How to Enhance Mathematics Outcomes in a Relatively Large Class?

A Lesson Study of the Mixed Pedagogical Approach

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Abstract

It is generally believed that the individualization of instructional method does not significantly contribute to learning outcomes since every single student has his own learning style. A mixed learning approach is thus more likely to have a general improvement than a lecture with a single approach only with a hypothesis that each approach could retain their own strength and reduce their weakness through interactions, and the students' academic performance would be improved eventually. The positive result of this action research is very likely to agree with the above hypothesis, such that the mixed learning approach is feasible and effective to boost learning outcomes.

Keywords: Mixed Learning Approach, Problem Based Learning Approach, Deductive Learning Approach, Project Based Learning Approach, Analogy Learning Approach, Mathematics Education

1   Introduction

Teacher in no doubt occupies an inevitable position in teaching and learning (Sharp, 2005). In Vygotsky's theory of intellectual development, the role of the teacher is to allow a greater and higher achievement than the student working alone (Vygotsky 1978). No matter the behaviourism or the constructivism is adopted, teacher is the key person responsible to the learning objectives and the

monitoring of the flow of the learning progress (Forcier, &Descy, 2005). Teachers' Pedagogical Content Knowledge (PCK) thus plays a critical role in determining students' learning progress (Rowland, 2014).

However, traditional education does not address individual differences such as students' academic backgrounds (Brusilovsky, Eklund, & Schwarz, 1998). In fact, it is nearly impossible to fit every student with a single instructional method since all students are unique, every student has his own learning style (Bhagat, Vyas, & Singh, 2015). Abundant studies shows that from the visual, auditory, iconic and kinesthetic sensory modalities suggested by Bruner (Bruner, 1967; Norman, 2009) to the macro learning strategies such as problem-based learning approach, students has their own learning preference (Baykan&Naçar,2007;Breckler,Joun& Ngo, 2009; Hughes,Fallis, Peel& Murchison,2009). A specific learning approach might results in a better performance on some particular types of learners but not on the others (Kumar,Voralu,Pani&Sethuraman,2011).As a result, individualization of instructional method does not significantly contribute to learning outcomes (Cook, Thompson, Thomas& Thomas,2009;Furnham, Jackson& Miller,1999;Vermetten,Vermunt&Lodewijks,1999).

In order to optimize the teaching and learning effect in the long term, therefore, developing a flexible, multiple and mixed approach learning approach(MLA) is essential and it should be encouraged. According to the nature of this objective, the format of this study will follow the lesson study, which has origins in Japanese elementary education, focusing on the teachers' professional development practice. The aim of this lesson study is to determine the effectiveness of the MLA and its feasibility such that the awareness of applying a suitable teaching approach could be promoted.

2   Current Problem and Problem Analysis in the topic of "Coding"

Recently, the teaching approaches of "coding" suggested by the common textbooks are mainly either simple inductive or deductive approach(Attwood, Clegg, Dyer, & Dyer, 2009). Although with a satisfactory result in public exam, students always show difficulties in it. According to the test conducted by seventeen senior three students who had learnt the topic in the previous academic year, the average mark is 42.1% with a standard deviation of 0.271 (Table 1). This result is relatively low compared to what they did in the public examination (GCE A-Level) in the same year with 20% of them achieved the top ranking "A" with about 80% passing rate.

The test is analysed and two students are then interviewed. The main errors are generalized as followings:

Table 1 Result of Tests

	Control (Full Mark:100)	Sample (Full Mark:100)
Mean ($\bar{x}$)	42.1	85.5
Standard Deviation (σ)	27.1	13.8
Max	92.0	100.0
Min	8.0	56.0
Median	36.0	92.0

2.1   Confusing / or Using the Wrong Equations

Student A said that she forgets the formula of E(X) and Var(X). She further reveals that she does not actually understand what does E(2X+4) or Var(2X+4) means. It contributes the common mistakes made among students.

2.2   Poor Linkages between Similar Topics

Student B can achieve E(2X+4) but not the coding in y = 4x. When asked about the relationship between E(2X+4) and coding, he said that they are different. The linkages between similar topics are very weak.

Therefore, the teaching and learning outcome by using the suggested teaching approach is not satisfactory. A revise on the teaching methodology has to be done in order to boost the performance.

3   Component of the MLA

Different kinds of teaching approaches have their own strengths and weaknesses (Suneetha et al 2004). In this study, four teaching approaches are selected as the core component of the MLA according to their characteristics. First, the Problem-Based Learning (PBL) is especially good to raise the learning incentive among the able students. However, it is not suitable for less-able students because it requires a certain amount of pre-required knowledge. Deductive approach is a very powerful approach which the students could have the chance to prove a law, idea or a formula by themselves. It is suitable for a wide range of students with different learning ability. Due to this active learning activity, the memory lasts longer. However, it is very time-consuming too. Proving all the laws and formula is very unlikely to be possible in practice. Students with diversity in learning ability may achieve the answer in different progress which usually makes the able-students feel boring. Eventually, it becomes a challenge to classroom management and discipline. A grouped-project based approach would certainly enhance co-operation among students and thus improving students' communication skills especially when the topic is interesting. It facilitates the work by appropriate job allocations. Analogy learning approach is

very useful in building up linkage among similar topics especially when the basic skills are very familiar by the students. It speeds up the learning progress especially in learning related topics. A shortlist summary is shown in Table 2.

Table 2 Summary of the Main Advantages and Disadvantages of different Teaching Approach

Learning Approach	Advantage	Disadvantage
Problem-Based	● Raise the learning incentive	● Lots of Pre-requires subject knowledge
Deductive	● Suitable for a wide level of students ● Memory can last longer due to active learning	● Very time consuming
Project-Based	● Enhance co-operation ● Enhance communication skills ● Saving time	● Classroom management
Analogy	● Building up linkage among similar topics ● Speeds up the learning progress in similar topics	● Pre-requires subject knowledge is needed

4   Methodology

This study will be divided into a lecture (intervention) and two tests: the control group and the sample group. The target sample is 17 senior three students (1 class) and 27 senior two students who all studying international GCE A-Level program in a China public school. Due to the similar academic background among senior two and three students, the standards between them could be assumed to be the same thus the 17 senior three students (mentioned before) could be used as the control group while the 27 senior two students served as the sample group.

The lecture could further be divided into three phases: PBL, deductive together with the project-based approach, Analogy teaching approach. In the PBL phase, a problem given to the students is designed as those come from their daily life or experience such that they may feel familiar with it. This increase their incentives to learn and decrease their efforts of understanding the question sentence in English. Although able students may have got some ideas about the solution, it is still difficult for most of them. Next, students are divided into 4 groups with their seatings are well planned such that

each group consists of four to five students. It is because experience has shown that groups of three to five students work well (Posamentier&Stepelman, 1999).It allows enough communication with satisfactory monitoring respect to classroom management. At the same time, able students are distributed to the groups evenly to get better synchronizing in the group progresses. Worksheets, consisting of seven questions with the same characteristics are distributed. In the meantime, the data and the last question are left for them to decide. It ensures each group is doing their own piece of work without copying from others. Moreover, it makes the activity more interesting.

The required work for each question involves at least three steps: solving the question by a direct method, solving the method by using their hypothesis and checking if the answers in these two methods are consistent or not. For example, if $y = x + 15$is being investigated, data should be first decided by the students themselves. Mean and variance are then calculated. The original set of data should be changed into a new set of data according to the coding formula to obtain the new mean and new variance. If their hypothesis suggests that the new mean is the same as the original mean, it could be verified by the calculated result.

When conducting the project activity, students are free to allocate their workload within the group in order to build up their leadership and communication skills. Students are free to make any discussion within the group. For the able students who may get ideas, the target of their exercises is deductive. It means they are going to verify their concepts through the exercises. On the other hand, the initial target among the less-able students is to find out the pattern, rules or formula behind the exercises first before they may do the deductive one. Enough exercises are necessary for providing enough information for drawing the conclusion while the group working is essential for ensuring the work is done on time. Moreover, the exercises could also serve as class work and thus balancing the teaching time compared to normal teaching.

Due to the inductive reasoning nature of the PBL, the teacher would only provide the students with a minimum of information – only those facts most vital to the investigation (Ronis, 2008). Instead of giving out the answer directly, the teacher act as a mentor, a guide or a tutor in explaining the objective of each phase, giving hints to who need help. The answer is what the students have to find out on their own. Since the mathematics writing and format of style is also a critical factor in evaluating students' work (Morgan, 1998), mathematic symbols such μ and E(X) are shown at the very beginning. Groups are also asked to present their work as a mean of the evaluation of their work.

No sooner all groups had reached the key concepts by than the original problem is shown.

In the last phase, the teacher recalls the fundamental concepts in a similar topic and the possibility of applying the same formula is asked. For example, the calculation of expected value in discrete random variable is recalled and the similarity between the expected value and mean is asked. Finally,

conclusions are made by the teacher and students are required to open their textbook so to highlight the corresponding equations and information. This leaves the footprints for students to do revision in the long run.

A test is conducted two weeks after the intervention using similar items compared to the test given to the control group. Two weeks is considered as a cool down period in order to test whether the knowledge could last long in students' memory. It also provides a fair footstone for the comparison between the tests. Within these two weeks, an unrelated chapter (Normal distribution) is taught instead. An interview is done two weeks later on four students in order to further investigate the effect on their improvements. Since Mandarin is the mother language of the students, the interview is conducted in Mandarin to allow better reflection given by students.

Finally, an independent sample t-test is conducted to investigate the effect of the intervention.

5   Ethical Issues

The self-ego and competition among students may be a source of uncertain factors and thus a student helper is recruited to reduce the biased effect in the interview. Since the public exam results are sensitive information which could easily lead to a competition among schools, confidentiality is the major concern in this research. All names and records of the participated schools and their students will be treated as confidential and will not be enclosed to others without permissions.

6   Result

The statistics show a significant difference between the two tests. Students in the sample group (M=85.5, SD=13.8) score higher than those in the control group (M=42.1, SD=27.1) with t(42)=3.06, p<.01 (one-tailed). The effect size is Cohen's d is 2.01 which indicate a very large effect size. Therefore, the MLA is found to be a feasible way to significantly enhance students' academic learning outcomes.

The after-intervention interview seems to agree with the above. As student Astated, "The formula and concepts now become more concrete compared to the traditional lecture". The MLA allows students to experience the formula and concepts by themselves and thus provides a better understanding of the abstract ideas. Linkages among similar topics are established better, as a result, students are more capable to apply the knowledge to new situations as well as developing their creativity. In the meantime, the MLA could facilitate students' learning incentive and communication skills through the interesting group project and activities. However, there is an interesting comment that the MLA is still being considered as time-consuming. A summary of the interview is shown in Table 3.

Table 3. Summary of the After-Intervention Interview

Perception towards MLA	Comments refer to Student
Subject content becomes concrete.	A (L4)
Better understanding	A (L4), B (L30, L34), C (L50), D (L74)
Greater learning incentive	A (L10), B (L32), C (L52)
Easier to apply to new situation	A (L16)
Enhance communication skills	B (L42), C (L62)
Develop creativity of new idea or formula	C (L60)
Time-consuming	D (L72)

7   Conclusion

Statistics show that using the MLA could significantly improve the students' academic performance by turning the abstract ideas into concrete. The result of the interview reveals that the fundamental hypothesis, which MLA could retain the strengths and suppress the weaknesses of several learning approaches, is correct. MLA is very effective in enhancing a better teaching and learning performance and it might be a good choice especially for a non-small class.

8   Potential Limitation and Further Study

However, extra care should be made when quoting the result because of the small sample size and the limited of subject disciplines. The geographical and cultural factors may also threaten the validity of this study. Further study of MLA could focus on different topics, different cultures or result in terms of some higher-order thinking skills.

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