Experiences on Manual vs. Automatic Formation of Learner Groups

Rahel Bekele *

Abstract: This study is concerned with computer-based approach to form effective hetero-generous learners group. Taking Mathematics as the subject of the experimental study, some characteristics were identified for inclusion in order to compose the groups. An automated grouping system (software tool) was then developed based on a vector space mathematical model. In order to evaluate the software tool, an experiment was conducted on three sections of students in a senior secondary school in Addis Ababa, Ethiopia. Students in the first section were grouped randomly while students in the second section were grouped based on self-selection. The students in the third section were grouped automatically based on some selected personality characteristics. The software tool developed was found to be a viable grouping technique to create effective groups.

Introduction

Cooperative learning has been one of the many alternative instructional techniques described in the academic literature to enhance students' performance (O'Donnell and Dansereau, 1992; Webb, 1992; Slavin, 1983, 429). Educators agree that performance on a subject is enhanced when an individual learns information with others as opposed to when she or he studies alone. Students who work in groups are observed to develop an increased ability to solve problems, show greater understanding of the subject being taught, and retain it longer than when the same content is presented in other instructional formats such as individualized instruction.

Benefits of cooperative learning are supported by extensive research, and are grounded in the theories of Educational Psychology. As such,

---

* Assistant Professor, Department of Information Science, Faculty of Informatics, Addis Ababa University

cooperative learning is supported by both cognitive and non-cognitive (Behavioural and Humanistic) theories.

Two issues which come to the forefront in cooperative learning are the size of groups and allocation of members into groups. In relation to the size, Slavin (1987) recommended a group size of three to five students as an ideal. A group size of four is especially recommended for a number of reasons such as students find it easier to organise meetings as there are less clashes with timetables; students get a larger piece of the work easier to do and feel they can make a meaningful contribution to the group assignment and students are more visible and accountable to each other.

Apple (2001) also made suggestions on what he called an optimal size of a group based on the learning objectives. These learning objectives included skill exercises (groups of two), where students demonstrate their understanding of a topic; guided discovery learning (groups of three) where students learn through discovery rather than being told the information directly; in-class problem-solving (group of four) where instructors allow students to practice problem-solving; and long-term problem-solving project (groups of five) where students are required to carry out a term- or semester- project with careful planning.

In relation to allocation of members into groups, although there is no "one right way" to allocate students into groups, there exist a number of practices in use, namely the Random assignment where some form of random appointment is used to form student groups, self-selection where students are asked to form groups by themselves and specific criteria where attempts are made to form heterogeneous groups (groups different from each other both in their academic abiliites and personal charactersitics). The specific criteria works on the assumption that groups work better when the members are balanced. Some of the more popular criteria use functional roles, learning styles or personalities. For instance, Romney (1996) employed collaborative learning method to a French translation course where groups were formed by taking the following factors into account: gender (the majority of language students were female, when no group contained more than one male); language proficiency in both English and French with each group comprising one individual with native or native like skills in French and one whose first language was one of the Canadian official languages; personality (for instance, not more than one argumentative or shy student was placed in each group); age, work, and life experience.

The resulting groups were as heterogeneous as possible so as to expose students to a variety of opinions. Romney's observation of the groups indicated that, on a personal level, the students were pleased to be able to share their difficulties with others. They gained confidence from observing that if their group-mates could solve problems, they would also be able to overcome them. Speaking in front of a small group with which they were familiar, rather than in front of the whole class, was also less stressful. They also formed close friendships with their group-mates, and many stress that they look forward to coming to class. On an academic level, there were definite gains in conformity with the findings of Johnson and Johnson (1985) that cooperative learning experiences promote higher achievement than do competitive and individualistic experiences.

In general, the most widely presented suggestions in the cooperative learning literature are that group composition should be heterogeneous whenever possible. In other words, students in groups should be diverse in background, idea, personality, ethnicity, and gender (Slavin, 1995).

Although homogeneous groups are better at achieving specific aims, when students with different abilities, experience, interest and personalities were combined (heterogeneous groups), they out-performed homogeneous groups in a broader range of tasks (Martin and Paredes, 2004; Nijstad and Carsten, 2002). Furthermore, according to Slavin (1987) and Johnson and Johnson(1985) the composition of group members (the allocation of students into groups) that takes into account inter-working ability among members, is important in forming effective groups. In relation to grouping based on academic ability, Oakes(1990) also stated that heterogeneous grouping is necessary in order to ensure equal opportunities for all students.

Students who get stuck in low-level tracks are deprived of opportunities to develop higher-level skills and study rich content.

As can be understood from the foregoing discussions such factors as determining the size of a group based on the learning objectives, the grouping methods and especially the creation of heterogeneous groups seem to be important in the group composition process.

Statement of the Problem

An issue that is gaining more and more popularity among workers in the field of cooperative learning is the formation of heterogeneous groups. This is done based on a set of specific criteria applicable to the learning objective under consideration. The implementation of the task usually involves students completing a questionnaire which is scored to determine a student's personality characteristics. Students with different performance levels and characteristics are then appointed to each group so as to achieve the desired balance in terms of diversity.

While generally considered very effective, such a task is not without its drawbacks especially in large size classes. Since it requires questionnaires to be developed, administered and scored (all prior to the group formation), it can be expensive and time consuming. Moreover, in a manual environment, a great deal of time and effort may be needed in the creation of heterogeneous groups with the required features. This is because, the numbers and combinations of performance level and values of personality characteristics to be considered may be too many to handle and manage. In addition, where most students have different abilities and styles, the manual application of this grouping method may lead to an over-representation of some styles and an under-representation of others. In the absence of effective practical models that fully consider the group formation with features incorporating performance and personality characteristics, difficulties may be experienced in the realization of the benefits from heterogeneity. Hence, the creation of effective heterogeneous groups may be difficult using the existing simple and manual methods.

Although the consideration of both academic performance and personality characteristics for group formation have been widely advocated as ideal and beneficial in terms of enhancing the effectiveness of collaborative learning, it has not been developed fully and thoroughly in practical terms. Most of the attempts so far reported were either anecdotal/sketchy or limited in scope and purpose. What is more, there are generally lack of publicly available software tools for use in the formation of groups that enhance cooperative learning.

The research questions that arose in view of the problems stated above are:

- How can one build and program a mathematical model to automate the formation of heterogeneous groups?
- Would there be an improvement in performance of students as a result of group work?
- Would the automated group composition increase performance of students as compared to the other grouping methods?

This article reports the research process undertaken to answer the research questions. Details are given on the experiments carried out to develop an appropriate software tool to consider both performance and personality characteristics in the formation of effective heterogeneous groups. The article also reports how the software tool was developed as well as the evaluations made against other methods of grouping.

The finding of this research may be considered a special contribution in terms of providing some useful direction to conduct further research in the areas of automated group composition, particularly in the context of the Ethiopian educational environment. Furthermore, the work might motivate computer Science, educational psychology and social psychology researchers to contribute (participate) in such multidisciplinary area of work.

Research Objectives

With the goal of developing a software tool to automate the group composition process, the specific aims of the research were to:

- (i) identify personality characteristics that may be considered in group composition;
- (ii) build a mathematical model which assists in the formation of heterogeneous groups;
- (iii) develop a software tool based on the mathematical model;
- (iv) test whether there would be an improvement in performance of students as a result of group work; and
- (v) test whether the automated heterogeneous group composition increases performance of students as compared to the manual grouping methods.

Method of the Study

Selection of Subject Area

To contextualize the experiments involved in this study, Mathematics was taken as the subject area. Among the factors considered in picking Mathematics for the purpose of this study were: familiarity of the researcher with the subject (teaching freshman Mathematics for more than five years) and the relationship between Mathematics performance and academic career opportunities, i.e., in most institutions, a successful performance in Mathematics is used as one of the selection criteria both for placement in higher education and for employment in the world of work.

Moreover, a preliminary study was conducted in February 2002 to get more insight into the local situation. This was particularly related to a review of letter grades of four batches of freshman students (1999-2002). As observed in the preliminary surveys, a greater number of freshman students (more than 50% out of the four batches) scored low grades in Mathematics (Rahel, 2002).

In view of the foregoing discussion, Mathematics was felt to be an appropriate school subject to be the focus in this study.

Selection of Personality Characteristics

As indicated earlier, group composition requires the identification and study of relevant personality characteristics. In order to understand the current situation of group work and performance in Mathematics tests, review of literature, formal and informal interviews were conducted with Mathematics teachers, educationists, and students at Addis Ababa University. This phase helped in initial identification of a list of personality characteristics for consideration in the process of group formation. The list was then validated by senior instructors, with relevant and rich experience in teaching and research, group composition as well as measurement and evaluation techniques in the field of education. Accordingly, the characteristics selected for the experiment were group work attitude, interest for Mathematics, achievement motivation, self-confidence, shyness, Mathematics performance and English performance.

Operational Definitions

The following operational definitions of the attributes were considered for the purpose of the study:

- **Group work attitude**: the way a student viewed and tended to behave towards group work.
- **Interest for Mathematics**: the liking/disliking the student developed towards Mathematics.
- **Achievement motivation**: the disposition of a student to approach success (to get a high standard in his/her academic performances.

- **Self-confidence**: the belief of a student in himself/herself (the student's internal/external locus of control).
- **Shyness**: the feeling of being insecure when the student is among other people or talking with other people.
- **Performance**: score/grade obtained in a given exam/test.

Data Collection Instruments

Once the personality characteristics were identified, instruments for data collection were developed and tested in consultation with educational psychologists. The instrument was first developed by collecting pool of items to measure each personality characteristics. A number of existing instruments were consulted. Experts' opinion were also solicited including the experience of other researchers for the purpose of determining how to measure each personality characteristics. Eventually, a three-page instrument consisting of the agreed upon items to measure the different personality characteristics identified above was prepared.

Subjects of the Study and Data Collection

The experiment was conducted in Yekatit 12 Senior Secondary School in Addis Ababa, Ethiopia. This school was specifically selected because of its proximity to the work place of the researcher, and willingness of instructors to help and the students to participate in the experiment.

The group work experiment was conducted during the second semester of the 2005 academic year; specifically, during the time when the 12^{th} graders were preparing for national examinations. For this reason, they were not able to participate in the experiment. The basis for the group work experiment were, therefore, 11^{th} grade students. In order to avoid possible bias arising from school time and stream (field of study), students in the Science stream attending the morning shift, were selected. The morning shift was specifically selected so that students could do their group work in the afternoon after attending their morning classes. Discussions with students prior to the experiments also indicated that students in Science stream were more willing to participate in the experiment than the social Science students. The information obtained from the school indicated that students in section 2, 4, and 6 in the morning shift were students in Science stream in the school. This was found convenient since the experiment involved three types of grouping (random, self-selection and automated grouping). There were 47 students in section two, 48 students in section four and 44 students in section six. Altogether, 139 students participated in the experiment. It is also important to note that with the recent introduction of the televised educational program from a central pool, all students who participated in the experiment attended the same type of lecture in the same format. This has actually reduced the bias that may have otherwise been introduced.

During data collection, while the values of students' English and Mathematics performance were obtained from students' school records, the values of the other characteristics, namely, group work attitude, interest for Mathematics, achievement motivation, self confidence and shyness were obtained through the developed data collection instrument.

Issues of Data Protection and Privacy

Because of the sensitive nature of the data (which also involved the identification of each student who completed the data gathering instrument to measure the respective values of the identified characteristics), students were first asked for their consent to participate in the experiment. Next, they were assured that the data supplied/collected would remain confidential. Almost all showed willingness to study in groups with the exception of very few. Oral instructions, in addition to the written general and specific directions, were also given to the students to emphasize honesty in filling out the instruments.

The Automatic Grouping System

The Mathematical Model

A mathematical model to support the creation of groups was first developed. This mathematical model applied the concepts of a vector space model where each student was represented in a multi-dimensional space by a vector whose features/components were made up of the values of personality and academic performances of the student.

Values of personality characteristics representing a student in space were weighted and mapped to numerical values. Since each of the seven characteristics had three possible values, the scores (numerical values) obtained on each characteristic were: 1 for low category value, 2 for average category value and 3 for high category value.

For instance, for S_1 (positive attitude to group work, indifferent to Mathematics, medium achievement motivation, low self confidence, extrovert personality, above satisfactory in English, satisfactory in Mathematics), the corresponding vector was represented by S_1(3,2,2,1,3,3,2)

The major mathematical function defined was the Difference measure Diff(S_i , S_j) which is the Euclidean distance between the vectors representing two students in space.

$$Diff(S_i, S_j) = \sqrt{\sum_{i=1}^{n}(C_i(S_i) - C_i(S_j))^2}$$

Where C_i (S_i) represents the value for a particular characteristic C_i for student 1.

Two students S_i and S_j are said to satisfy the heterogeneity requirement if

$$Diff(S_i, S_j) \geq \text{pair-threshold}$$

Pair threshold was the average difference measure computed as the sum of the difference measure of all pairs of students divided by the number of pairs. Moreover, a student-score for a particular student represented the total score of a student computed as the sum of values of the student score on each of the characteristics. In other words, for a particular student j, the student-score was computed as:

$$\textbf{Student-score} = \sum_{i=1}^{n} \mathrm{C_i}\ (\mathrm{S_j})$$

The Student-Average-score was then computed as a simple average of the student-score of all students. i.e.,

$$\textbf{Student-Average-Score} = \frac{\left(\sum_{j=1}^{j=n}\sum_{i=1}^{i=t} C_i (S_j)\right)}{n}$$

Where n referred to the number of students and t referred to the number of characteristics.

This mathematical model formed the basis for the software tool developed to create heterogeneous groups.

The Developed Software Tool

This software tool (developed in java programming language) has eight modules running repeatedly before they reach the final assignment of students to groups.

The peculiar property of this software tool was that in the first module, a new/incoming student is assigned to a group if the difference measure between this new student and the student who joined the group last, is greater than the pair threshold. In other words, the check for membership of a new/incoming student into a group is made by comparing the student with the one who joined the group last. This way, more than one student in a group will have a chance to be the group representative. (A student has an opportunity to pick a member and then transfer the opportunity to the one picked).

The second module runs only if there are students who are not yet grouped. It sequentially takes a student from the outlier file; sequentially selects a group which is not yet filled and applies the difference measure on the student from the outlier file and one member from the group. If the difference measure is greater than the pair-threshold with at least one of the students in the group, then the student from the outlier file is included in the group. The checking is done until each group is filled or until there are no more students in the outlier file.

The third module runs if there are still outliers. It performs a trial and error process starting from the 1st group. It temporarily removes a student from a group and replaces him/her by a student who is not yet grouped. It then checks whether the new student fits the join-requirement by applying the difference measure and comparing it with the pair-threshold. This actually continuous until it finds a pair or until all students are checked. If such a pair is found, the exchange is performed. This module does not reduce the number of students who are not yet grouped. (i.e., simply exchange is done).

The fourth module creates new groups with the newly exchanged students. It runs only if the outlier file contains students and it assumes that some students who were already grouped have now been exchanged to join the outlier students. The steps are actually the same as the algorithm in the first module (the beginning of group formation).

The fifth module examines the final group candidates. It sequentially checks all groups created. If all group members have low values for a specific characteristic or if the group-average is less than the group-threshold, then the group is discarded and all members are put back to the outlier file. This module actually selects the final groups and drops those groups which do not meet the criteria specified.

The sixth module runs only if there are groups which are dropped when the final grouping is made. It simply repeats the first five modules. These five modules are repeated until there are no more students who can be grouped together.

The seventh and eighth modules are concerned with outlier inclusion and finalizing of the grouping process. In the seventh module, outliers are included on condition that a group size is not yet filled and only if the group average becomes greater than the group-threshold after the inclusion of the student from outlier file. After checking all groups, if there are still outliers, the eighth module is run in order to append students from the outlier file sequentially to each group.

The next section presents the experiment conducted to evaluate the software tool and test the existing claim that students placed in groups based on personality are more likely to have a better performance than those placed randomly or on self-selection basis.

Evaluation of the Grouping System in Real Environment

Pre-Group Work Exam

The subjects of the study were made fill in the instrument developed to obtain information on the various personality characteristics. They were also asked to give information on their English language fluency. The Mathematics performances of these students were predicted based on a performance prediction model developed for the purpose. All these students were given pre-group work exam and their Mathematics performance was recorded. This also helped to make later comparisons on their performance after group work.

The pre-group work exam results had mean score of 12 and standard deviation of 4. Assuming a normal distribution, those students who obtained scores > = 16 were categorized as “above satisfactory”, those in between 8–16 were categorized as “satisfactory” and those with scores < = 8 were categorized as “below satisfactory”. The following table shows the total number of students in each performance category.

Table 1: Frequency Distribution of Actual Performance – Pre-group Work

Performance Category	Number of Students	Percent
Below Satisfactory	24	17.30
Satisfactory	89	64
Above Satisfactory	26	18.70
Total	**139**	**100**

Group Formation

A lottery method was employed in order to decide which grouping method to apply in each of the sections. Accordingly, section two were made to select their own groups (self-assigned groups). Students in section four were grouped based on their personality characteristics using the developed group composition software. These students were made to fill out the instrument prepared to obtain values of the various personality characteristics. Students of section six were randomly-assigned to groups. i.e., they were made to draw numbers (group labels: 1, 2, etc.) written on a slip of paper of the same size, colour and shape. Groups were then formed by putting members who picked the same labels together. With the respective grouping methods, 11 groups were made in each section.

The Mathematics teachers in the school cooperated in informing the students about the assignment of groups as well as time and place for the group work.

Group Work Environment

Before the group work actually started, orientations were given to students on how they would go about the group work, group-leadership and submission of the exercises. During the orientation, students agreed that having only one member in the group as a group leader for the duration of the group work, was too much of a responsibility particularly for students who had no prior experience in group work. Accordingly, the role of leadership started with one member in the group in an alphabetical order, and each member of the group took turns on a weekly basis. The leader was responsible for reporting problems during group work, and submitting the weekly group report form. After attending lectures in the morning, the students were made to meet regularly in the afternoons. A specific location was chosen for students during group work, where they would work in their groups of four or five for about six hours per week. The group work generally consisted of a weekly cycle of activities as follows:

- A worksheet consisting of exercises was distributed at the beginning of each week;
- Each group discussed the worksheets distributed prior to working on the exercises;
- Each group, then, worked together on problems, compared answers, and helped each other with difficult problems;
- In cases of difficulty, each group consulted Mathematics instructors who regularly visited the group work;
- At the end of the week, the group leader submitted the answers; and
- Submitted answers were corrected and returned to the group.

Supervisions and Duration of Group Work

Since all the three sections met mostly at the same time, three monitors were employed to supervise the three types of group work. These monitors were essentially laboratory instructors who have some experience in handling group work. Additionally, the monitors were not from the Mathematics profession so as to avoid the bias of helping one group more than the other during the group work. Their tasks were mainly assisting in taking attendance, attending to problems of students during group work, controlling disciplinary problems, and collecting weekly reports submitted by the group leaders.

The Students were encouraged by their Mathematics instructors to help and actively explain to one the way they could solve the problems in the worksheet. This was needed mainly to ensure the active participation of member in the group work.

The group work took place from February 16 - April 16, 2004. A total of 48 hours were spent in group work before the post-group work exam was administered.

Problems Observed

One of the problems experienced was that students simply lacked the experience on how to function and behave in a group setting. During the first two weeks, there was a problem of lateness and absenteeism in some groups. Students had difficulty taking turns in leadership. There were, however, groups that worked well from the very beginning and seemed to be able to get along well.

It was also observed during the group work that some students came unprepared. They just sat in the sessions and did not try to actively participate in the group. There were also some interruptions caused by exams scheduled by other instructors during group sessions.

Overall, there was a noticeable progress in the activities of students during the group sessions. The weekly report form collected from students did not indicate any discomfort resulting from working together.

Post-Group Work Exam

In order to evaluate the change in performance, post-group work exams were administered after the students' completion of the group work. The questions were more or less similar in nature to what the students had been working on during their group study. Before the administration, the test questions were discussed with the Mathematics instructors at the school to check their appropriateness to measure performance after group work.

Among 139 subjects of the study at the time of administering the post-group work exam, 10 students who participated both in the pre-group work exam and group study, were not available. Thus only 129 students were considered for further analysis. The maximum score out of possible 20, was found to be 20 and the minimum was 7.50. The mean score was 14.5 and the standard deviation 3.76.

For the purpose of comparison, the mean and standard deviation of the results of the pre-group work exam were taken to categorize the scores into the three levels of performance. Accordingly, those students who obtained scores > = 16 were categorized as "above satisfactory", those in between 8–16 were categorized as "satisfactory" and those with scores < = 8 were categorized as "below satisfactory". The following table shows the total number of students in each category.

Table 2: Performance after Group Work

Performance Category	Frequency	Percent
Above Satisfactory	52	40.30
Satisfactory	74	57.40
Below Satisfactory	3	2.30
Total	**129**	**100**

A comparison of the pre- and post-group work exam results (Tables 1 and 2) showed that after the group work, there was an increase in the number of students who were in the category of “satisfactory” and “above satisfactory”. There was also a considerable decrease in the number of students who were in the “below satisfactory” category.

Post- Group Work Questionnaire

Students were also asked to complete a group evaluation survey at the end of the group work. The survey contents mainly included opinion of students on group formation; how well they worked together and improvement in performance. In order to control the misunderstandings that may arise from language barriers, the survey contents were prepared in Amharic language. The data collected from the survey was then organized and analyzed using the SPSS package.

Further discussions of the results of the experiments, the statistical tests applied, and the feed back received from students are presented in the next section.

Results and Discussion

Comparison of Pre- and Post- group Work Exam Results

Change in Performance

The following is a summary table comparing the two exam results (pre- and post-group work).

Table 3: Summary of the Pre- and Post- group Exam Results

	Maximum	**Minimum**	**Mean**	**Standard dev.**	**Coefficient of variation**
Pre-group work exam	20.00	2.50	12.00	4.00	33.30%
Post group work exam	20.00	7.00	14.50	3.76	25.90%
t-test	10.45*				

* p = 0.00

The summary results showed that the mean score of the post-group work exam results is higher than the mean score of the pre-group work exam results. Moreover, with a coefficient of variation of 25.90%, the post group work exam results showed more consistency as compared to the pre-group work exam results.

The test for significance of correlations made at $\alpha = 0.05$ ($r = 0.507$, $p < 0.05$), revealed that there is a highly significant correlation between pre-group work and post-group work exam. i.e., students who did well on the pre-group work exam also did well on the post- group work exam.

The paired samples T-test was also applied to test whether there is a significant difference between the two exam results. The following is a summary table.

The result of the paired samples test ($t = 10.45$, $p = 0.00$) confirms that there is a significant difference between the pre- and post-group work exam results, favouring the post-group work exam results.

Hours of Attendance vs. Change in Performance

A regression analysis was also carried out in order to explain the relation between total hours of group work attendance and change in performance. The dependent variable, in this case, was the change in performance. The following is a summary generated by the SPSS package.

Table 4: Regression Analysis of Hours of Attendance and Change in Performance

Model	Un-standardized coefficients		Standardized coefficients	Z	Sig
	B	Std. error	β		
Constant	-0.48	0.74		-6.50	0.00
Total hours attended	0.25	0.02	0.71	11.32	0.00

This confirmed that the number of hours of group work and change in performance are significantly related at $\alpha = 0.05$, i.e., students who attended group work for more hours performed significantly better than students who did not ($z = 11.324$, $p = 0.00$).

The test for significance of correlations also showed that a significant correlations ($r = 0.71$, $p = 00$) exist between hours of attendance in group work and change in performance. Furthermore, the coefficient of determination revealed that about 50% of the variation in change of performance was explained by total hours of attendance in the group work.

On the basis of this statistical evidence, one may conjecture that, over and above making a student join what seems a reasonably heterogeneous group, how much a student spends in group work significantly affects his/her performance.

Comparison of Grouping Methods

Table 5 exhibit a cross tabulation of the grouping methods by change in performance.

Table 5: Cross Tabulation of Grouping Methods by Change in Performance

		Grouping Method						Total
		Program Assigned		Self-Assigned		Randomly Assigned		
Change in performance	Decreased	-	0.00%	3	6.00%	4	10.53%	7
	No change	13	31.71%	23	46.00%	17	44.74%	53
	Increased	28	68.29%	24	48.00%	17	44.74%	69
Total		**41**		**50**		**38**		**129**

As may be observed from the Table 5, the program-assigned method has the highest proportion of students who have increased in performance (68.29%) followed by those who were in self-assigned groups.

In addition to what is revealed by the percentage figures, a statistical test was carried out in order to examine which grouping method is better in terms of yielding a higher proportion of increase in performance (referred to as success). The test used for this purpose was the two-sample test for proportion. For the purpose of carrying out the statistical test, proportion of success was defined as “the proportion of those who have increased their performance" and proportion of failure is referred to as "those who have not increased performance (those who have decreased or not changed their performance)". The following proportions of success and failure were summarized from Table 6.

Table 6: Proportions of Success in the Three Grouping Methods

	Grouping Method		
Proportion	**Program-assigned**	**Self-Assigned**	**Randomly-Assigned**
No. of students	41	50	38
Success	0.683	0.480	0.447
Failure	0.317	0.520	0.003

More over, The test of significance for difference of proportions between Program-Assigned and Self-Assigned Methods at $\alpha = 0.05$ (Z = 1.93), revealed that there is a significant difference in academic performance between students who attended the two grouping methods (i.e., better performance was in favour of the Program-Assigned method). Similarly the test of significance for difference of proportions between Program-Assigned and Randomly-assigned Methods $\alpha = 0.05$ (Z = 2.165), revealed that there is a significant difference in academic performance between the two grouping methods (the program-assigned method showed a better academic performance).

From the results of the above two statistical tests, one can generally conclude that performance has definitely increased as a result of group work. What is more, the program-assigned method has significantly improved performance of students as compared to both the self-assignment and random-assignment methods.

In this connection, it is also interesting to note that those who have above satisfactory performance before group work have not decreased their performance. Rather, their results either have improved or remained unchanged. Based on the results, we can safely claim that while low achievers improved their performance significantly, there is no loss of performance from high ability students.

One may come out with various reasons why the students with program-assigned groups have performed better than the others. For instance, socialising, exaggerated funs, and private matters might not have been exercised since most students were grouped based on their personalities. Moreover, we find that there was at least one motivated/serious student in the group who encourages the group work.

It has been noted, however, that there were regular absentees from group work. This might be attributed to their lack of willingness and seriousness. But we can not overlook the possibility that students might have been required to go straight home from school instead of staying for group work. Addressing this issue may require instructors and school administrators to put more efforts in informing parents and preparing students for group work activities. This can probably be done through conducting appropriate orientation and encouragement.

Another issue worth raising is the effect of the topics that the students worked on during group work. The study focused on specific topics that the students had been doing during the first semester of grade 11 (these are relatively easier topics compared to those in the second semester). The topics selected might have positively contributed to the observed better level of performance of the students. As such, one might need to conduct the research further with more difficult topics (for instance geometry topics) in order to ensure the consistency of the results.

Conclusion and Directions for Future Work

This research generally aimed at exploring a computer-based approach to from effective heterogeneous groups by taking into account both the level of academic performance of students and some relevant personality characteristics.

In general, the results of the group composition experiment confirmed that group learning improves performance. The evaluation results indicated that students grouped based on level of performance and personality characteristics, performed better than the randomly-assigned or self-selected groups. The developed automatic tool has also proved to be a viable grouping technique to create effective groups.

The automation tool for group composition has been developed with a mathematical model that gave equal weight to all the characteristics considered. This was due to lack of proper justification on which certain characteristics can be judged to be more relevant than the others. Even if the information on relevance was available, quantifying the weights requires more detailed examination of the characteristics. As such, improving the grouping tool by revisiting the algorithm through the incorporation of weights that indicate the relative importance of the characteristics in the vector representation is worth exploring.

Moreover, incorporating the mathematical model into such areas as optimization techniques and genetic algorithms might be useful to generate more optimized groups.

References

Apple, D., et al. (2001). **A Handbook On Cooperative Learning. 3rd ed***.* Illinois: Pacific Crest.

Bradley, J. H., and Herbert, F. J. (1997). *The Effect Of Personality Type On Group Performance*. **Journal of Management Development**,16, 337-353.

Johnson, D. W. and Johnson, R. T. (1985). *The Internal Dynamics Of Cooperative Learning Groups.* In Slavin, et al. (*ed.*) **Learning To Cooperate, Cooperating to Learn,**103-124. New York: Plenum.

Martin, E., and Paredes, P. (2004). *Using Learning Styles For Dynamic Group Formation In Adaptive Collaborative Hypermedia System.* Retrieved from: http://www.ii.uam.es/~rcarro/AHCW04/MartinParedes.pdf.

Nijstad, B. A., and Carsten, K. W. D. (2002). Creativity and Group Innovation*.* ***Applied*** **Psychology**, 51(3): 400-405.

Oakes, J. (1990). **Multiplying Inequalities: The Effects Of Races, Social Class, And Tracking On Opportunities To Learn Mathematics And Science**. Santa Monica, CA: RAND.

O'Donnell, A. M. and Dansereau, D. F. (1992). *Scripted Cooperation in Student Dyads: A Method for Analyzing and Enhancing Academic Learning and Performance*. In Hertz-Lazarowitz and Miller(eds.) **Interaction in Cooperative Groups: The Theoretical Anatomy of Group Learnin***g*, 120-144. New York: Cambridge University Press.

Rahel Bekele.(2005). *Computer-Assisted Learner Group Formation Based on Personality Traits.* PhD Dissertation, University of Hamburg, Hamburg, Germany. Retrieved from: http://deposit.ddb.de/cgi-bin/dokserv?idn=977952940&dok_var =d1&dok_ext=pdf &filename =977952940.pdf.

Rahel Bekele. (2002) *Analysis Of Students' Grades Of Freshman Mathematics At Addis Ababa University***.** A Research Report. Department of Information Science. Addis Ababa University.

Romney, C. (1996). **The Benefits Of Collaborative Learning**. Retrieved from: http://Www.Ucalgary.Ca/Pubs/Newsletters/Currents/Vol3.6/Benefits.Html.

Slavin, R. E. (1995). **Cooperative Learning: Theory, Research, and Practice, 2nd Ed**. Boston: Allyn and Bacon.

Slavin, R. E. (1987). *Developmental And Motivational Perspectives On Cooperative Learning: A Reconciliation*. **Child Development**, 58, 1161-1167.

Slavin, R. E. (1983). *When Does Cooperative Learning Increase Achievement?* ***Psychological Bulletin****,* 94, 429-445.

Webb, N.M. (1992). *Testing a Theoretical Model of Student Interaction and Learning in Small Groups.* In Hertz-Lazarowitz and .Miller(eds.) **Interaction in Cooperative Groups: A Theoretical Anatomy of Group Learning**, 102-119. Cambridge: University Press.