TEAM FORMATION AND GROUPING PROBLEM FOR GRADUATION PROJECTS

Dyek Chungwang Michael
Department of Industrial Engineering, Faculty of Engineering, Cyprus International University, North Cyprus.
dyekchuwee@gmail.com.

Nidai Kordal
Department of Industrial Engineering, Faculty of Engineering, Cyprus International University, North Cyprus.
nkordal@ciu.edu.tr.

Benjamin Mukadi
Department of Environmental Engineering, Faculty of Engineering, Cyprus International University, North Cyprus.
franckyulquiorra@gmail.com.

ABSTRACT
The aim of this study is to develop an assignment system for Graduation Project Group Formation (GPGF). In the Faculty of Engineering, Cyprus International University (CIU), students from different departments are forming interdisciplinary project groups depending on the requirements of the proposed project. Current assignment method is causing problems like students can be assigned to project where their knowledge on specific courses required by that project is very limited or the ones that they don't want to study. These two reasons can decrease the quality of the project. Another problem is the group setup, where the attitude of the students and their personal characteristics affects the performance of the team. In this study, an assignment methodology is being designed, which considers students characteristics (behavior) and academic performance to achieve team harmony and improve quality of the graduation projects. An assignment algorithm is formulated for assigning students to the graduation projects.
Keywords: Personal Behavior, Team formation, Assignment algorithms

1. INTRODUCTION

This paper pertaining assignment problem within the education domain. Assignment problem arises in diverse situations, where problem involves the allocation of resources or people to enable jobs or tasks to be performed satisfactorily. In this study, information of students and project requirements are recorded in a database. It can be accessed via a website. Students are asked to fill a questionnaire that determines their personal characteristics. Instructors and the project coordinators will use the website for project description and requirements entry.

Designed assignment algorithm assigns students according to their personal characteristics and their academic performances. Groups should have students with openness, conscientiousness, emotional stability, agreeableness and extraversion characteristics to achieve a balance for heightened performance of the group. At the same time, group member's knowledge on project topic should be above acceptable level. In this paper, assignment algorithms, collected personal characteristics, project requirements and future work have been discussed.

1. 1 Assignment Problem

According to Andrew J. W. (2007), this type of problem involves the allocation of resources or people to enable jobs or tasks to be performed satisfactorily. In our study, problem is classified as a problem where each student will be assigned (become a group member) to one single Graduation Project.

1.2 Group Allocation Problem

Group allocation problem is categorized into three sub problems by Andrew J. W. (2007).

The New Student Allocation Problem (NSAP): The new student allocation problem (NSAP) is a clustering problem in allocating new students to their corresponding class with minimum intelligence gap by sorting method.

Student Project Allocation Problem (SPAP): This is related to assigning a person to a particular project or cases based on performance and preference or interest of student and lecturer.

Space Allocation Problem (SAP): This refers to a problem to allocate resources to space areas, for example, allocating rooms and at the same time satisfying several requirements and constraints.

1.3 Solution Techniques

In addition to algorithm for finding feasible and optimal assignments to groups, in literature Mathematical modeling and Metaheuristics algorithms are also been used.

Mathematical Modeling is translating of problems from an application area into tractable mathematical formulations whose theoretical and numerical analysis provides insight, answers, and guidance useful for the originating application.

Metaheuristic is a higher-level procedure or heuristic designed to find, generate, or select a heuristic (partial search_algorithm) that may provide a sufficiently good solution to an optimization problem, especially with incomplete or imperfect information or limited computation capacity. (Kallrarth, 2014).

2. METHODOLOGY

In this research designed methodology could be summarized in 3 steps.

1. Project descriptions obtained from instructors
2. Attributes of students will be collected
   - Academic Attribute: grades of students will be obtained from Registrar
   - Behavioral Attribute: students were asked to fill a questioner
3. Assignment algorithm will be run to assign students to projects

2.1 Project Description

Project Supervisors are asked to fill the Project Description Form on the web site, as seen in figures 1, which contains:

- Project description: fully describe the objective and requirements of the project.
- Number of students and departments
- Requirements courses for the project for every student (discipline related departmental courses).

Project Title	**The Team Formation Problem for Graduation Project Selection**
Project Summary:	
Project Requirements: **It is vital that instrumentation, experimental equipment, computer software etc, be functional at the start of the project. Please indicate your requirements as follows:-**	
i) Equipment service/repair calibration etc.	----------
ii) Technician effort prior to project	----------
iii) Technician effort during the project	----------
iv) Visits for data collection off-campus	----------
v) Materials & other consumables	----------

Student Requirements

Program	Course 1	Course 2	Course 3
INDE			
INDE			
CMPE/ISE/MIS			

Figure 1: Project Description Form

2.2 Attributes Classification and Questionnaire

There are two major attribute classifications for each student, the Academic attribute and Behavioral attribute. The Grade attribute places students in categories base on their performances and departmental courses they have taken while the behavioral attribute deals with the physical and emotional behavioral state of students.

Emotional state of humans mostly determines their actions in certain activities. For example, if a certain student has issues of 'quick to anger', other students will have issues working in groups with them. The best way to handle people like this is to pair them with students who can tolerate such behavior and do not have similar emotions, which is students that are not easily provoked or those who are slow to anger. The behavioral attribute can further be broken down into five sub-categories.

2.2.1 Academic Attribute

Performance of the student in their departmental courses is defined as Academic attribute. In CIU Engineering Faculty, there are ten departments and for each department ten departmental courses have been selected which are used by students in their graduation projects. For determining Academic attribute, letter grade of students have been entered for courses they passed. Following table contains list of those departments and selected departmental courses.

Table 1: Departmental Course List

DEPT.	Course 1	Course 2	Course 3	Course 4	Course 5	Course 6	Course 7	Course 8	Course 9	Course 10
Civil Eng.	CVLE 262	CVLE 222	CVLE 212	CVLE 351	CVLE 331	CVLE 332	CVLE 381	CVLE 361	CVLE 372	CVLE 341
Industrial Eng.	INDE204	INDE212	INDE232	INDE372	INDE441	INDE221	INDE321	INDE341	INDE352	INDE433
Electrical Eng.	EELE362	EELE324	EELE321	EELE342	EELE234	EELE212	EELE202`	EELE262	EELE221	EELE212
Petrol, Oil and Gas Eng.	MCLE 270	ENRE 404	ENVE 202	EELE342	MCLE 476	ENRE 405	ENRE 402	EELE234	MCLE 371	INDE352
Computer Eng.	CMPE 214	CMPE 226	CMPE 213	CMPE 242	CMPE 313	CMPE 314	CMPE 381	CMPE 361	CMPE 372	CMPE 331
Bioengineering	BIOE213	BIOE401	BIOE112	BIOE308	BIOE252	BIOE252	BIOE305	BIOE101	BIOE361	BIOE302
Environmental Eng.	ENVE 343	ENVE 104	ENVE 201	ENVE 202	ENVE 206	ENVE 305	ENVE 301	ENVE 402	ENVE 411	ENVE 431
Energy Systems Eng.	ENRE 315	ENRE 404	ENRE 308	ENRE 403	ENRE 306	ENRE 403	ENRE 402	ENRE 405	ENRE 302	ENRE 303
MIS	MIS479	IT102	ITEC101	WP101	ISE100	ISE464	MIS479	MIS402	WP102	ISE400
Mechanical Eng.	MCLE 222	MCLE 270	MCLE 475	MCLE 212	MCLE 372	MCLE 445	MCLE 476	MCLE 303	MCLE 312	MCLE 371

As defined in the Project Description Form, students who took required course for a project will become a candidate for that project. One among those candidate students will be assigned to that projects by the Assignment Algorithm.

2.2.2 Behavioral Attribute

The Big Five personality traits are Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. These five factors are assumed to represent the basic structure behind all personality traits (John M. & Grohol P. 2019).

1. **Openness**: students in this category are open to others, they share ideas and are always open to new experiences, which will guarantee that they will agree to work with other people's ideas and methods. Two or more can be placed in the same group.
2. **Conscientiousness:** conscientious people tend to be efficient and organized. They are mostly dependable. They are people who will not want to participate much in a group work, as they will always want to work singly. Though they might be hardworking, they cannot be put as group leaders. Maximum of two in a group.
3. **Extraversion**: Extraversion people enjoy being around people more than being alone. They get their energy from being around others, so they tend to be more sociable. People in this category will be good leaders if appointed, as they will always try to bring the group together. Two or more can be placed in a group.
4. **Agreeableness**: High scorers for this trait are often trusting, helpful and compassionate. This checks if an individual will relate easily with other group members, especially strangers. Two or more can be placed in the same group.

5. Emotional stability: People with high scores for this trait are usually confident and do not tend to worry often, they can be appointed as group leaders because they are mostly focused. Though focused, they will always want to be in charge of every group activity. Not more than one in a group.

Table 2: Behavioral Attribute Questionnaire

No	QUESTION	EXPLANATION
1	Will you love to work on topics from other departments?	The answer to this question will help narrow down topic selection to the topic the student is interested in, which will increase the student's participation in the group work. (**TOPIC PREFERENCE**) ***Agreeableness.***
2	Do you prefer working in a large or small group of people? (from 1 for very small to 10 for very large)	This question will help in placing students in topics with large or small group of participants. **(GROUP NUMBER PREFERENCE)** ***Conscientiousness.***
3	Do you prefer telling people what to do or prefer being told what to do? (from 1 for being told what to do to 10 telling people what to do)	This will help pick out those who want to be leaders and want to control their groups so they can be distributed evenly to get all group works done. **(GROUP LEADER PREFERENCE)** ***Emotional stability.***
4	How deep do you like group work?	This will give idea on how members love group work. **(LOVE FOR GROUP WORK)** ***Openness.***
5	How deep do you participate in a group works?	This will give full idea and help categorize students on level of group work participation. **(MEMBERS PARTICIPATION)** ***Extraversion***
6	At what level (1 – 10) will you like to help other group members do their own part of work?	This will how members who can help other group members to make sure the group work is completed. **(DEDICATION TO COMPLETION)** ***Emotional stability.***
7	In estimation, how many group works have you participated in? (from 1 to 10 or more)	This will give the level of experience individuals have in a group work **(GROUP WORK EXPERIENCE)** ***Extraversion.***
8	How much time can you dedicate to your group work? (from 1 to 10 or more)	This will point out those who will put full effort in achieving the goal of the group work. **(GROUP WORK DEDICATION)** ***Emotional stability.***
9	Do you know how to lead people in a group work? (from 1 for no experience to 10 for very experienced in leader people)	This question will help point out those who can and will want to control a group work **(GROUP LEADER SELECTION)** ***Emotional stability.***
10	Do you love to meet new people? (from 1 for don't like meeting new people to 10 for love meeting new people)	This will show students who won't mind working with anyone, not necessarily friends **(FAMILIARIZATION/MEMBERS ACCEPTANCE)** ***Openness.***
11	Among this three, which will you classify as your attitude towards others. Polite(P), Neutral(N), Rude(R)	This will tell the way of approach of group members towards each other.

Measuring scale used in the questioner is from 1 to 10, 1 being very poor and 10 being very good.

- Questions 4 and 10 are used to check students Openness → Score must be > 7 to be qualified in this group.
- Questions 1 and 6 are used to check students Agreeableness → Score must be > 6 to be qualified in this group.
- Questions 2, 5 and 7 are used to check students Extraversion Score must be > 7 to be qualified in this group.
- Questions 3 and 11 are used to check students Conscientiousness. Score must be > 8 to be qualified in this group.
- Questions 8 and 9 are used to check students Neuroticism. Score must be > 6 to be qualified in this group.

3. ASSIGNMENT ALGORITHM

3.1 Assignment Algorithm

The grouping of students and assignment of projects depend on the characteristics of that project such as course requirements and the constraints that must be followed.

In the case here, students are to be assigned into group's base on their characteristics, which was obtained using a questionnaire and then assigning project topics to those groups. To achieve successful placements, we tried to ***maximize the benefits*** of each student and followed some constrains which gave us the possibility of grouping and placement.

3.2 Algorithm Steps

1. Project topics from different departments are been saved in the system with their departmental and course requirements.
2. The system will pick a non-assigned topic from list of topics.
3. Then pick students from table of required department that have not yet been assigned topics.
4. Then the system will check the sum of their scores on the required courses for that project topic.
5. The student with the highest sum will be selected and assigned to that project topic.
6. The whole process will repeat itself until number of students required for that topic is reached.
7. The loop continues until all students and topics have been assigned.

3.3 Database Requirements and Constraints

- A list of students is saved in database according to their departments and their departmental course grades.
- Each department has its identification number. E.g. computer engineering is department number '5'.
- All project topics are saved using their numbers in the database e.g. project 1 = 1, project 2 = 2 … project 20 = 20.
- A sample of a saved project topic with its complete requirement will look like this: 3((5,1,5), (2,2,6), (2,2,6), (10,3,7)), topic number 3 requires courses '1' and '5' from department number 5, courses '2' and '6' from department number 2, courses '2' and '6' from department number 2 and course '3' and '7' from department number 10.
- Grades are out of 4 depending on the letter grades, which are from (A (4) to D (1))

Table 3: letter Grade to Point Table

NO	LETTERS	POINTS
1	**A**	**4**
2	**A-**	**3.7**
3	**B+**	**3.3**
4	**B**	**3**
5	**B-**	**2.7**
6	**C+**	**2.3**
7	**C**	**2**
8	**C-**	**1.7**
9	**D+**	**1.3**
10	**D**	**1**
11	**D-**	**0.7**
12	**F**	**0**

- Score for empty course is zero (0). (Courses that student have not taken yet) for students who failed a course or might have been delayed for some reason.

Students List Tables (table i)

P.NO. = Project Number GIVEN
C1 = Course 1
S.NO = Student Number

Table 4: table showing how unselected students will appear

CMPE(5)											
S.NO	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**P.NO.**
1234	1	2.3	1	3.7	4	2	1.7	2	1.3	2	0
2345	3.7	2	1	2	4	3	1	3.7	1	2	0
3456	1.7	2	1.7	4	2	2.7	1	2	2.7	3.3	0
4567	2.7	2	1	.3	4	2	3.7	3	1	2	0

3.4 Selection Method

"Select project topic to be given to students"
Project '3' selected which has the following requirements
3(, (5,1,5), (2,2,6), (2,2,6), (10,3,7)).

3.4.1 Requirement Explanation

- One student from CMPE (5) department who is good in 'database' (1) and 'visual programming' (5).
- Two students from IENG (2) department who are good in 'modelling and optimization' (2) and 'operations research' (6).
- One student from MIS (10) department who is good in 'web development' (3) and 'web design' (7).

3.5 Pseudo code

Default point score before selection of project topic is '0'
Default Course max = 0
y = (y1, y2, y3, … yn) "number of students"
k = (k1, k2, k3, …, k10) "for 10 departmental courses"
x = "department"
j = "students in group"
i = groups = (i1, i2, i3, …, i20)
z = "project assigned"
For Project (i, j, k)
Group = i1(j1, j2, j3, j4)
Find =j1(x, y1, z12)
If j1(x, y1, z12) ≠ 0
Skip y1.
Else If j1(x,y1,z12) = 0
Sum Course points = y1(k1 + k2)
If (k1 +k2 = course max)
Δ course max = course score y1
Else If (k1 + k2 > course max)
Δ course max = course score y1
Else If (k1 + k2 < course max)
Course max = course max
End
End when yn = y15
Assign project 'i1' to yn (course max)
End when "j" = 4
End when "i" = 20.

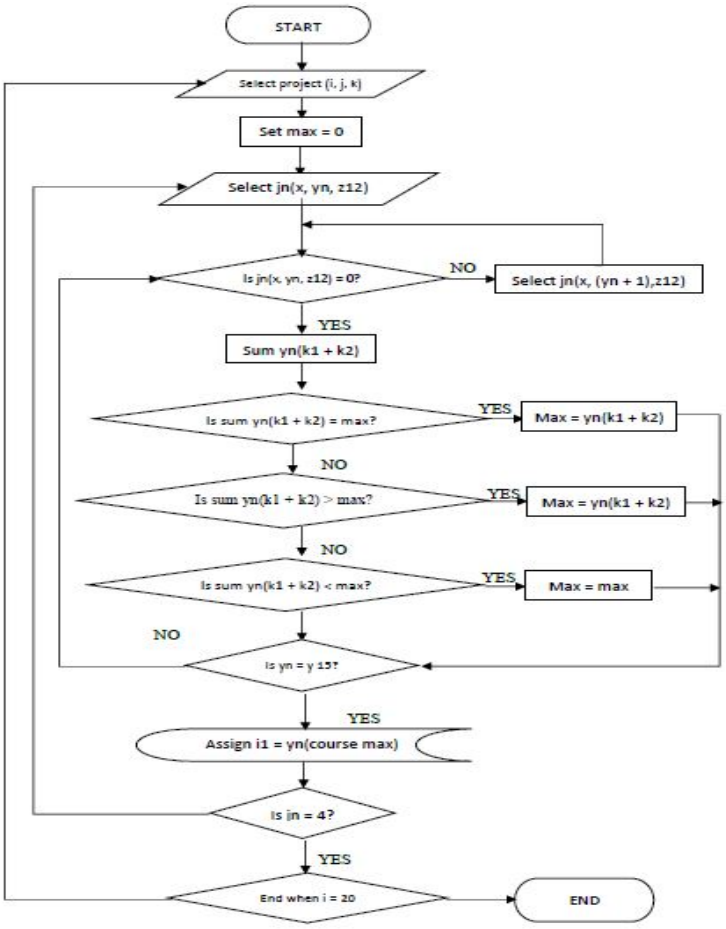

Figure 2: Algorithm Flow Chart

"Table below will show how selected students will appear in their departmental table after selection."

P.NO. = Project Number
C1 = Course 1
S.NO = Student Number

Table 5: How a Selected Student will appear

CMPE(5)											
S.NO	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**P.NO.**
1234	1	2.3	1	3.7	4	2	1.7	2	1.3	2	0
2345	**3.7**	**2**	**1**	**2**	**4**	**3**	**1**	**3.7**	**1**	**2**	**3**
3456	1.7	2	1.7	4	2	2.7	1	2	2.7	3.3	0
4567	2.7	2	1	.3	4	2	3.7	3	1	2	0

4. WEBPAGE INTERFACE

The programming tools used in creating the webpage are CSS3, Java Script, PHP, my SQL and HTML 5, though PHP being the core programming language used. Below are some of the properties in which we brought into consideration during our webpage development.

- User Friendly
- Clarity
- Responsive
- Efficiency
- Consistency

The system is developed as a webpage to increase ease of access and reachability to all parties (students and lecturers).

4.1 Welcome Page

This page is the welcome page in which a user will see when he or she enters the webpage link. The welcome page contains information about the webpage, the student login and the lecturer login.

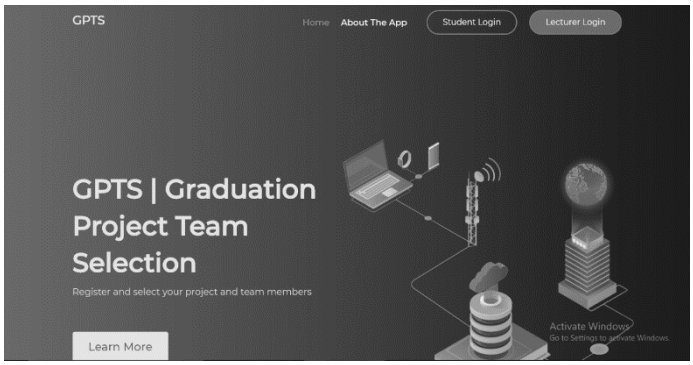

Figure 3: Welcome/Home Page

4.2 Login Page

The student login page is where the students go to login to the webpage. The username and password of all students is the same with the one of their school portal. Which means there is no need to create a username or password and the same implies to lecturer login.

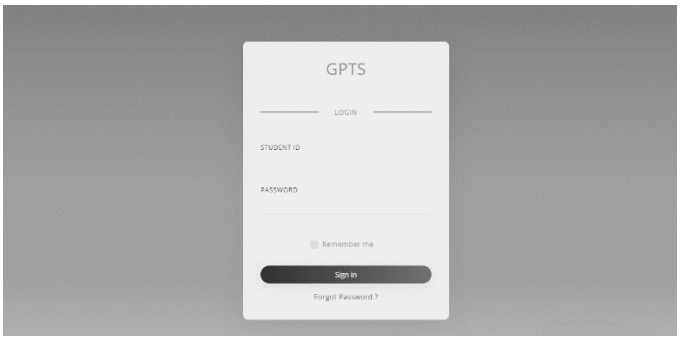

Figure 4: Login Page

4.3 User profile

This page is the display of all the information of the user such as name, email address, home address etc. the user profile is also taped from students/lecturers school profile, therefore having the exact information as the individual's school profile.

Figure 5: User Profile

4.4 Topic proposal

This page is where students go to propose or suggest a topic. This page is a suggestion page for the students. They can suggest or propose topics they feel are important and also should be included in the list of project topics. The student suggesting the topic will write the name of his or her topic and also provide the topic description and requirements.

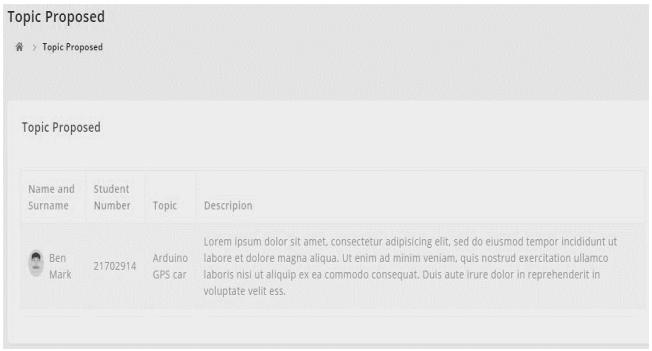

Figure 6: Topic Proposed by Student

4.5 Lecturer page

Lecture login page contains the same information as the student login page. A student cannot login on the lecturer's login page and vice versa. The lecture profile contains the following pages:

4.6 List of students

This page displays the list of students with their grades from departmental courses only. Since the matchmaker makes use of only their departmental courses, the profile will hold only their departmental courses, in which the grades will be scanned and used during matchmaking.

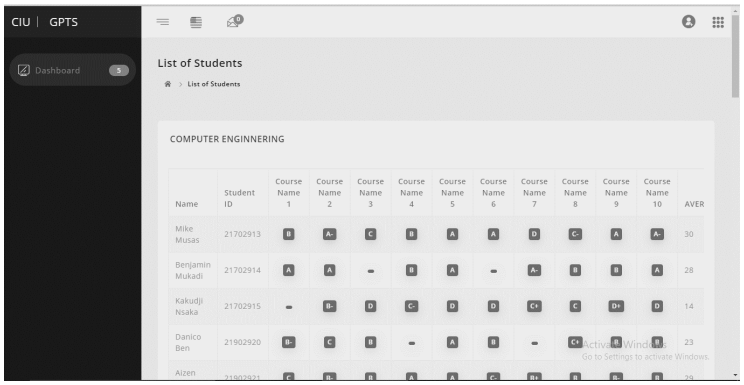

Figure 7: List of Students with Grades

4.7 Matching Page

This generates and creates groups for all the students in the system. The Matching page is the most important page in the system as it holds the major responsibility of the system, which is generating and pairing of students into groups. First, student's information and grades of their departmental courses are stored in the system. When the generate button is clicked, the system runs the algorithm shown in chapter three and then automatically pairs students according to their requirements. After generating the groups, it displays all students in their groups, tagging them to their proposed topics. The matching page is easy to operate, as it requires just a click of a button to generate the groups.

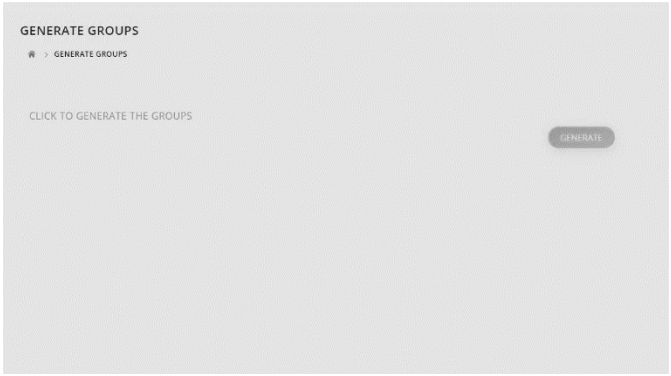

Figure 8: Matchmaker before Matching

CONCLUSION

Although the solution to group placement was not an optimal one, but a feasible and usable solution to project grouping problem was developed. In this study only academic performance of students had been used for group assignment which will ease the allocation of project topics to students and team member's selection. A general methodology is been designed on how the Graduation Project Group assignments can be done in the CIU Faculty of Engineering. Personal characteristics which are defined as Behavioral attribute needs further study because of the validity check. After that, Behavioral attributes will be added to the developed assignment algorithm and achieve a balance in team member's ability, and maximize the effort or every group member.

As a future work inclusion of Behavioral attributes will need better algorithmic method, which may require use of Multi-objective optimization techniques and Metaheuristics for finding optimal group assignments.

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