Proceedings of the 1st WSEAS / IASME Int. Conf. on EDUCATIONAL TECHNOLOGIES, Tenerife, Canary Islands, Spain, December 16-18, 2005 (pp169-174)

A two phases grouping framework for achieving educational equality in heterogeneous group learning

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Abstract: - Many CSCL systems emphasize the use of technical tools to support effective/productive social interaction, social knowledge construction, and reflection. Rare CSCL mediating tools provide help in composing promising groups, even less offer recommendation algorithms in selecting team members from a large pool of students with various characteristics or learning capacities. In this paper, a computer supported grouping system named DIANA was proposed in accordance with educational scholars' principles: (a) composing heterogeneous groups by students' psychological features; (b) keeping equity among all students. To achieve the goals, the first phase of grouping framework, categorizing, was designed to find out the suitable diversity for whole class. The second phase, grouping, was designed to control the diversity of all groups and to make similar between groups. Thereby, every student can start cooperative learning equitably.

Key-Words: - Cooperative learning, small group learning, computer-supported cooperative learning, computer assisted grouping system, group composition

1 Introduction

Computer-supported cooperative learning (CSCL) is one of the promising innovations to improve teaching and learning with the help of modern information technology [1-3]. Many researchers have demonstrated the sophisticated use of different technical applications in facilitating cooperative learning through e-mail, electronic bulletin boards, conferencing systems, and specialized groupware [4]. In particular, they emphasized the use of technical tools to support effective/productive social interaction, social knowledge construction, and reflection.

However, experienced teachers know that simply putting students together to perform a group task does not ensure quality cooperative learning. In managing cooperative learning, teachers face a critical problem: who should work together with whom? Nonetheless, rare CSCL mediating tools provide help in composing promising groups, even less offer recommendation algorithms in selecting team members from a large pool of students with various characteristics or learning capacities. Therefore, CSCL has been widely used, but the management poses challenges for the majority of teachers.

Meanwhile, researchers found that some psychological features (e.g., self efficacy [5] or learning styles [6] have strong effects on the outcomes of cooperative learning. Therefore in composing small group, it is reasonable to consider students' psychological features that are highly relevant to learning outcomes. For example, Sternberg suggests teachers take thinking styles (TSs) into account to promote effective cooperative learning for individuals with different thinking preferences. In this study we use TSs as an exemplar to represent all possible psychological aspects of learners. Heterogeneity is a better composing goal than homogeneity because it promotes diversity of student characteristics and equips a group for the possibility to achieve multiple learning purposes [7].

This paper describes a computer-supported grouping system named DIANA using genetic algorithms to help and guide teachers' group composition. The goal of DIANA is to ensure fairness, meaning that everyone waiting for being assigned to groups has an encouraging and equity start. Moreover, we especially concerned its flexibility and easy implementation for the reduction of teachers' load in the management of CSCL.

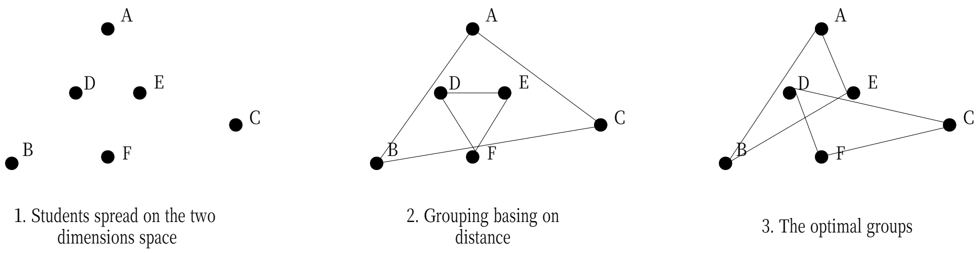

Fig. 1: An example of comparing the groups composing based on distance and the optimal groups

2 Problem Analysis

2.1 Problems occurred by using psychological features

Though the composition of heterogeneous groups based on TSs is an innovative and beneficial idea, unfortunately psychological variables are relatively embedded, not easy to be observed by teachers. However, this problem can be resolved if we have a well-developed psychological inventory, in this case Thinking Styles Questionnaire [8]. DIANA needs an online questionnaire module allowing easy distribution of any questionnaire to student respondents and collecting ready to use testing scores as the input for grouping algorithm.

The second problem of using psychological variables for group composition is the complex nature of them. For example, TSs are ways how we prefer to use the abilities we have, and people have profiles or multiple patterns of TSs. Sternberg [6], as a cognitive psychologist, argued that people possess a combination of possible TSs, e.g., executive, legislative and judicial. Executive TS is a thinking tendency to follow given rules rigidly, legislative – a thinking tendency to ignore given rules and creative self regulated rule, and judicial – a tendency to always evaluate various given rules. Teachers need to take all styles into account simultaneously and it increases the complexity of composition problem.

If teachers hope to keep simplicity and use the single most significant TS, they then become ignorance about the effects of other TSs and the diversity of students is not full acknowledged. For example, a student's combinational pattern of executive, legislative and judicial thinking style is (0.1, 0.7, 0.5), given that each TS score can be normalized to the range between 0 and 1. If this TSs pattern is simplified and the highest value, legislative TS, is selected to stand for the student's learning feature. Whereby, the legislative TS is recognized with the cost to neglect executive TS and judicial TS.

Third, data of psychological variables are continuous in nature that results a greater difficulty to perform group composition than using categorical data, such as gender. Perhaps, one may argue that teachers can always divide continuous data into categorical. In the case of TSs, teacher may divide upper, middle, and lower 1/3 of executive Ts scores into three categories. However, arbitrary division of a continuous data leads to information lost that many researchers have opposed.

2.2 Problems occurred by composing group

Besides the above discussions about continuous and numerous natures of psychological variables that make grouping complex and difficult, the grouping problem requests global optimal rather then local optimal solution. It is necessary to compose all groups to maintain within-group heterogeneity and between-group balance, or so-called as balanced group. That is, the diversity can not be determined intuitively merely by group distance.

For example, if there are six students in a class, their teacher hopes to group them for three teams according to two of their 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.

Based on the request of educational equity, we hope every student benefits form cooperative learning, not just a small group of friends or a few capable students. To ensure everyone in the classroom be assigned to a group for an equally successful start, we cannot intuitively choose the best students to form several high effective groups. It

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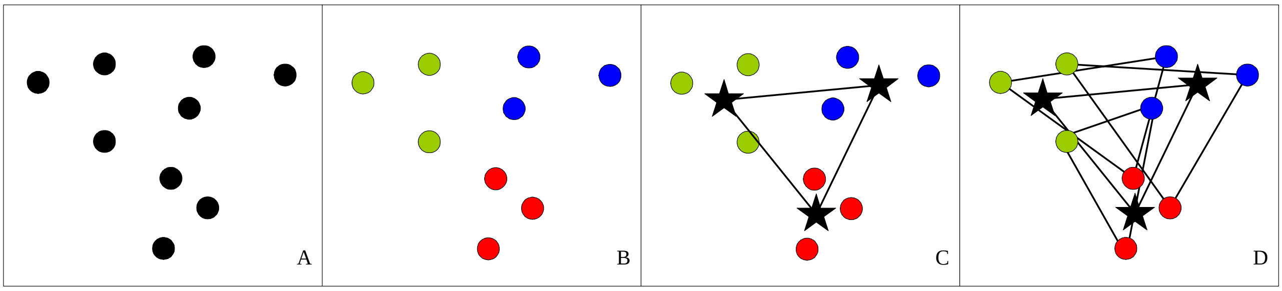

A. Nine students as nine spot in a two dimension space;
B. Splitting students into three categories (in three various colors) for the group size of 3;
C. Connecting the centers (black starts) of each category to form ideal groups of these nine students.
D. Selecting one student of each category to form a nearest ideal group.

Fig. 2: The example of two pahses grouping model

inevitably leaves a bunch of less capable students for less prosperous entering points. Therefore, the group composition problem is not merely to produce refined teams; instead, it is to group the whole pool of students for everyone's good. Therefore, teachers consider both the performance of individual group and those of all groups.

When researchers assigning individuals into groups, they often disregard partial students who are unfavorable or have vague features in terms of experiment purpose. In real life classroom situations, educators cannot do what researchers do. The DIANA system is design for the aid of teachers and so we plan not to ignore anyone of students waiting for assigning. In doing so, we value everyone's right for education and achieving excellence.

In conclusion, grouping is the fundamental stage of cooperative leaning, but it has several critical problems needing to be solved. One is that we should deal properly with multiple factors that may be numerical. Another is that we should confirm that student is assigned to the relative suitable group. This paper proposes a computer-assisted grouping method which can solve these two problems, help teacher to assign students to suitable group when he want to adopt researches suggestions.

3 Two phases grouping model

To 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 preferment and global preferment. Hence, grouping system should be designed into two phases (categorizing and grouping).

The first is *categorizing*, in which the diversity of all groups can be controlled. In this phase, Students are separated into some categories that form naturally by recursion. After that, the suitable categorization for the class formed automatically and the ideal structure of whole class could be drawn out.

The second phase is *grouping*, in which the diversity within group is manipulated for the appropriateness for the whole class. In this phase, one student of each category was selected to form a group in which group structure is kept similar according to a typical or ideal group structure.

Fig. 2 illustrates the steps of grouping nine students into three groups in terms of two psychometric features.

4 Methodology

In the *categorizing* phase, students should be divided into some categories, and the number of category is decided by the number of group members (the group size). While no one can absence from grouping, all category size should be the same. However, this requirement disobeys the opinion on clustering, which is to maintain similar within group and different between groups.

Therefore, we referred to the k-means algorithm [9] and added a re-allot function into the while-loop of finding static cluster. This function can disperse some students who belong to the over-size cluster to their second nearest cluster that are sufficient. The category algorithm is illustrated in Fig. 3.

On the other hand, teachers or researchers may hope the result of categorization could like the result of the most significant the most representation, which they used to adopt. Hence, we can set the initial cluster center at the utmost of each dimension in order to product the greatest distinct types. In this phase, teachers can consider more than one learning characteristics at the same time and treat them of equal importance.

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Algorithm categorization(features of students)
begin
  set the initial cluster center at the utmost of each dimension
  for while the new clusters isn't the same as the old ones do
    begin
    dispatch each student to his nearest cluster
    for while cluster sizes are not equal do
     begin
     choose a suitable student to reallot to his second nearest cluster
     end
    end
    compute new clusters
end
```

```
Algorithm choose a suitable student (over-size cluster)
begin
compute the distance between each student in over-size cluster and other clusters
return the student who's distance is shortest and his second nearest cluster
end
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Fig. 3. The algorithm of categorization

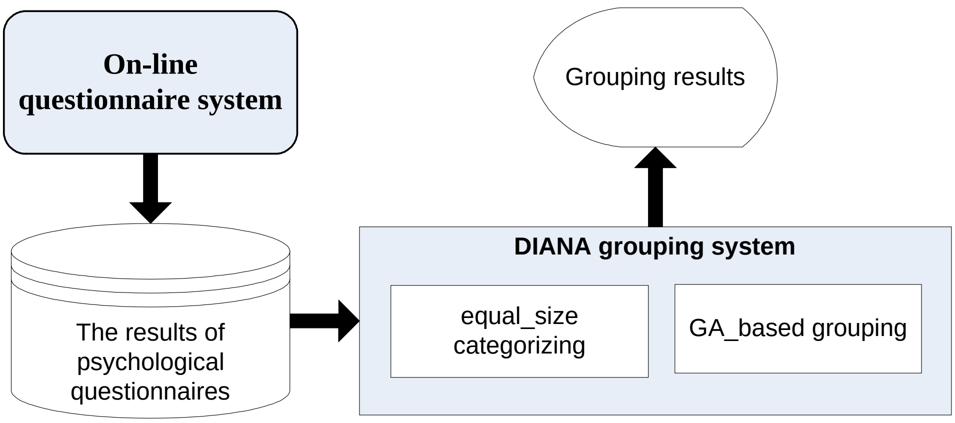

Fig. 4. The framework of computer supported grouping system

In the *grouping* phase, we adopted a genetic algorithm [10] to evolve the approximate solution of this combination problem. One chromosome represents one group, and each gene within a chromosome representing one student in each cluster. Whole class constitutes a population. The fitness function is guided by the ideal group structure. The fitness equals the inverse of the absolute value of the difference; the higher the fitness value, the better the performance.

Because every student should be grouped, no one can disappear. In this project, we used a static genetic algorithm and only performed a single-point crossover when the fitness of the offspring exceeded that of its parents. But the mutation operator allows for the crossing over of two chromosomes even if the fitness value does not improve.

5 Implement

To make teacher convenient to acquire students' psychological features, we designed an online questionnaires. Connecting to questionnaire system, a grouping system named DIANA (Different Inner groups And Non-different Among groups) was proposed (Fig. 4).

5.1 Online questionnaire system

Fig. 5 shows the interface of online questionnaire system. This questionnaire system is also designed to allow researchers or teachers to establish various questionnaires. Teachers may ask students to fill with the online questionnaires, and the data will be stored into database. Students' characteristics measured by psychological questionnaires that are multiple, continuous in nature.

Fig.5. On-line Thinking Styles Questionnaire. The lift frame showed the guides and the meaning of 5-point scale (A: not at all similar, B: little similar, C: cannot judged, D: somewhat similar, D: all similar). The right frame showed the content of questionnaire. Because this system was designed for students in Taiwan, the interface is in Chinese.

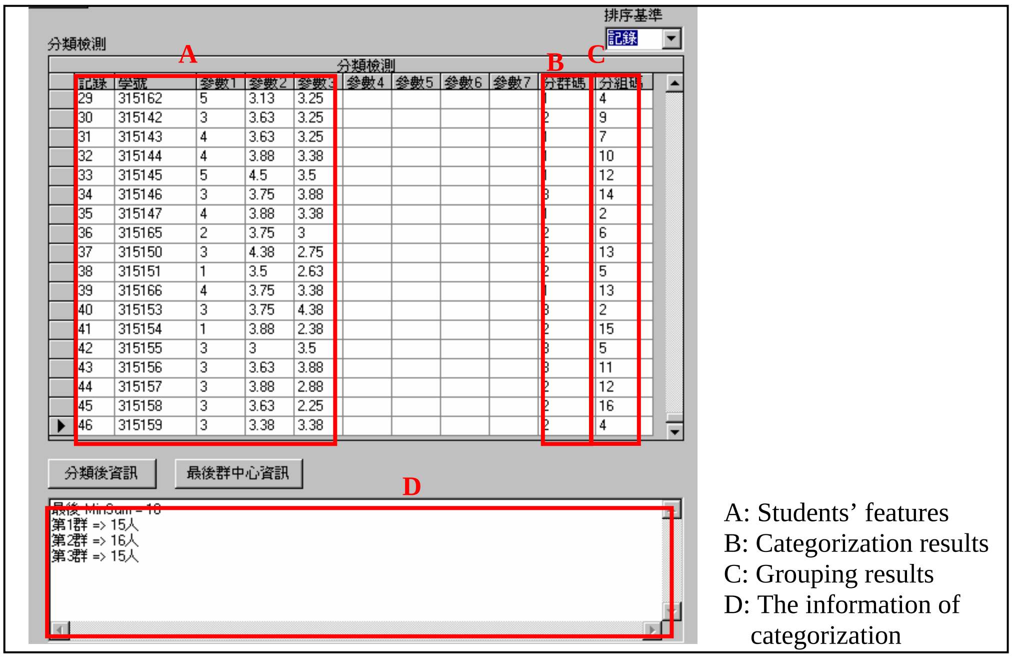

Fig. 6. The interface of DIANA grouping system

5.2 DIANA grouping system

Fig. 6 shows the interface of DIANA grouping system. Teachers can determine the size of the group depends on the purpose of his/her instructional objects. DIANA System then performs computation and recommends heterogeneous group compositions without imitations discussed in the second section. The purpose of this system is to allocate students to the most suitable group in both levels of individual and whole class.

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