The Application of Discovery Learning Method and Small Group Discussion in PAM – 472 Topics in Combinatorial Mathematics II

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Abstract: This research concerns classroom action research conducted in the academic year 2017 – 2018, involving undergraduate students who took the Topics in Combinatorial Mathematics II Course, an eighth semester course in Department of Mathematics, Faculty of Mathematics and Natural Science in Andalas University. In this research, we combined two learning methods, namely Discovery Learning and Small Group Discussion to increase the ability of the students to understand the course material. By comparing the final grade in the academic years 2016 – 2017 with 2017 – 2018, we found that this combination of the methods successfully improved grades.

1 INTRODUCTION

The course PAM 472 Topics in Combinatorial Mathematics II is an elective course in the Combinatorial Mathematics Research Group. The course is a 3 hour a week course (3 SKS) at level IV (semester VIII). The prerequisite courses for this elective course are two other elective course taught by the Combinatorial Mathematics Research Group, i.e. PAM 271 Introduction to Graph Theory, given at level II, semester III, and PAM 272 Discrete Mathematics (given at level II, semester IV).

Another course related to Topics in Combinatorial Mathematics II is PAM 471 Topics in Combinatorial Mathematics I, which is given at level IV (semester VII), but this course is not a prerequisite for students who will take the Topics in Combinatorial Mathematics II course because both courses appeared in the 2015 – 2016 academic year. Topics in Combinatorial Mathematics II is not a continuation of Topics in Combinatorial Mathematics I.

In Topics in Combinatorial Mathematics II, we focus on understanding some of the latest results in the field of graph theory, namely (a) the metric dimension, (b) the partition dimension and (c) locating chromatic-number of a graph.

We provide several definitions, theorems, and their proofs, as well as detailed explanations through examples. The course materials are some recent articles related to the topics given, as well as some lecture handouts which contain summaries of articles in the previously mentioned topics (a), (b) and (c).

After attending this course, the students are expected to have a strong understanding of the concepts of the metric dimensions, the partition dimensions and the locating-chromatic number of a given graph. Furthermore, the students are expected to be able to use the concepts required to determine the metric dimensions, partition dimensions and location chromatic numbers of a given graph themselves. It is expected that students can think critically, analytically and innovatively, structure arguments logically, and be able to communicate their thoughts systematically, be able to work together and adapt themselves to other students in the group and conduct some good discussions.

In the academic year 2016 – 2017, fifteen students took the course Topics in Combinatorial Mathematics II. In that semester, the lecturer applied the Small Group Discussion (SGD) method as follows. Students were divided into five groups, where the students themselves determined members of each group. After the basic concepts of each topic was provided by the lecturer, the lecturer gave assignments to each group to be presented in the next meeting. Each group was directed to search for an article related to the topics discussed, in international or national journals, and then give a presentation of their understanding of the article. The lecturer chose the presenting group randomly so that each group had to be well prepared for each presentation assignment.

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During the group presentation the lecturer acted as a facilitator and moderator for the discussion. The lecturer assessed the presenting group on their understanding of the article material. The lecturer also assessed the attitudes and presentation technique. The presentation material was then collected after the presentation was complete.

The lecturer provided assessments to students from non-presenter groups, based on their activeness in responding to the first group's presentation. Assessment was made of all groups when they presented their major assignments in the last three weeks of the semester. This presented the results of the group's determination of (a) the metric dimension, (b) the partition dimension or (c) the location chromatic number of a graph chosen by each group.

The lecturer provided assessment criteria to measure the student's learning outcomes as listed in Table 1.

Table 1. Assessment Criteria

No	Assessment Components	Bobot (%)
Assessment of Results		
1	Mid-test	30 %
2	Final-test	30 %
Assessment of Process		
1	The ability to think critically and logically	20 %
2	Analytical ability	10 %
3	Ability to cooperate in teams	10 %
TOTAL		**100 %**

The distribution of the final grade in the 2016 – 2017 academic year is given in Figure 1.1.

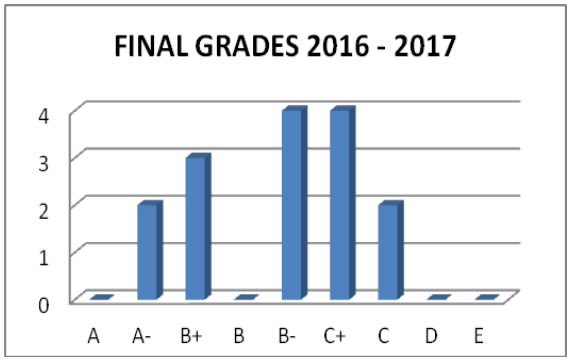


Fig.1 The Final Grade of PAM 472 in 2016 – 2017 Academic Year.

From Figure 1.1 it can be seen that the distribution of the students' final grades is not satisfactory, because 10 out of 15 students scored less than B+. The lecturer thought that one reason for the unsatisfactory results was the inappropriate application of learning methods. Therefore, in the 2017–2018 academic year, we combined two learning methods, the Small Group Discussion (SGD) method and the Discovery Learning (DL) method. We hoped that the combination would increase the students' level of understanding of the course materials and increase their final grades eventually.

2 THE SMALL GROUP DISCUSSION AND DISCOVERY LEARNING

This section contains brief definitions of SGD and the DL methods.

2.1 Small Group Discussion

SGD is a process of learning that takes place when students work together in groups of 4 – 5. It is a learning method that spurs student activity. The lecturer presents the course materials, and then the issues to be discussed are given presented as a whole. Next, the problem is divided into several sub-problems to be solved by each group. After discussion in the group, representatives of each group present the results of the discussion.

Meo (2013) stated that over the last four decades, SGD has achieved an admirable position in education and is well-liked as a means of encouraging students and enhances the process of deep learning. SGD increases student interest and retention of knowledge, enhances the transfer of concepts to novel issues, students' critical skills, teamwork ability, self-directed learning, communication skills, and student-faculty and peer-peer interaction. It provides an opportunity for articulating thoughts and formulating views, and also provides a chance for the students to monitor their learning and gain experience of self-direction and independence from the instructors.

2.2 Discovery Learning

DL is a teaching method that governs teaching in such a way that students gain knowledge that they have not previously known not directly though instruction but partially or wholly by themselves. In DL, activities or learning are designed in such a way that students can discover concepts and principles through their mental processes. In finding concepts, students observe,

classify, make guesses, explain, and draw conclusions to construct concepts or principles for themselves.

Bruner (1961) is often credited with originating discovery learning in the 1960s. He argued that practice in discovering for oneself teaches one to acquire information in a way that makes that information more readily viable in problem-solving. This philosophy later became the basis of the discovery learning movement of the 1960s. The mantra of this philosophical movement suggests that we should 'learn by doing'.

The DL method is defined as a teaching procedure that emphasizes teaching manipulation of objects before reaching generalization. Discovery carried out by students to find a concept or principle. It is a series of mental processes that enables students to assimilate a concept or principle. The mental processes in question include: observing, digesting, understanding, classifying, making assumptions, explaining, measuring, and making conclusions. With these technique students are allowed to find out things by themselves using their own mental processes. The lecturers only guide and provide instructions. It involves students in brainstorming, discussing, reading by themselves and trying things out, so that they can learn by themselves.

As the lecturer only acts as a mentor and facilitator to direct students to find concepts, propositions, procedures, algorithms on their own DL is a teaching method that focuses on student activities in learning.

2.3 Class Action Research Parameters

This research, uses the following parameters.

a) Student Learning Outcomes Results

Learning outcomes are measured by (i) the questions posed by the lecturer to the presenting groups and to the listening groups, (ii) the mid-test and final-test results which measure the competency level of the students against the semester learning plan objectives. In (i), the competencies measured are psychomotor abilities, while in (ii), the competencies measured are cognitive and affective abilities. The results are processed in order to obtain grades at the end of the semester.

b) Student response to the implementation of the learning method

To find out whether the students consider the learning method to be effective, the lecturer conducted a student survey at the end of the semester. This survey data illustrated how students responded to the learning methods and helps direct any follow up action based on the findings in this class research.

3 RESEARCH METHODOLOGY

This research was conducted in class within one semester, in the 2017 – 2018 academic year, and involved students who took Topics in Combinatorial Mathematics II courses. This research is qualitative research, conducted by observing students and participating in class actions. Researchers acted as observers and students as observed objects. In this research, we combined the *Discovery Learning* and *Small Group Discussion* methods to increase the ability of the students to understand the course material. A comparison of the final grade of this course with the same course run in the previous year was used to determine the success of the method.

4 RESULTS AND DISCUSSIONS

In the academic year 2017 – 2018, there were twenty students in Topics in Combinatorial Mathematics II class. The lecturer applied the combination of Small Group Discussion (SGD) method and Discovery Learning as follows. Students were divided into 7 (seven) groups, where members were assigned to each group randomly and stayed in the same group until the end of the semester. The course materials were similar to the previous academic year: (a) the metric dimension, (b) the partition dimension and (c) the locating-chromatic number of a graph.

After the basic concepts of the material in each topic was explained the lecturer gave assignments to each group that was to be presented in the next meeting. Each group was given a different type of graph and was assigned to determine the value of (a) the metric dimension, (b) the partition dimension, and (c) the locating-chromatic number of the graph by themselves. The presentation was carried out by one group for 40 minutes; every student in the group was required to play a role in the presentation. After the presentation, a discussion was held regarding the presented material.

As in the previous academic year, the lecturer acted as a facilitator and moderator during the presentations and in the discussion. The lecturer assessed the presenting group based on (i) their understanding of the material that they found and (ii) the attitudes and presentation technique of the group. The lecturer observed the ability of the presenters to cooperate in teams, their logical arguments, and their analytical skills. The lecturer also provided assessments to students in non-presenter groups,

based on their activeness in responding to the first group's presentation.

Presentation assignments began in the fifth meeting. Reference materials are left up to students, but the primary references are Chartrand (1998; 2000; 2002). All basic definitions and notations in graph theory used in this class are taken from Meo (2013).

Table 2, lists the presentation topics given to every group. These are similar to those given in the 2016 – 2017 academic year.

Table 2: Group Presentation Material.

Week	Material	Group
5	On the metric dimension of some graphs	I
6	On the partition dimension of some connected graphs	II
7	On the partition dimension of some disconnected graphs	III
9	On the locating chromatic number of some connected graphs	IV
10	On the locating chromatic number of some connected graphs	V
11	On the locating chromatic number of some disconnected graphs	VI
12	On the locating chromatic number of some disconnected graphs	VII
13	On the metric dimension, partition dimension and locating a chromatic number of some connected graphs	I, II, III, IV
14	On the partition dimension and locating a chromatic number of some disconnected graphs	V, VI, VII

There were also additional tasks given to every group to be finished during the meeting. If the assignment was not completed in class, then the assignment was used as homework. The lecturer observed the students' ability to work together in teams, think critically and analyze problems.

In table 3, we list the tasks given to every group. These are similar to those given in the 2016 – 2017 academic year. The assessment rubric is displayed in table 4.

Table 3: Tasks.

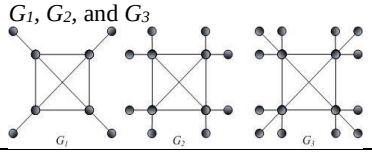
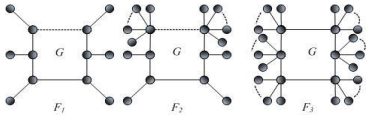
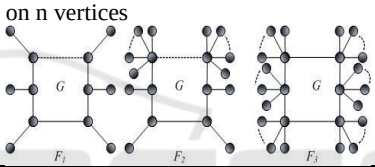
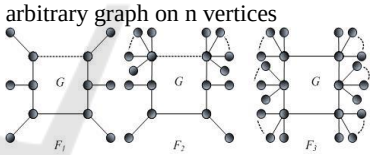
No	Task	Due date
1	Give some examples of graphs G and H that fulfill the condition G, H, H, G	2nd meeting
2	Find the metric dimension of graphs G_1, G_2, and G_3 	3rd meeting
3	Find the metric dimension of F_1, F_2 and F_3, where G is an arbitrary graph on n vertices 	4th meeting
4	Find the partition dimension of cycle C_n and wheel W_n	5th meeting
5	Find the partition dimension of F_1, F_2, and F_3, where G is an arbitrary graph on n vertices 	6th meeting
6	Find the partition dimension of disconnected graphs kP_5, $K_{1,n}$ □ C_t □ P_m for some k, t, and m	7th meeting
7	Find the locating chromatic number of graphs F_1, F_2, and F_3, where G is an arbitrary graph on n vertices 	10th meeting
8	Find the locating-chromatic number of disconnected graphs kP_5, $K_{1,n}$ C_t P_m for some k, t, and m	12th meeting

Table 4: Assessment Rubric.

Grade	Score	Performance Indicator
Poor	≤ 20	No clear discussion is written (included in this category, the students that did not collect their tasks)
Less	21 – 40	There are discussions put forward, but only in small parts, only what is written in the textbook
Standard	41 – 60	The discussion presented was clear enough, covering the entire task order, but less innovative (in the sense of only translating textbooks)
Good	61 – 80	The discussion is quite clear, covers the whole, but not too broad (in a sense, there should be more than just translating textbooks)
Very Good	≥ 81	The discussion is clear, covers the whole, innovative and broad

Figure 3 – Figure 4.10 compares presentation, tasks, mid-test, final test, and the final grade results between 2016 – 2017 and 2017 – 2018 academic years.

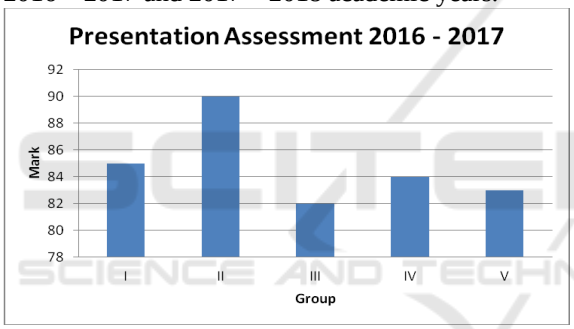


Figure 3: Presentation Assessment in 2016 – 2017 Academic Year.

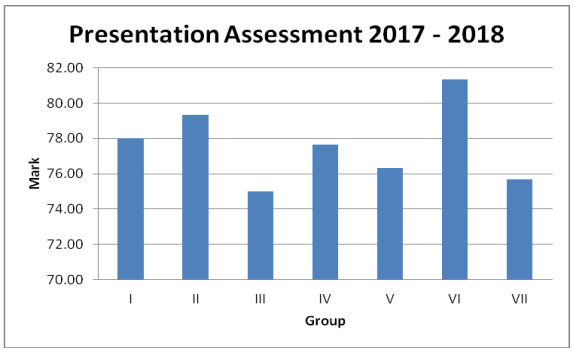


Figure 4: Presentation Assessment in 2017 – 2018 Academic Year.

From Figure 3 - Figure 4, it can be seen that the average grade for student presentations in the 2017 – 2018 academic year was lower than in the 2016 – 2017 academic year. After being evaluated at the end of the semester, the problem occurred because the students focused more on the more massive presentation material, with a narrow preparation time of only one week, because they have to find the metric dimensions, partition dimensions and to locate chromatic numbers of a new graph chosen by themselves rather than by reading the papers. In the future, it is planned that the lecturer would give the presentation material two or three weeks before. It is hoped with longer preparation time; students can prepare their presentations better.

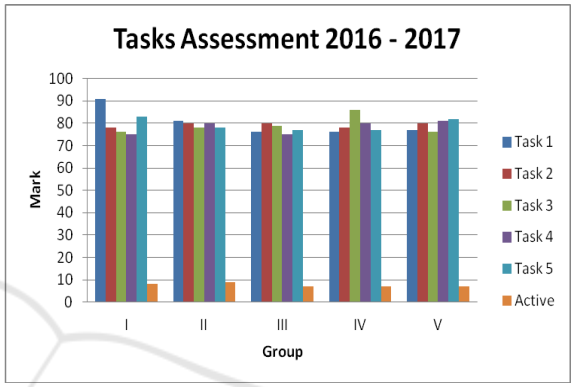


Figure 5: Tasks Assessment in 2016 – 2017 Academic Year.

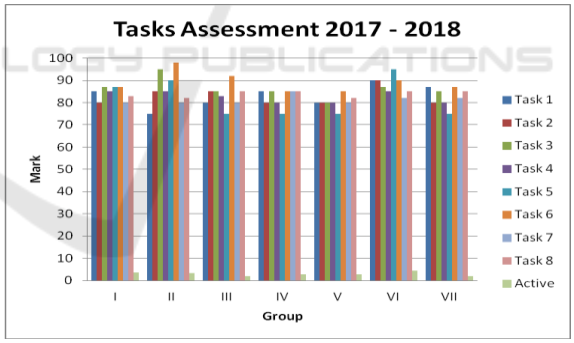


Figure 6: Tasks Assessment in 2017 – 2018 Academic Year.

Figure 5 – Figure 6 show that the average grades for of student tasks in the 2017 – 2018 academic year is higher than in the 2016 – 2017 academic year. After being evaluated at the end of the semester, the students said that they felt challenged to find something new, namely the metric dimension, partition dimension and locating a chromatic number of new graphs, and always eager to do all the assignments given.

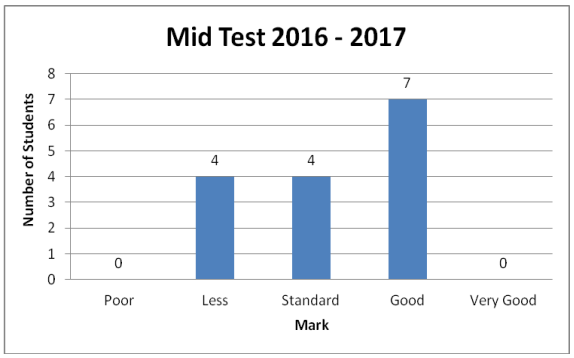


Figure 7: Mid Test Assessment in 2016 – 2017 Academic Year.

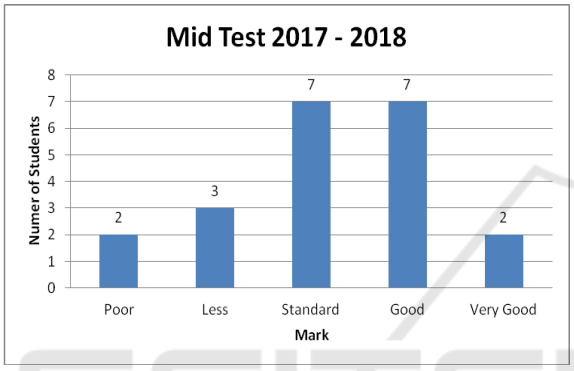


Figure 8: Mid Test Assessment in 2017 – 2018 Academic Year.

From Figure 7 – Figure 8, the average value of the mid-test exam in the 2017–2018 academic year was higher than that of the 2016 –2017 academic year. After being evaluated at the end of the semester, the students said that because they are pushed to find the metric dimension, partition dimension and locating a chromatic number of graphs they chose themselves, and then explained their discovery in their presentation they understood the course material much better.

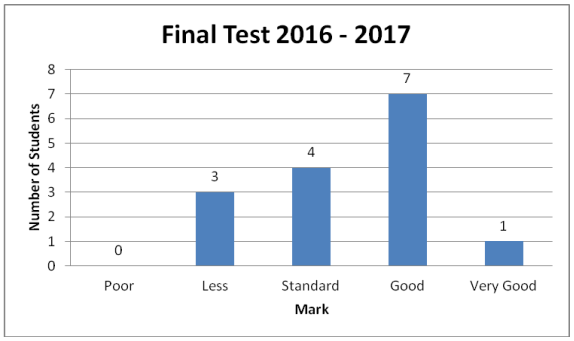


Figure 9: Final Test Assessment in 2016 – 2017 Academic Year.

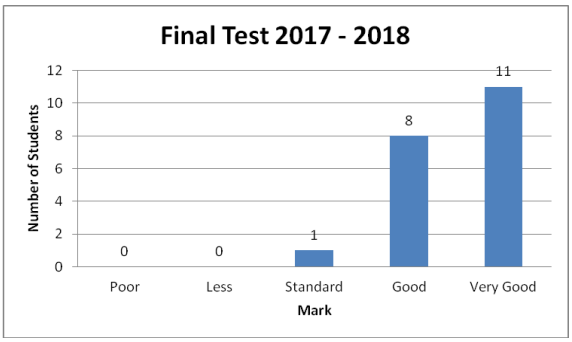


Figure 10: Final Test Assessment in 2017 – 2018 Academic Year.

From Figure 9 – Figure 10, it can be seen that the average value of the final test exam in the 2017 – 2018 academic year was higher than that of the 2016 – 2017 academic year. After being evaluated at the end of the semester, the students said, as with their mid-tests, it was because they were pushed to find the metric dimension, partition dimension and to locate a chromatic number of some graphs they chose themselves, and then explained their discovery in their presentation they understood the course material much better.

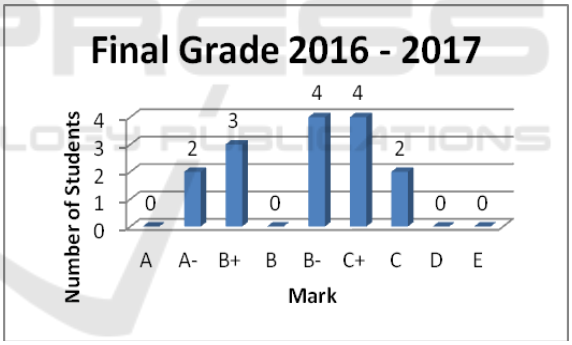


Figure 11: Final Grade in 2016 – 2017 Academic Year.

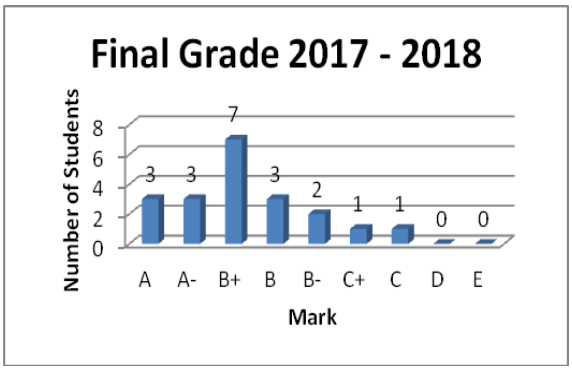


Figure 12: Final Grade in 2017 – 2018 Academic Year.

Figure 11 – Figure 12, compares the final grade in the 2017 – 2018 academic year with the final grade in 2016 – 2017 academic year. The final score was obtained from 20% presentation assessment, 20% task and activeness assessment, 30% mid-test score and 30% final test score, according to the assessment criteria in Table 1.1. It can be seen as the percentage of students with a final grade of less than B+ decreased from 66.67% (10 out of 15 students) to 35% (7 out of 20 students).

5 CONCLUSION

In this research, we combined two learning methods, the *Discovery Learning* and *Small Group Discussion*. We aimed to increase the ability of the students to understand the course material. By comparing the final grade in the academic year 2016 – 2017 and 2017 – 2018, we found that the combination of the methods was successful as is evidenced by the decreased percentage of students with a final grade less than B+.

REFERENCES

Bondy, J.A, Murty, U.S.R, 2010, *Graph Theory with Applications*, the Macmillan Press Ltd., New York

Bruner, J. S, 1961, The act of discovery, *Harvard Educational Review*. 31(1): 21 – 32

Chartrand, G., L. Eroh, M.S Johnson, O.R. Oellerman, 2000, Resolvability in Graphs and the Metric Dimension of a Graph, *Discrete Appl. Math*., 105: 99 – 113

Chartrand, G., Erwin, D., Henning, M., Slater, P., Zhang, P., 2002, The Locating-chromatic number of a graph, *Bull. Inst. Combin. Appl* 36: 89 – 101

Chartrand, G., Salehi, E., Zhang, P., 1998, On the partition dimension of graph, *Cong. Numer*. 130: 157 – 168

Meo, S.A., 2013, Basic Steps in Establishing Effective Small Group Teaching Sessions in Medical Schools, Pak. J. Med. Sci 29(4) : 1071 – 1076

Moore, R., Lopes, J., 1999. Paper templates. In *TEMPLATE'06, 1st International Conference on Template Production*. SCITEPRESS.

Smith, J., 1998. *The book*, The publishing company. London, 2nd edition.