FACILITATING COOPERATIVE LEARNING AMONG MATRICULATION BIOLOGY STUDENTS

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Abstract

This paper reports on a study that examined the effectiveness of cooperative learning (CL) as compared to individualistic learning. The subject matter tested was a topic of Biology i.e. 'Expression of Biological Information'. An earlier quiz had showed that the subjects from both groups were not significantly different in terms of test performance. However after CL was structured, the mean for the experimental group was 14.25 (SD=3.23), while the mean for the control was 9.19 (SD=1.91). Independent samples t-test showed that this difference was significant t(62)=7.629, p=.0005). Students who participated in cooperative learning had performed significantly better than the control group. This agrees with most of the literature reviewed. I conclude that by its very nature, CL is effective to stimulate higher order thinking and critical thinking, and that more research should be carried out on the use of CL for science education in Malaysian schools and colleges.

Introduction

It was my duty and privilege to teach Biology for four tutorial groups in the first semester of the previous year. My past experiences as a teacher have taught me that I need to know about innovations/ breakthroughs in education research, theory and practice (Campbell, 1990) and to be learning all the time; so that I may optimize learning for my students.

Reflections

I was very concerned about my students, because not all of them were performing well. They were from very diverse backgrounds. They differed in terms of academic achievement and many students had problems with English language. However, Matriculation colleges provide pre-university education to prepare students for university where the lingua franca is English; and we, the lecturers, have been told are to use English fully during the lesson. Matriculation colleges continue the practice of PPSMI, the Malay acronym for Teaching and Learning of Science and Mathematics in English.

Within each of my classes, there were many differences in terms of student ability. So, I decided to use cooperative or collaborative learning (CL) which is discussion and learning activities within a small group of four students with different abilities. Within each group I assigned roles for everyone: leader, assistant, checker, and recorder(s). Each member is responsible for their own learning as well as the learning of their team-mates so as to nourish the cooperative spirit and enable all students to perform better. If students were to learn individually and competitively, those who did well might be seen as keeping their knowledge to themselves, and may be labeled as selfish. This is what I wanted to avoid. When the

whole group or class is able to achieve well in an open cooperative situation, the students will be more motivated to get better grades.

In order to face the challenges in life and work's demands, my students should be provided with adequate knowledge. They should also be trained with problem-solving skills, communication skills as well as critical and analytical thinking skills. Therefore, cooperative or collaborative group work is seen as an effective method of learning to produce students with the skills above. However, setting students in groups and asking them to work together will not guarantee to produce knowledgeable and skillful students. Nevertheless, I wanted the groups to function well and benefit all its members. So, I monitored the groups closely and advised them often to be disciplined and focused in their discussion, and not to get side-tracked; and to be committed to the success of self and group members. They were to inform me when there were signs that the members lacked discipline, cooperation or commitment. I gathered my students at an evening class (June 2013) and emphasized the five elements of cooperative learning according to Johnson, Johnson, & Smith (1991).There are five essential elements for collaborative learning to work effectively. These are:

a) Positive interdependence: Each member is responsible for maximizing other members' learning. The success of learning is dependent on the effort of every member of the group.
b) 'Promotive' interaction: Occurs as individuals help each other learn, challenge each other, and strive together to accomplish the group's goal. The interactions carried out by the group are meant to promote academic performance of every member.
c) Individual accountability: The performance of each member is taken individually and the result will be shared with other group members. Each member is assessed through individual test or weekly group presentation.
d) Interpersonal and small-group skills: Students have the opportunity to know other group members, to support and accept each other, to communicate accurately and resolve different opinions in a positive manner.
e) Group processing: Reflecting on the efforts that each member has contributed by checking group progress. This aims to improve the effectiveness of a collaborative group work. I encourage my students to do this reflecting regularly; and at times, I participate in this activity.

Brief Review

Most of the studies on CL have been done at primary and secondary school levels. There is some empirical evidence on its effectiveness at university level (Gokhale, 1995). The proponents of Cooperative learning, Johnson, Johnson and Stanne (2000) have compiled a meta-analysis of 164 studies that produced 194 independent effect sizes representing academic achievement. Eight CL methods were investigated, and all had significant positive impact on achievement. However, the method 'Learning Together' (LT) promoted the greatest effect. I will use this method in my research.

Vygotsky (1978) had already stated that students are capable of performing at a much higher intellectual level when they work together in collaborative/cooperative situations than when they are required to work individually. The diverse backgrounds, diverse existing knowledge and experiences of the members in a group are the resources to which the group has access. This contributes positively to the learning process. CL allows its members to apply, synthesize and evaluate their knowledge beyond mere knowing and remembering. All these are not available to the individualistic learner.

According to Bruner (1985), CL methods improve problem solving strategies because the students in the group will come up with different interpretations of the given situation. When confronted with these differences that must be resolved, the thinking processes that are used, the group resources and peer support enable each member to internalize the external knowledge and the critical thinking skills; these are then used for the learner's intellectual functioning, increasing intellectual capacity. Through promotive interaction, new knowledge is constructed upon the learner's existing and increasing body of knowledge.

Besides academic gains, CL also gives students opportunities to develop values that they would need in their future professions. The American Association for the Advancement of Science (1989) had stated the need for students to learn to cooperate while at school and college to inculcate skills and values that they will need as scientists of the future who need to collaborate together for the advancement of knowledge. "*The collaborative nature of scientific and technological work should be strongly reinforced by frequent group activity in the classroom. Scientist and engineers work mostly in groups and less often isolated investigators. Similarly, students should gain experiences in sharing responsibility for learning with each other. In the process of coming to understandings, students in a group must frequently inform each other about procedures and meanings, argue over findings and assess how the task is progressing*." This Association went on to compare CL with individualistic learning; by stating that within the*"context of team responsibility, feedback and communication become more realistic and of a character very different from the usual individualistic textbook-homework-recitation approach"* (American Association for the Advancement of Science, 1989: p. 202).

In 1990, the National Research Council (USA) identified problems with US secondary biology education; and in 2003, it had stated its dissatisfaction with undergraduate biology education, where students usually resort to memorizing. In each instance, it urged teachers to use active learning approaches that involved students in the learning process; to focus on problem solving so that learning is more meaningful and long-lasting (Michael, 2006). Active learning includes cooperative learning.

Gokhale (1995) found that CL did not significantly affect test scores when the subject matter was 'drill and practice' items about series and parallel direct current circuits ($t = 1.73$, $p = .09$). Analysis of covariance produced an F-value that was not statistically significant ($F=1.91$, $p>0.05$). However for 'critical thinking' items, a t-test showed that students performed better when they studied collaboratively ($t = 3.53$, $p=0.001$). Analysis of covariance yielded an F-value that was statistically significant ($F=3.96$, $p<0.001$). The results of the study were in line with Vygotsky (1978) and Bruner (1985). Students did perform at higher intellectual levels and improved at problem solving strategies, when they worked cooperatively than when they worked individually or competitively.

Rosini (1997) had found that there was no significant difference in Home Economics students' achievement and retention whether CL or individual learning was employed. Concerning achievement, the adjusted mean score for the cooperative learning group ($n = 90$) was 19.61, while the adjusted mean score for the non-cooperative/ competitive learning group ($n = 104$) was 19.52. Concerning students' retention, the adjusted mean score for the cooperative learning group was 18.49, and the adjusted mean score for the non-cooperative/ competitive learning group was 18.41. Similarly the mean attitude score for students using cooperative learning was 81.45 ($SD = 15.96$) while the mean attitude score for students using non-cooperative learning was 77.00 ($SD = 15.21$). Using a t-test, she showed that there was

also no significant difference in student attitudes toward the teaching methods t(164) = 1.84, p = .07). The researcher concluded that the study showed that CL was at least as effective as competitive learning, besides yielding added benefits of preparing students that are able to work with others and have gained inter-personal skills.

Other Malaysian researchers/educators have shown that the teaching of science via CL is very practical. Nor Azizah (1996) stated that science students are already used to working in groups in laboratories, sharing resources and dividing their labour in Practical classes. Traditionally designed lab tables in schools/colleges allow four to six students to sit comfortably; these group sizes are within the recommended ranges recommended by proponents of cooperative learning (Johnson *et al*., 1991). This collaboration does not have to be practiced during Practical sessions only, but also used in discussions of theoretical science concepts.

Cooperative learning will provide opportunities to enable students to inculcate moral values. Certainly our students need to be responsible, cooperative, and tolerant; they can learn these values when they work together at their practical, even when cleaning up after an experiment. It is necessary to note that our Malaysian science curriculum places importance upon the development of noble values besides acquisition of knowledge, skills and developing critical thinking strategies among our students (Ministry of Education, Malaysia, 2002).

Siti Rahayah (1998) also proposed that teachers of science should practice CL to enhance scientific skills and to improve achievement; in line with the aspirations of our science syllabus. More recently in 2007, Effandi Zakaria and Zanaton Iksan discussed CL as an alternative to teacher-centered methods in Science and Mathematics education practiced in most Malaysian schools. They highlighted a need for reform in our teaching, based on results of Malaysian (Form 2) students in comparison to students from 44 participating countries. In Science, our students ranked at the 20th position (of 44), while the top three positions went to students of Singapore, Chinese Taipei and the Korean Republic. This shows a great need for our science teachers to practice more effective students centered teaching methods; and the researchers recommended cooperative learning.

Research Focus

My issue of focus is to facilitate cooperative learning among my Biology students. Their diverse background and abilities will be pooled to the advantage of the group and its individual members.

Besides being concerned to help my students improve in their academic performance, I also hoped that by structuring cooperation among the students, they will be trained to serve the nation as scientists in the future, who are able to practice moral values such as cooperation, responsibility and tolerance. I am aware that there are few quantitative studies in CL carried out in matriculation colleges in Malaysia. This study will serve to fill in the gap of knowledge concerning CL in Matriculation Biology in Malaysia. It will examine the effectiveness of cooperative learning in the teaching of 'Expression of Biological Information'. The method 'Learning Together' is used in this study. The implementation of CL requires students to talk and listen to one another. Through such interactions and working relationships, communication skills, soft skills or social skill are developed to enable students to fulfill future roles as collaborative scientists, as described by the American Association for the Advancement of Science (1989).

Objectives

The objective of this study is to facilitate CL, and to determine if there is significant difference in students' achievement in Matriculation Biology on the topic 'Expression of Biological Information', when CL is employed as compared with individualistic learning approach.

Methodology

I had two classes of 32 students each. The marks of an earlier quiz (Quiz 1) showed that the 2 groups (experimental and control) did not show a significant difference. The group means (and SD) were 12.81(SD=2.02) and 13.56(SD=1.92). Using SPSS, Independent Samples t-test showed the slight difference in achievement was not significant t(62) =-1.522, p=.133. Both the control and experimental groups received the same input at their lectures. They have three lectures in a week. When the students come to tutorial class, they have received some input on the topic. Students are supposed to have tried their tutorial questions prior to attending the class. There are ten objective questions, three structured questions and two essay questions, followed by several past year questions (structured and essay). All the questions had parts that are more challenging, requiring beyond mere knowledge and understanding.

My students work on the question that I have assigned to them on a large piece of brown paper, in groups of four. They take turns to teach by presenting their answers while other groups of students are accountable to pay attention. This presentation gives me an opportunity to assess each student's understanding, detect misconceptions, as well as to assess how well they are working together. It is very informative to watch and listen to students as they work together. Educators and psychologists have discovered that having students who are given the opportunity to teach new concepts to others will enhance their own understanding and recall (Cherry, 2010). After each presentation of about five to ten minutes, I would do a brief summary.

The topic "Expression of Biological Information" was the sixth topic to be taught in that semester. It was a difficult topic because it involved new concepts. Students would have much to learn, understand and remember. Before answering the tutorial questions, the class agreed to divide the content roughly equally into four parts. Each member of a group was assigned to prepare and deliver a discrete part (a piece of jigsaw) to the whole class. The first member (A) prepared/organized information on DNA and genetic information, including the Watson and Crick model; Griffith's experiment and experiment of Avery *et al.* to show DNA as carrier of genetic information and Beadle and Tatum's experiments and hypothesis. The second member (B) prepared/organized information on DNA replication including three models of replication: dispersive, conservative and semi-conservative.

The third member (C) prepared information on protein synthesis including transcription, translation and the genetic code. The fourth member (D) organized information on the structure and mechanism of the *Lac*Operon and its set of related genes in the bacteria *Escherichia coli.*

All the students similarly labeled worked on their topic together, before going back to their own groups to teach their members who had each a specialized task. This 'jigsaw' seemed to

work quite well for the students to grasp the knowledge for the chapter 'Expression of Biological Information'.

Students in the control group/class work individually at the questions. They are also required to present their answers individually to the class. This presentation also gives me an opportunity to assess each student's understanding, detect and correct misconceptions. But students in the control group did not have group support or a common pool of talent. The instrument (question paper) used in the study was developed by a team of lecturers of the Biology Unit of Selangor Matriculation College. Students were required to answer both questions: a structured question and an essay question. The questions on 'Expression of Biological Information' included DNA transcription, events that occur in protein synthesis, differences in structure of tRNA and mRNA, prediction of base sequences on DNA or mRNA and amino acid sequences of a polypeptide, Griffith's experiment, Avery's experiment and the *Lac* Operon. The quiz consisted of questions requiring recall (40%), understanding (40%) and application (20%).

Results and Discussion

The total marks for each quiz was 20. The results were analyzed using SPSS. Quiz 1 showed that the two groups were not significantly different before CL was carried out. Quiz 3 tested students' knowledge on "Expression of Biological Information".

Table 1
Results of t-Test

Marks of Quiz 1	Learning method	N	Mean	SD	t	p (2-tailed)
Experimental	Cooperative	32	12.81	2.02	-1.522	0.133
Control	Individualistic	32	13.56	1.92		
Marks of Quiz 3	**Learning method**	**N**	**Mean**	**SD**	**t**	**p (2-tailed)**
Experimental	Cooperative	32	14.25	3.23	7.629	.0005
Control	Individualistic	32	9.19	1.91		

The study shows that students who worked cooperatively had benefited from peer support. When CL was structured, the mean for the experimental group was 14.25 (SD=3.23), while the mean for the control was 9.19 (SD=1.91). Using SPSS, Independent Samples t-test showed that this difference was significant t(62) =7.629, p=.0005 as shown in Table 1. The student proved worked cooperatively had been more able to internalize external knowledge and critical thinking skills and these things have become their tools for intellectual functioning. They had been confronted with different approaches and interpretations of a problem, and had to learn to resolve these differences.

When I discussed with my students, at our 'group processing' sessions, when we reflected together about the progress of the group and the participation of each member, they responded that each member of a group had contributed significantly. Even the slow learners

had contributed; precisely by their needing more attention and extra explanations. The students providing explanations had consolidated their understandings. Every student had had practice at evaluating and synthesizing different views in attempting to judge what is the best method to deal with their problem (Bruner, 1985; Gokhale, 1995; Johnson *et al*., 1991; Vygotsky, 1978).

However, I was still quite puzzled. A year earlier, I had carried out CL on the 2012 batch of students. The value of t-statistic was lower, $t(62) = 3.52$, $p = .005$. Although lower, it was very close to the value obtained by Gokhale (1995). When I questioned why CL seemed to work better with them; I found that this 2013 batch of students had even gone further to collaborate on writing a 'bio-song' (musical mnemonics) for *Lac* Operon reactions. They had behaved more creatively than my previous batch of students; they had imitated their teacher (Yeoh, 2012, 2013a, 2013b, 2013c). This had facilitated their recall during Quiz 3. When I asked if they had faced any other problems, they responded that at some of their discussions, their concentration was not always at the maximum level. Nevertheless, their commitment, cooperation and creativity were beyond reproach.

Conclusion and Recommendations

From this study, CL was effective to improve student performance in Biology significantly. CL was effective to stimulate the development of higher order thinking or critical thinking through its very nature of discussing as a group that is enriched by the abilities, talents and experiences contributed by each member. Ideas are voiced out, clarified, defended, and evaluated objectively. The teacher is a facilitator to develop, encourage and enhance the student's desire to learn.The results of this study also show that the concern expressed by Malaysian educators (Effandi Zakaria & Zanaton Iksan, 2007; Nor Azizah, 1996; Siti Rahayah, 1998) who have recommended that CL should be used in schools, rather than a teacher-centred approach, is justified.

Besides its effectiveness at improving academic achievement as shown in this study as well as in several previous studies reviewed, CL has provided real life and real work situations where it is definitely a requirement to work with others. Students learn that by working for the team, they benefit themselves, even when it is necessary that some members need to do more; because it is not always possible to share the work equally. Students learn to give and to serve. They acquire interpersonal skills. While working closely, their strengths and weaknesses are in the open. They learn to accept the weaknesses of others and to appreciate the good points in others. They have gone beyond mere tolerance; they have learnt to accept others. All these are essential in our multi-ethnic society. All in all, they have developed their overall character.

On reflection, it is very feasible that all the ten chapters of Matriculation Biology of the first semester be approached using CL and I intend to use this approach with the next cohort. This study has shown that 'Jigsaw' was effective for students to gain exposure and familiarity with one of the most difficult chapters, 'Expression of biological information'. In conclusion, I recommend that more CL research should be carried out on science education in Malaysian schools and colleges. Furthermore, CL should be practiced for both Practical/laboratory and non-laboratory or tutorial science classes. Our educators should then act upon research findings rather than by force of habit or inclinations.

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