. This technique incorporated by the instructor in classrooms allows groups to achieve common goals with positive interdependence and to receive immediate feedback from the instructor at the same time [9]. Learning mathematics at universities using the cooperative learning method withstands multiple promising outcomes that can be summarized by i) significant increase in academic achievements ii) more civilized social and behavioral attitudes [15]. Results illustrate that students undergone cooperative learning engage higher educational goals and significant retention than those with individual learning experience [11]. Self-esteem, social behavioral and lecturer ratings of students have been documented to show a dramatic increase by applying this teaching method upon universities programs [9-16]. Although this learning approach requires more lecturer preparations of group material and monitoring activities, the outcomes behind this teaching strategy targets both the lecturer and students simultaneously in a positive matter. Moreover, mathematics lecturers should work on supporting interdependence among group members by dividing tasks, course materials in order to work together to accomplish shared goals in class. Recently studies performed on mathematic university classes have shown to positive feedback by increasing academic achievements using cooperative learning activities [11].

3 Our New Method

In this paper, our teaching method is considered to be cooperative by design. It consists of dividing a given class into groups of 4 to 5 students during any "learning then assessment" activity. Based on the number of groups, we select top students having a high average grade in the total course from the LMS. As an example, a total class of 30 students is divided into 6 groups, each containing 1 top student selected from the LMS course total (Refer to Figure 3 that shows the different group structures). In total, each group consists of 5 students, 4 of them are considered to be good students known as the "Good Group" and 1 top student designated to be an excellent student among its given group (Figure 4 shows the groups of good students). The role of the faculty member in this teaching method focuses on being a facilitator rather than an instructor. This faculty member serves in preparing the new materials or notes and conduct a quiz at the end of the session. At the beginning of the lecture, the faculty distributes the new material or notes to each of the excellent students (see sample in the appendix A). The excellent students are then asked by the faculty member to sit together in order to read, discuss and solve the designated task/problems provided by the facilitator (faculty member). We call this group as the "Excellent Group" (Figure 5 show the group of excellent students). The facilitator's task focuses on checking and monitoring properly the group's work, giving them more attention and time to assure their understanding, grasping the correct information and finalizing the solution of the given task. Later on, the facilitator asks each member of the Excellent Group to join their Good Groups. They are responsible in explaining, discussing and sharing the information with their group members. Finally, the faculty provides each individual member an assessment quiz on the studied materials.

4 Our Method, Dale Cone and Bloom's Taxonomy

It's imperative to categorize or classify any new method against the two well-known educational frameworks: Dale cone and Bloom's taxonomy. These two frameworks have been presented for more than 50 years and yet, it is commonly accepted that their general findings are still valid; also today they create foundations for effective teaching and learning, regardless significant development of technology and use of new teaching-learning methods.

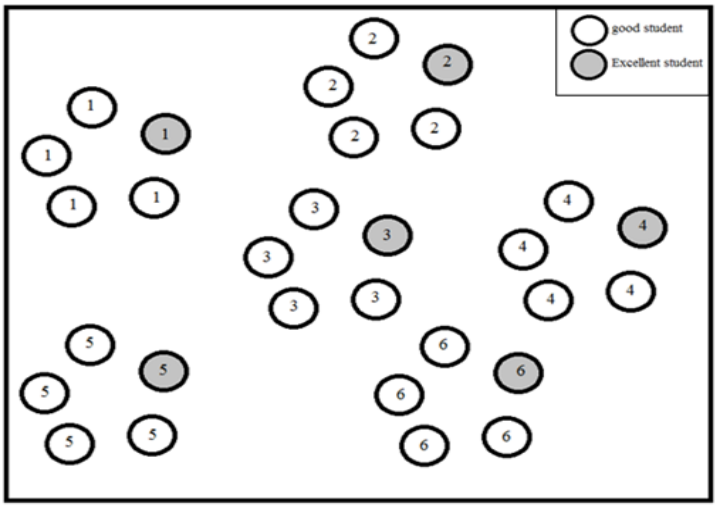

Fig. 3: Students grouping

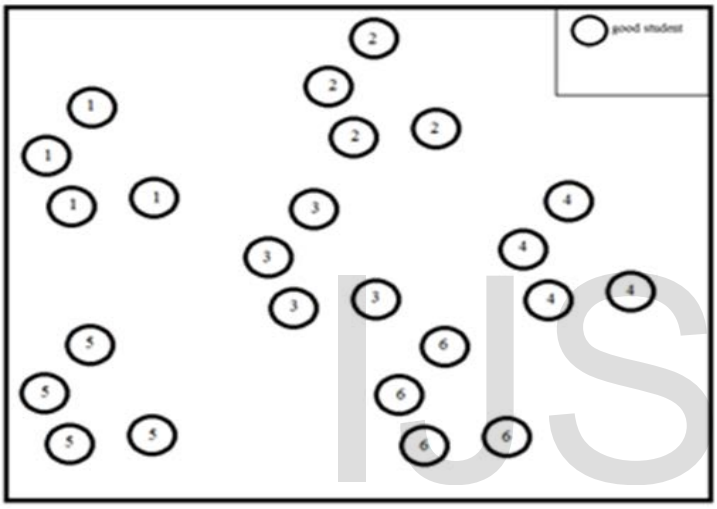

Fig. 4: Groups of good students

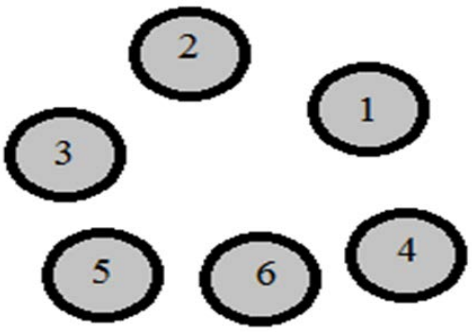

Fig. 5: Group of Excellent Students

information learned. The classification or cone of experience was developed by Edgar Dale, an American educationalist, in 1957 [10].

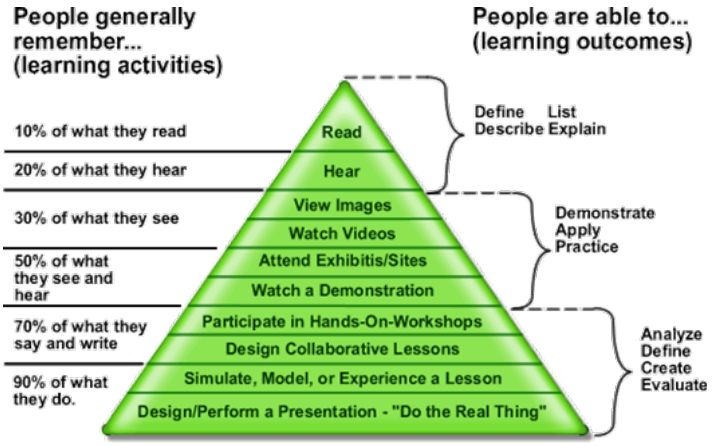

Fig. 6: Dale's cone

4.2 Bloom's Taxonomy

Bloom's taxonomy (Figure 7) is a classification of thinking skills. Bloom's taxonomy was created in 1956 by the leadership of educational psychologist Dr. Benjamin Bloom. This taxonomy promotes higher forms of thinking in education such as analyzing rather than just remembering. The taxonomy was revised by Bloom's student in 2001 [11].

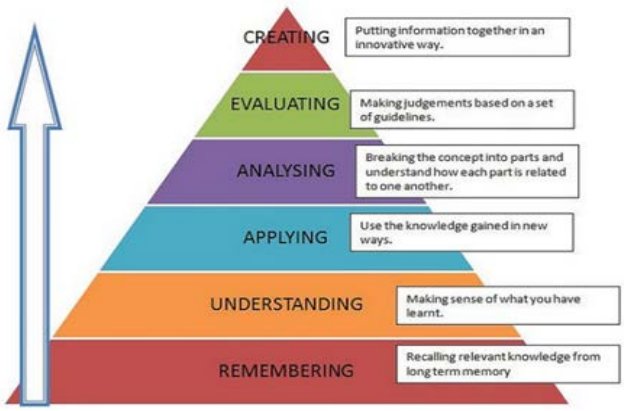

Fig. 7: Bloom's taxonomy

4.1 Dale's Cone

Dale's cone (Figure 6) is a categorization of different types of learning methods and the corresponding retention rates of

A list of verbs used in mathematics provided in Table 1 are used to facilitate the classification of the faculty's assessment in taxonomy level. Each level in taxonomy describes different

leaning outcomes.

	New Terms	Actions	Learning Activities
Higher-order thinking	**Creating** (Putting together ideas or elements to develop an original idea or engage in creative thinking).	Designing, Constructing, Planning, Producing, Inventing, Devising, Making	***Creating:*** (Generating new ideas, products, or ways of viewing things) *How could we determine the number of pennies in a jar without counting them? Apply and integrate several different strategies to solve a mathematical problem. Design a new monetary system or an experiment for establishing ...* Designing, constructing, planning, producing, inventing. *Invent a machine to do a specific task. Develop a menu for a new healthy foods restaurant.*
	Evaluating (Judging the value of ideas, materials and methods by developing and applying standards and criteria).	Checking, Hypothesizing, Critiquing, Experimenting, Judging, Testing, Detecting, Monitoring	***Evaluating:*** (Judging the value of a product for a given purpose, using definite criteria) *Develop a proof ... and justify each step ..., Using a definition ... determine ...* Justifying a decision or course of action, checking, hypothesizing, critiquing, experimenting, judging *What criteria would you use to evaluate if your answer is correct? Prepare a list of criteria to judge... Evaluate expressions.*
	Analyzing (Breaking information into its component elements to explore relationships).	Comparing, Organizing, Deconstructing, Attributing, Outlining, Structuring, Integrating	***Analyzing:*** (Breaking information into parts to explore understandings and relationships) *Given a math word problem, determine the strategies that would be necessary to solve it. Write a paragraph describing the relationship ..., How does ... compare to ...* Comparing, organizing, deconstructing, interrogating, finding *Design a survey to find out ... Graph your results. Use a Venn Diagram to show how two topics are the same and different. Translate between visual representations, sentences, and symbolic notation. Make predictions based on experimental or statistical data.*
Lower-order thinking	**Applying** (Using strategies, concepts, principles and theories in new situations).	Implementing, Carrying out, Using, Executing	***Applying:*** (Using information in concrete situations) *Compute the area of actual circles. Use the given graph to ..., Choose and describe the best method to ...* Using information in another familiar situation, implementing, carrying out, using, executing *Draw a diagram which shows these fractions or take photographs of the fractions. Determine measures of central tendency and dispersion Write a journal entry. Write an explanation about this topic for others.*
	Understanding (Understanding of given information).	Interpreting, Exemplifying, Summarizing, Inferring, Paraphrasing, Classifying, Comparing, Explaining	***Understanding:*** (Grasping the meaning of material) *Given the mathematical formula for the area of a circle, paraphrase it using your own words. Select the graph that illustrates* Explaining ideas or concepts Interpreting, summarizing, paraphrasing, classifying, explaining *Find items that you can use to show the fractions. Retell or write in your own words... Report to the class... Write a summary report of the event.*
	Remembering (Recall or recognition of specific information).	Recognizing, Listing, Describing, Identifying, Retrieving, Naming, Locating, Finding	***Remembering:*** (Remembering previously learned material) *State the formula for the area of a circle. State the rule of ..., Explain and use the procedure for ...* Recalling information, recognizing, listing, describing, retrieving, naming, finding, locating *List the fractions you know and can show. List the attributes of your shape. Make a concept map of the topic. Make a chart showing...*

Table 1: List of verbs used in mathematics

Table 2 shows the position of our new learning method and the given assessment on the Bloom's Taxonomy vs. Dale's Cone of Experience matrix:

Bloom / Dale	Reading	Hearing	Looking	Watching	Participating	Doing
Creating						
Evaluating					Our method	
Analyzing						
Applying					Our method	
Understanding						
Remembering						

Table 2: Bloom's Taxonomy vs. Dale's Cone of Experience matrix

Based on this matrix, our teaching method falls in the "participation level" in the Dale's cone level and in the "Applying / Evaluating" in the Bloom's level.

5 Design of the Proposal Method

The material and the assessment used in our method are presented in the appendix A and B. A topic known by the name "Exact Differential Equation" inthe "Differential equation course" was the main topic of study. It is widely accepted that this topic is considered to be a challenging since it includes partial derivatives and some integration equations and indeed delivers essential learning outcomes. Based on previous semester grades, this topic showed a low average to high grade variance among classes using traditional teaching methodology. Our new method below shows a lecture plan (over 80 minutes):

1- Select top 6-7 students based on the course total in LMS. These are the grouped as "Excellent Students".

2- Divide student into groups of 4-5 students. Assign one "Excellent" student to each group.

3- 25 minutes for each group (groups of good and group of excellent) to read the materials.

4- 20 minutes for each group (now the excellent students join back their good group) to discuss again any issue and to check the solution of the problems given at the end of the notes

5- 15 minutes individual quiz duration.

6- 20 minutes for solving the quiz and general discussion on the topic then small survey at the end of the class.

6 Conclusion

In this paper a new proposed cooperative learning methodology was presented. This method was designed and applied in Mathematics course but can also be applicable to any other course in different majors among diverse university departments. We have selected a difficult topic to apply our method through prepared notes followed by quiz at the end of the lecture. The topic is one of the course learning outcomes. Our proposed learning method target many sectors including improvement on the class average grade, minimizing the variance between students' grades through knowledge transfer, and increase students' retention of materials. This designed framework illustrates a major impact on academic achievements and a positive influence on the attitudes of (and towards) students. Our technique employ structured groups of students having complex tasks capable of working together towards a common goal with positive interdependence, individual accountability, and heterogeneous groupings. We advise the use of this technique on each course learning outcomes. Our future work will be structured towards implementing this study in large classrooms holding different major courses including mathematics and analyzing the student retention rate before and after application of our method. This study may act as a survey form a wide variety of active learning techniques that can be used to supplement and aid lectures. Considering the efficient information passed on during traditional lectures, the use of this single mode of instruction might create some problems for both the instructor and the students at a large scale. Cooperative learning strategies has indeed showed benefits with more radical departure from traditional techniques, aiming to enhance student retention of

materials presented in class.

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