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網路合作設計應用於自然與生活科技領域之整合型研究：

環境、學習、評估、與應用

總計畫(3/3)

中文摘要

合作學習一直被認為是重要且有效的教學策略，許多關於如何促進良好合作學習的研究不斷地深入探討著，例如：任務型態、組隊模式、互動歷程...等。近年來，許多教育研究者發現自我效能與思考風格等心理變項與學習成效有高度相關，適當地以此類心理變項為依據來組合學生，將可促進良好合作的產生。然而老師在課堂上進行合作學習時，可能沒有多餘的時間和精力可以精巧地設計出如此複雜的分組方法。一來是因為心理變項可能含有多個維度，同時考量多變項其計算複雜度對老師而言太高了；二是因為心理變項多為連續數值型態，若老師單純的切割為高、中、低，可能泯滅了被編到同類族群內的學生其原本差異性，但若是直接考量連續數值，其複雜度更高。因此，本研究發展一個可以同時考慮多變數且變數可為連續數值的電腦化分組方法，使得所有學生都能被有效分組，且整個班級的效能仍能維持住一定水準。這個分組方法在群組人力規劃和配置上將可兼顧平衡與效能兩方面的考慮，不會為了組成精英小組，而產生更多不良的組隊。經過教學實驗證實，採用電腦化分組方法的實驗組在成績上明顯高過隨機分組的對照組，且實驗組的成績較為集中。

關鍵字：合作學習、電腦支援合作學習、小組學習、組隊方法、思考風格、大學生

Abstract: Cooperative learning has been adopted widely but not such deeply as the research, because grouping is difficult. The problems and difficulty arose from multiple features and continuous data type. To solve the former problem, teacher often choose the most striking one to identify students. This would ignore the effect of the other features then cause the experiment invalid. To solve the latter problem, teacher may category continuous feature into categorical feature. This would lead to ignore the difference within the same category. In this paper, we proposed a novel grouping system called DIANA to solve these problems. It balanced the performance between individual and individuals and formed heterogeneous groups between which all groups are similar. We investigated the effectiveness of our system via experiment. The results showed that the achievements of the groups formed by DIANA are better and more centralized than random groups.

Keywords: Cooperative learning, small group learning, computer assisted grouping system, group composition, grouping techniques, thinking styles, university students.

Introduction

Cooperative learning has long been recognized as an important and effective teaching method (Cohen, 1994a; Johnson & Johnson, 1989; Sharan, 1999; Slavin, 1995). Research results showed that cooperative learning benefits students in cognitive perspective (such as gaining higher achievement), affect perspective (such as positive motivation), and behavior perspective (such as social skills). During past three decades, many studies have suggested different formats of cooperative learning. Therefore, teachers who favor students to learn through cooperation have choices over various team processes (Dembo, 1994). Researchers (Abrami, Chambers, Poulsen, De Simone, d' Apollonia, S., & Howden, 1995; Cohen, 1994b; Johnson & Johnson, 1994; Kagan, 1994; Sharan & Sharan, 1992; Slavin, 1995) also suggest that several factors influence the effectiveness of cooperative learning. For example, group interdependence, group development, task demands, resource and process during cooperation, and interracial and interethnic relations. The relations among these factors were also searched. In general, previous studies have formed a solid bank of evidences to guide teachers' implementation.

However, teachers often found management of cooperative learning quite difficult. Many teachers realized that students lack of social skills to work with peers (Johnson & Johnson, 1991). Some faced the problems of social loafing (Steiner, 1972) and others admitted time consuming problem (Fox & Lorge, 1962). However simply putting students to work together may not promise quality cooperative learning. From the review of Cohen (1994b) and process loss perspective of Steiner (1972), teacher should pay particular attention to design an adequate

cooperative task. From the review of Johnson and Johnson (1990) and Slavin (1995), positive interdependence among group members, members' meaningful interaction, individual accountability for learning, training for collaborative skills, and group rewards are essential.

However, one of the major problems occurs in the very beginning of group process: teachers do not know how to form groups that leads to a successful teamwork. Unfortunately, few studies provide little evidences about various effects of grouping methods. Therefore, most teachers allow students to form groups by themselves, by random assignment, or according to seat arrangement.

Teachers have to know what kind of group is of more value. From limited evidences, many researchers suggest to form heterogeneous group (Dembo, 1994). Others suggest that ability-heterogeneous group is suitable for enhancing achievement and ability-homogeneous group for keeping learning interest (Lou et al., 1996). Besides knowing the type of groups, teachers also need to know to what student characteristics (ability? gender? race? or social skill?) should they pay more attention in the selection of group members.

More and more researchers found that some psychological features (e.g., self efficacy, Bandura, 1997 or learning styles, Sternberg, 1998) have strong effects on the outcomes of cooperative learning but are relatively embedded, not easy to be observed by teachers. Contrastively, many demographic variables (e.g., gender or race) are relatively easier to be detected by teachers and so ready to serve as a base of grouping (Cohen, 1997; Cordero, Di Tomaso, & Farris, 1996; Savicki, Kelley, & Lingenfelter, 1996). In taking psychological variables into account in grouping, the continuous nature of data also causes troubles. For example, it's easy for teacher to group students based on a single, demographic factor, say, gender because it is categorical in nature. While it is very hard to assign students by their self efficacy scores, say, ranging from 15 to 55. Surely, teachers can classify continuous data into categorical data but this process is time consuming, ignores diversity of students, and loses valuable information obtained from psychological measurements. In the case when more than one psychological features are considered together in grouping, teachers face a problem with no easy solution.

Considering educational equity, we strongly suggest that every student should benefit from cooperative learning. To achieve this goal, we recommend seeking a strategy to accommodate every student in an adequate group for a successful start of cooperative learning. Therefore, we oppose to the strategy that merely group the best students together and ignore other weaker ones. In this paper, we hope to find out some workable ways in

grouping cooperative teams that consider all students at the same time, no matter of high or low, clear or vague degrees in targeted psychological variables. In addition, we consider grouping adequacy in both individual level and whole class level so that an allocation of a student to a suitable group does not increase debts of other groups.

In conclusion, grouping is a fundamental stage of cooperative learning while two problems needed to be solved. First of all, multiple psychological variables, instead of one single demographic variable, are measured and served as grouping factors. Keep in mind that these variables are continuous data and strongly related to learning performances. Second, the goal of our grouping strategy is to assign students to the most suitable group so that all groups have similar capacities to achieve high. This paper proposes a novel computer-assisted grouping system that can solve these two problems. Thus to help teacher assigning students to suitable groups when he/she adopt psychological variables as grouping factors as well as to help researchers to find optimal combination in a pool of students for cooperative learning.

Literature Review

The educational study on grouping

Abrami et al. (1995) listed some of the critical decisions about grouping students before teachers structure cooperative learning activities. A teacher should consider: 1) The size of the groups. 2) The duration students should stay together. 3) What characteristics of the students to be considered. 4) How to compose and organize the groups. 5) How to assign students to the groups. These decisions could be made according to the age and interpersonal skills of students, the goals of instruction, the properties of activity, the trust-climate of the class, and the belief of the teacher.

Most of time teachers use three methods to organize students into groups.

1. Students choose their own groups.

Students often choose their teammates on account of friendship and interest about the learning topics. When students become more mature, they are more likely to choose appropriate teammates. However, shy or less sociable students are easily be left out. Friendship groups are very likely leading to homogeneous group, no matter considered in terms of ability, race, or gender. It facilitated cooperation as a result of harmonious communication. Interest groups may form groups of difference size. If groups varied in size many crisis may occur. For example, students in a large group may not interact efficiently and those in a small group cannot take the advantage of sharing multiple perspectives.

2. *Teachers group randomly or casually.*

One of the most simple and frequent used grouping method is to form proximity groups that member works with his/her neighbors. In forming proximity groups, it takes time to decide who is going to be in which group. Teachers often assign students to groups in a random or any spontaneous way. Using this method, no one will be rejected or left out and it spends less time to structure group. However, spontaneous groups are not suitable for complex tasks, because some groups may compose of low-ability students.

3. *Teachers group students according to students' characteristics.*

Considering students' characteristics, teachers may group students in two alternative ways, to form heterogeneous group or homogeneous group. Heterogeneous group provide an ample chance for students to learning how to work effectively with different people. Many studies (Cohen, 1994b; Johnson & Johnson, 1994) have showed that heterogeneous grouping enable students to achieve better in academic knowledge and social skills. But the range of member difference within group should not be too extreme to prevent the impairment of possible cooperation (Webb, 1989).

On the other hand, homogeneous groups were sometimes organized to have smooth communication. A comparison between heterogeneous-ability group and homogeneous-ability group is illustrated in Tab. 1. Tab. 2 lists characteristics that are often used when construct heterogeneous group and homogeneous group.

In general, more researchers use heterogeneous groups while adopting cooperative learning. Heterogeneous composing would bring positive interdependence and then encourage the process of cooperation. Hence, in this study our grouping goal is to achieve suitable heterogeneity.

	Advantage	Disadvantage
Heterogeneous-ability group	This arrangement benefits high-ability students as well as low-ability students learning.	High-ability students may complain of taking much time to teach others, and low-ability students may feel singled out for needing special attention.
Homogeneous-ability group	Judicious use of homogeneous groups can encourage high ability students to work to their potential.	The polarization of whole classroom may occur.

Table 1: The advantages and disadvantages of heterogeneous-ability group and

homogeneous-ability group.

Heterogeneous group	gender, race, ethnicity, language, status, learning style, thinking style, and personality traits.
Homogeneous group	living location and first language other than English.

Table 2: The characteristics are often used when constructing heterogeneous group and homogeneous group.

The computational study on grouping

Perceiving the importance of grouping, our research team has contributed many efforts to design computer-assisted grouping systems (Cheng, 2000; Wang, 2002; Lin, 2003). For the field of computer science, grouping students (or recommend students to form groups) is a question of mathematical combination. It is different from general clustering, grouping for cooperative learning has several requirements. First, teachers often ask to form groups with equal size. Second, all participants should be taken care of and assigned to the most suitable group.

The first computer-assisted group system proposed by one of our researchers, Cheng, (2000) allowed teachers to use multiple psychological variables (in her study, five thinking styles, Sternberg, 1994) in assigning students and worked out the approximate solutions via grouping algorithm. In her algorithm, each student is treated as a spot in a space defined by psychological factors and the spot can be denoted as a vector of several numbers measured by the thinking style scales. The differences between students are conceived as Euclidian distance in this given space. Any pair of three students may form a triangle shape in the space and may be considered as a group.

In her study, the goal is to search heterogeneous grouping. Hence, the first step is to construct distance matrix of all possible pairs, then the pairs with the largest distance are aggregated, and go on until there are three spots aggregated each other, a group produced. Repeat aggregating all other possible triads until no more triad can be found. The computing complexity of this aggregation algorithm based on computing distance is heavy. In fact, such solution is not suit for the exhaustive algorithm. Some researchers have adopted greedy algorithm to skip over local optimal, such as hill climbing.

The previous grouping algorithm based on computing distance intuitively seems reasonable, but it may end up drive away from the original goal – forming heterogeneous groups. Groups recommended by this algorithm became more and more non-heterogeneous. For example, if six students are in a class where teacher hopes to group them for two teams according to two learning characteristics. This problem is illustrated in a geometric space, as shown in three sequences of fig. 1. Each student can be viewed as a spot in the two dimensional psychological space in sequence 1. The most heterogeneous group is composed by A, B and C shown in sequence 2. If A, B and C is grouped as team 1, D, E and F are remained inevitably to form team 2. Hereby, team 2 of D, E and F is not heterogeneous enough. While, the allocation of C into team 1 seems going to an extreme that the diversity of team 1 increases the cost of team 2 and thus jeopardize the original grouping goal. Therefore, this outcome contradicts the original goal of heterogeneous grouping in the whole class level. The optimal grouping recommended is to aggregate (A, B, E) and (C, D, F) and shown in sequence 3, because members are various within groups and an allocation of a student to a suitable group does not increase debts of other groups.

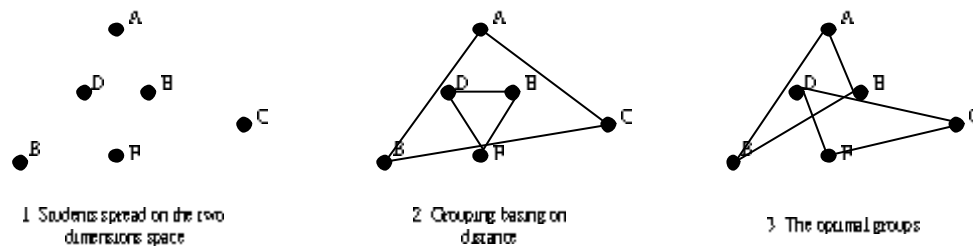


Figure 1 : An example of the grouping algorithm based on distance

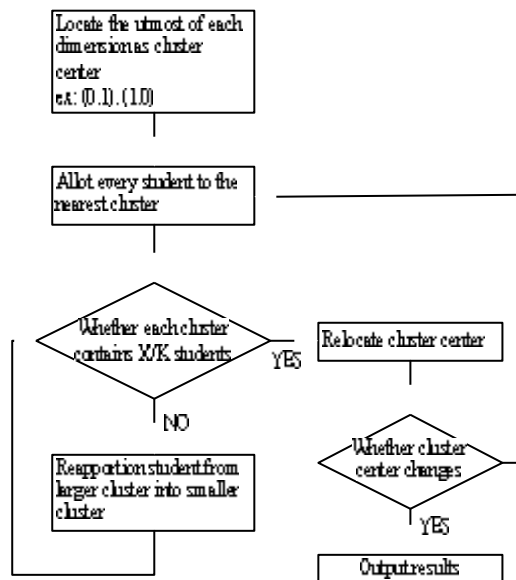
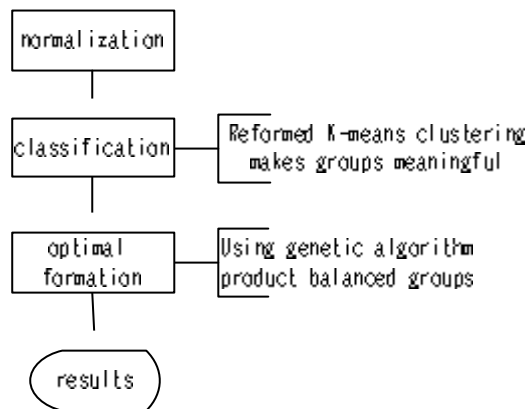
The purpose of the grouping method based on distance is to find dyads of largest distance. To reach this goal best team-compositions are produced, but very unfortunately some worse teams also exist. Webb (1989) suggests that extremely varied teams do not work as well as somewhat varied teams.

In addition, if we consider heterogeneous teams are valuable in terms of learning theory, then the recommendation of forming teams with small distance opposes educational equity. The grouping method using greedy algorithm may end up with such troublesome solution because it considers individual benefit but not benefit of all individuals as a whole. Therefore, we propose a novel computer-assisted grouping system in the following section.

Methodology

Construct a novel computer-assisted grouping system

In this section, we propose a grouping system, DIANA (Different Inner groups And Non-different Among groups). Teacher can input students' characteristics measured by psychological questionnaires that are multiple, continuous in nature. Teachers can determine the size of the group depends on the purpose of his/her instructional objects. System then performs computation and recommends heterogeneous group compositions without imitations discussed in the previous section. The purpose of this system is to allocate students to the most suitable group in both levels of individual and whole class.



to the range between 0 and 1. Thereby, each factor is of equal weight.

The goal of grouping is to organize balanced groups. That means we select group members to keep a certain degree of diversity within group and then to maintain a certain degree of balance between groups. Thus we equally emphasize individual preference and global preference. Moreover, we recommend meaningful groups, that is, we need to know with what characteristics group-members work well rather than just assign those of large difference into a team. Hence, after normalization, students are classified to various clusters in the second stage of classification. In the classification, teachers can consider more than one learning characteristics at the same time and treat them of equal importance.

The technique of classification we adopt is a refined K-means clustering method and the flow chart is shown in fig. 3. The steps of refined K-means clustering are listed in the following:

1. Locate cluster center.
2. Allot every student to the nearest cluster.
3. Reapportion student for equal amount of groups.
4. Relocate cluster center, if cluster center changes, go to step 2.

In order to form balanced groups, we need distinct types – each of the same size - of students. Besides, we set the initial cluster center at the utmost of each dimension in order to produce the greatest distinct types. This method is easy to compute and must converge. K-means needs to decide the exact number of cluster in the beginning of computation that is always a very difficult decision when everything is uncertain. Fortunately, our method forsakes teacher from doing this awkward decision, because the number of clusters is the number of members within a group.

After ascertaining students' cluster identity, this system begins to form groups in the third stage, optimal formation. One student is selected from each cluster and then grouped. In order to get optimal solution, we adopted genetic algorithm to evolve the approximate solution. The design of genetic algorithm is listed in the following:

1. One chromosome represents one group, so the length of chromosome equals the number of group members. The population contains chromosomes with the number equals to the number of whole classroom. For example, if there are ninety-nine students in a class and we hope to form three-person (triad) group. That is, the population contains thirty-three chromosomes with length of three.

2. As mentioned in section two, pair difference defined by distance may cause problem, we then innovatively define pair difference by “shape”. First, we seek out a targeted shape composed by the final cluster centers generated from stage 2. Next, we compute variations of each shape obtained by each chromosome and target shape. Finally, the fitness of each chromosome is determined by the inverse of the absolute value of the variation.
3. Randomly choose two chromosomes and check whether the fitness becomes better after crossover. If later value is greater then easier, then crossover. Otherwise, keep original.
4. Set mutation rate as 0.001. So that, sometimes although they will not become better, we allow they to crossover.
5. Above mentioned steps present a generation of GA.

Although this algorithm seems like hill-climbing, it will not fall into local optimal. In the point of global, distanced method is part of greedy algorithm, which forms the most heterogeneous group as it find, but then it may destroy the global performance. On the other hand, although shaped method is possible not to find the most heterogeneous group, it can make all groups have certain heterogeneity and extreme homogeneous between each other. That is grouping of balanced groups, which are different within group and similar with groups.

Experiment

The goal of the experiment is to compare the cooperative learning effects of groups recommended by the DIANA grouping method and groups formed randomly. Subjects are 72 computer science freshmen enrolled in a beginning level class of computer science at a technology university in northern Taiwan. Because it was their first semester of university learning, students were not familiar with each other.

Three students were grouped as a team. Forty-two students were recommended by our grouping strategy to form 14 teams, while other 30 students were randomly grouped into 10 teams. Each team was asked to work together for a cooperative design project during a 4-week period.

All students underwent the same experiment process and group task. The group work is to design the topological network for the offices in the enterprise. Finally, each group presented the power point file of the proposal.

Thinking styles as grouping factor

We regarded thinking style is an important learning factor that may influence the process and outcome of cooperative learning. Thinking style is proposed by Sternberg (1998) to describe personal habits and attitudes of utilizing one's own thinking. It is not talent or ability per se but personal preferences of the directions to bring out intelligence. Sternberg uses an analogy of mental government to indicate how we manage our various cognitive capacities and how people conduct their mental government in different manners.

People show different thinking styles and Sternberg (1998) suggests 13 styles. For example, legislative thinking style people like to think innovative ideas and do things according to their own rules so they tend to neglect pre-structuralized rules in doing works. Executive thinking style people tend to follow prescribed rules in performing their works and they like ideas that can be fully understand. Judicial people do not pay much attention to follow rules or not; instead they like to judge and compare various ideas, even rules. Legislative, executive, and judicial thinking styles are three examples of various functions of mental government. For a detail description of all 13 thinking styles belonging to 5 dimensions, please see the book of Sternberg (1998).

Sternberg (1998) indicated if one's thinking style matches the environmental conditions one would perform well. Whereas, he/she may not learn well, if his/her thinking style is not incompatible with the environment requirements. Sternberg (1996) also suggests teachers to compose cooperative teams according to students' various thinking styles, specifically to invite three members of the above three thinking styles to complement each other in carrying out a task. He proposes that groups composed of people with different thinking styles would perform better.

Therefore, in this study, we adopted legislative, executive, and judicial styles as three grouping factors. Any one of us encompasses legislative, executive, and judicial styles simultaneously but show these styles in strong or weak degrees. If we categorized students by their most striking style, we ignored the effects of the other two thinking styles. This is not what we expect to do. In this study, all students were asked to fill in Thinking Style Inventory-Taiwan version (TSIT, Lin & Chao, 1999) in the pretest. Each thinking style is measured by 8 items of 5-point

scale so data of thinking styles are continuous. Hence, the DIANA grouping system is good at dealing with this problem where grouping factors are multiple and data is continuous in nature.

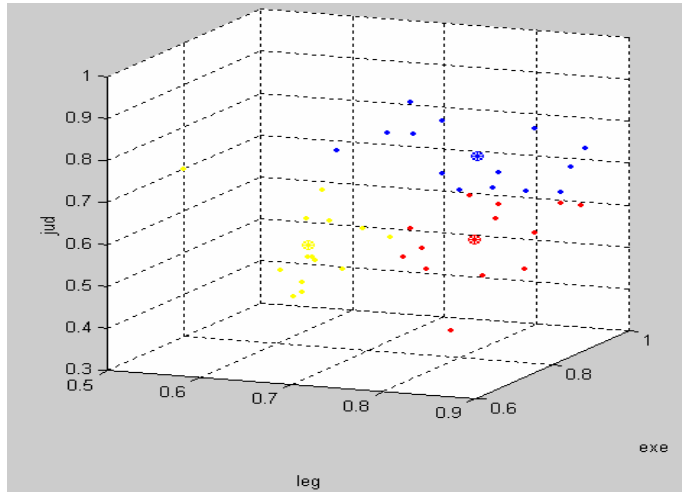
The distribution of sample and the result of classification

The right part of table 3 showed the means and SD of all students' thinking styles before normalization stage. From the left of Table 3 we observe that in this experimental sample executive style and judicial style had significant correlation. This testified again that all features should be considered at the same time. If researcher adopted the most striking style to identify the student, he would not ascertain whether executive style or judicial style bring the final results. Then Figure 4 showed the result of the classification stage, the second stage of our grouping system. It classed the students into three, which center respectively are (0.82, 0.79, 0.59), (0.79, 0.87, 0.75), and (0.66, 0.74, 0.57). Observing Figure 4, we can know that class 1 represented high legislative class, class 2 represented high executive and high judicial class, and class 3 represented all law class. These three classes are mutual and answer to our expectations.

	Mean	SD		Exe	Leg	Jud
Exe	31.9286	3.4244	Exe Pearson Sig.	1.000 .		
Leg	30.3333	3.7264	Leg Pearson Sig.	.247 .115	1.000 .	
Jud	25.3333	4.5568	Jud Pearson Sig.	.408** .007	.200 .204	1.000 .

** . p < .01

Table 3: The description of experimental sample and correlation between them



Red: Cluster 1
 Blue: Cluster 2
 Yellow: Cluster 3
 Center of Cluster 1: (0.82, 0.79, 0.59)
 Center of Cluster 2: (0.79, 0.87, 0.75)
 Center of Cluster 3: (0.66, 0.74, 0.57)

Figure 4: The result of the classification stage

Assessment

Due to the elasticity of the designing work, we did not only assess the accuracy of the request (AR) but also the accuracy of the completion (AC). And the final score is composed by these two, formula below.

$$AR = \frac{\text{the accuracy of final product}}{\text{the request of teacher}} \quad AC = \frac{\text{the accuracy of final product}}{\text{the completion of final product}}$$

$$Score = \frac{2 \times AR \times AC}{AR + AC} \quad (\text{The 2 on the numerator is used to magnify the difference})$$

Data analysis

In order to show the difference between random group and out engineered group, we use T-test to evaluate. Because the controlling groups are only ten, we raised the significant level to 0.1. Table 4 shows the experimental groups significantly outperformed the controlling groups in the evaluation criteria, AR and score. On the other hand, from Table 4 we observe that the standard deviations of the AR, AC and score of experimental groups are all smaller than them of controlling groups. We use the statistic method, F tests, to evaluate the significant of the difference. Table 5 shows all evaluation criteria are more centralized.

In conclusion, integrate the above-mentioned evidences, and then we can know that the performance of experimental groups is better and centralized than the controlling groups. This implied that our grouping method is effective and better than random grouping.

No.	of	Mean	SD	T-value
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	groups			(significant)	
AR	Controlling groups	10	.4840	.2748	-1.691
	Experimental groups	12	.6413	.1548	(.106*)
AC	Controlling groups	10	.8242	.1908	-.540
	Experimental groups	12	.8577	.0942	(.595)
Score	Controlling groups	10	.5759	.2641	-1.716
	Experimental groups	12	.7237	.1284	(.102*)

*. P < .10

Table 4: The criteria compared between experimental and controlling groups

	No. of groups	SD	F-value (significant <0.32 or >2.90)
AR	Controlling groups	10	.2748
	Experimental groups	12	.1548
AC	Controlling groups	10	.1908
	Experimental groups	12	.0942
Score	Controlling groups	10	.2641
	Experimental groups	12	.1284

Table 5: The F-tests of the standard deviations of controlling and experimental groups

Conclusion

Cooperative learning is effective and helpful. However, gathering some people to work together is not really called cooperation. An important feature of cooperative learning is that there are positive interdependent between group members. Structured group is one of the ways to achieve. Hence, cooperative group should be designed especially, and then students would receive effective learning.

Aimed at three problems those occurs when grouping, multiple features/characteristics, continuous type of variable, and the requisition of balancing individual performance and global performance, we proposed DIANA grouping method, a new computer-assisted grouping system based on shape. It is efficacious to group all students and achieve the most global

performance and helpful for teacher to proceed effective cooperative learning by adopting the findings of educational studies. Through this system, every student would be allocated at the best location and reap the benefit of cooperative learning.

In addition, we experimented and verified that the DIANA groups perform better than the random groups. The achievements of our balanced groups are also more centralized. This implies that DIANA grouping accomplished our desired purpose, different inner groups and similar among groups.

Reference

- Abrami, P. C., Chambers, B., Poulsen, C., De Simone, C., d' Apollonia, S., & Howden, J. (1995). *Classroom connections: Understanding and using cooperative learning*. Toronto: Harcourt Brace & Company.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W. H. Freeman and Company.
- Cohen, E. G. (1994a). Restructuring the classroom: Conditions for productive small group. *Review of Education Research*, 64(1), 1-35.
- Cohen, E. G. (1994b). *Designing groupwork* (2nd ed.). New York: Teachers College Press.
- Cohen, E. G., & Lotan, R. A. (Eds.) (1997). *Working for equity in heterogeneous classrooms: Sociological theory in practice*. New York: Teachers College Press.
- Cordero, R., DiTomaso, N., & Farris, G. F. (1996). Gender and race/ethnic composition of technical work group: relationship to creative productivity and morale. *Journal of Engineering and Technology Management*, 13, 205-221.
- Dembo, M. H. (1994). *Applying educational psychology* (pp. 172). NY: Longman.
- Fox, D. & Lorge, I. (1962). The relative quality of decisions written by individuals and by groups as the available time for problem solving is increased. *Journal of Social Psychology*, 57, 227-242.
- Johnson, D. W. & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Edina, MN: interaction Book Company.
- Johnson, D. W. & Johnson, R. T. (1994). *Learning together and alone: Cooperative, competitive, and individualistic learning*. Boston: Allyn and Bacon.
- Johnson, D. W. & Johnson, R. T. (1990). *Cooperation in the classroom*. Edina, MN: interaction Book Company.
- Kagan, S. (1994). *Cooperative learning* (10th ed.). San Juan Capistrano, CA: Kagan Cooperative Learning.
- Lin, S. S. J. & Chao, I.-C. (1999). *The Manual for use with Thinking Style Inventory-Taiwan version*. Unpublished manual.

- Lou, Y., Abrami, P. C., Spence, J. C., Poulsen, C., Chambers, B., & d'Apollonia, S. (1996). Within-class grouping: A meta-analysis. *Review of Educational Research*, 66(4), 423-458.
- Savicki, V., Kelley, M., & Lingenfelter, D. (1996). Gender and group composition in small task groups using computer-mediated communication. *Computers in Human Behavior*, 12(2), 209-224.
- Sharan, S. (1999). *Handbook of cooperative learning methods* (2nd ed.). Westport, CT: Praeger.
- Sharan, Y., & Sharan, S. (1992). *Expanding cooperative learning through group investigation*. New York: Teachers College Press.
- Slavin, R. E. (1995). *Cooperative Learning: Theory, research, and practice*. Boston: Allyn and Bacon.
- Steiner, I. D. (1972). *Group process and productivity*. New York: Academic Press.
- Sternberg, R. J. (1994). Thinking styles: Theory and assessment at the interface between intelligence and personality. In R. J. Sternberg & Ruzgis, P. (Eds.), *Personality and Intelligence* (pp.169-187). New York: Cambridge University Press.
- Sternberg, R. J. (1998). *Thinking styles*. NY: Cambridge University Press.
- Sternberg, R. J. & Louise, S. S. (1996). *Teaching for thinking*. Washington, DC :American Psychological Association.
- Webb, N. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research*, 13, 21-39.