

GROUP-FORMATION SYSTEM TO FACILITATE HETEROGENEOUS GROUPING IN COLLABORATIVE LEARNING FOR NON-TECHNICAL COURSES

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ABSTRACT

The ability of students to work in groups to solve a problem or complete a task is important. However, the current method of forming a group for projects is based on convenience. This self-selection grouping method could result in an imbalance knowledge, skills and personality. Grouping the students based on criteria manually is tedious and time-consuming. This paper presents the development of a system, called GrouPro that could automatically group the students based on the student's personality, skills and academic performance. This is to ensure a group will consist of students with diverse skills, personality and academic performance, thus establishing a well-balanced student group in the class throughout the semester. The results of the user acceptance test have indicated that the system is easy to use. The lecturers are considering using the system in their class as they perceived the system to be effective and useful in grouping the students based on the determined criteria. The students perceived that the system is easy to use and useful but have mixed responses in using the system in actual settings.

Keywords: teaching, learning, group work, students

INTRODUCTION

Working in teams is one of the desirable skills of a graduate by employers of various industries [1]-[3]. In universities, lecturers incorporate group work as a pedagogical mode not only to enhance student's understanding of the subject but also to develop teamwork skills. One of the active learning approaches that use student group work is collaborative learning. Collaborative learning is defined as a teaching practice that includes a group of students working together to solve a problem, complete a task or create a product [4]. Collaborative learning can be informal, formal and base cooperative learning groups [5]. In informal cooperative learning, the groups are typically small, temporary and ad-hoc. The group is formed for

answering questions or executing tasks posed by the lecturer. Examples of informal cooperative learning are think-pair-share, peer instruction and jigsaw [6]. Formal cooperative learning requires the group to exist for more than one class session, several weeks or throughout the semester. The tasks in this cooperative learning involve analyzing, making decisions and write reports. The cooperative base groups are long-term and heterogeneous cooperative learning with stable membership. The group's purpose is to provide support, help, encouragement, and assistance each member needs to make academic progress [5]. Examples of formal cooperative learning are team-based learning, problem-based learning, and process-oriented guided inquiry learning [6].

In university, working in groups is one of the activities of learning. Groups can be formed based on convenience or self-selected, which results in the group being homogenous. Srba & Bielikova [7] stated that the self-selection group could be highly unbalanced, which leads to a compelling composition of groups. Chiriac [8] conducted a study on student's experience of group work, and they discovered that working in a group facilitated learning and developed the student's collaborative skills. They also stated that in order for the students to learn from group work, their composition should be heterogeneous. A heterogeneous group means that the formation of the group is non-random. A non-random group formation involves the use of criteria as the basis to group the students. If this approach is taken in a class, the lecturer must first collect information from each student based on the criteria of the project. Secondly, from the students' information, the lecturer will group them according to the requirements of the project.

In any group, compatibility among team members can be an issue that leads to conflict [9]. For example, a team that consists of different working styles could lead to conflict as one member is not able to confirm or to adapt to other member's working style. This situation provides a negative work environment. Forming a well-balanced group this way is tedious, especially in large classes. Thus, this article is designed for a system that could facilitate non-random grouping to achieve a well-balanced group. The criteria used as the basis to form the group are academic performance, skills and personality type. Academic performance and skills demonstrate the capabilities of the team members while personality is the criteria used to address team members compatibility

LITERATURE REVIEW

Group work is defined as a "form of cooperative learning which aims to develop student's knowledge attitudes and generic skills in areas such as communication, collaboration and critical thinking" [10]. One of the most popular theories about teams is Belbin's team role theory. Generally, this theory states that a well-

balanced team performs better than the unbalanced team. A good balance team, according to Belbin's team role theory, consists of nine roles which are Shaper, Coordinator, Plant, Resource Investigator, Monitor Evaluator, Specialist, Teamworker, Implementer, Completer Finisher. Meslec & Curşeu [11] conducted a study on well-balanced groups in education using Belbin's team role theory. Their findings indicate that a well-balanced team increase group performance in the initial phases and have persistent effects on the level of group cognitive complexity. They also found out that the percentage of women positively predicts teamwork quality. Groups can be formed by the instructor or self-selection [12].

Existing Group Formation Methods

Odo [13] stated that groups could be formed in various ways. The groupings can be based on specific criteria or based on convenience. Blowers [14] describes the approach in group formation as random and non-random. Groups can be formed by the instructor or non-random. In this approach, the lecturer determined the members of the group. The author used skills as grouping criteria rather than academic performance to achieve a balanced group. The author claims that using grade-based criteria would lead to student conflict and affect the student's motivation in the group. This grouping is non-random because the formation of the group is based on criteria that are needed to achieve the group's objective.

Nonetheless, this grouping still has that degree of randomness because the students do not know who will be their group mates. Oakley et al. [12] suggested that lecturers should form groups. However, a group with all weak students will cause the group to progress without direction. A group with all high achievers operates by having the work divided and less discussion among group members. Nevertheless, this is different from Harding [15] that suggested that students who are grouped according to their willingness and availability to contribute experience less free-riding in the group. The group's performed better on the group and individual assignments too. Mesquite & Lopes [16] investigated the student's participation in different group formation strategies. In one of their

findings, the authors found out that students prefer self-selection group formation because they are aware of the colleagues' skills and abilities. It makes them comfortable to work in a group. Nonetheless, the students perceived that the instructor-formed group could enhance their communication and socialization skills.

An instructor-formed group has its benefits. Oakley et al. [12] stated that the instructor-formed group benefits the students, particularly the weak students. The weak students can see how good students approach the task in hand. The good students benefit in the sense that they are able to tutor the weak students. Mahenthiran & Rouse [17] conducted a study on the impact of group selection on student performance and satisfaction. Their findings indicate that student attitudes were positive when the instructor forms the groups. The grades were also better than the self-selection group, regardless of the student's grade point average. The drawback of the instructor-formed group is that the group members have low interaction among the group members compared to the self-selection group [12].

The mechanism to group students based on self-selection is a straight forward process. The students generally can form a group with whomever they want. The mechanism for lecturers to group students based on certain criteria requires several steps. Firstly, information from the students needs to be collected. This information can be skills, grade point average [14] or prerequisites [12]. Next, the lecturer has to sort, rank and finally group the students accordingly. Oakley et al. [12] use physical forms that are distributed, filled out and collected on the first day of class. The use of forms can be daunting in large class sizes.

Group Formation Criteria

For a group to perform effectively and be productive, a group must have balanced skills, abilities and personalities among its group members [18]. Thus, during group formation, members need to be assessed through a given set of criteria required for the project. The context of this study is project groups in educational settings; therefore, three criteria are

considered namely personality, skills and cumulative grade point average.

Personality

Personality is regarded as the characteristics or qualities that define the character of a person. Jackson et al. [19] stated that team members' interpersonal compatibility is distinctly to be the essential element for a team to run effectively. Furthermore, what makes an individual highly demanded is their individual characteristics in general. Carnevale et al. [20], Eby & Dobbins [21] and Barrick et al. [22] found that team performance may have improved with higher levels of general agreeableness, mental ability, and conscientiousness in the selection of team members. What makes it more reliable is that they also found that total team processes and performance can be negatively affected by just one team member lacking the desirable interpersonal traits.

Skills

Skill, experience and expertise are importantly related to effectiveness measures and group measures [23]-[24]. Therefore, task-appropriate knowledge and interpersonal skill have come into sight to be significant criteria for group performance. In this study, a group member is regarded as having a skill if the member has the ability to do something well. Sanjeev & Kent [25] emphasized that soft skills are highly critical to cater to the fast-changing work environment. Denise [26] came up with the idea of 'ability to working effectively with others' (WEWO) as an essential skill that graduates must be possessed. The WEWO framework developed by Jackson et al. [19] listed the skills as working effectively with others, communicating effectively, self-awareness, thinking critically, analyzing data and using technology, problem-solving, developing initiative and enterprise, self-management, social responsibility, and accountability and developing professionalism.

Grade Point Average

This study posits that grade point average (GPA) serves as an essential criterion in group formation as GPA determines the level of academic performance of a student. Mahenthiran & Rouse [17] highlighted that

students of good standing tend to group together while underperforming students are left together. As a result, students who are paired or grouped together tend to have a better outcome as compared to those underperforming groups. Using GPA as a criterion seems typical.

Existing Group Formation Tools

The use of group formation systems can make the process of grouping becomes less arduous. Group formation systems are designed by including various criteria and developed using technologies such as web-based, artificial intelligence [27]-[29] and programming languages such as Java, web-based languages. Christodoulopoulos et al. [30] developed a web-based group formation tool that supports the instructor to automatically create both homogeneous and heterogeneous groups based on three criteria which are knowledge level and learning style, and the learners to negotiate the grouping. The tool allows the instructor to group the students manually based on specific criteria. The tool uses the fuzzy c-means algorithm allows students to be in different groups. Thanh et al. [31] develop a platform where learners can search for peers with compatible characteristics. This idea shares the same perspective with Shih et al. [28], which group students based on familiarity. Thanh also proposed a recommender system called the Learning Partner Recommender System (LPRS) that allow students to find the peers that they feel comfortable and trust. The authors argue that the existing grouping system is based on the lecturer's perspective, such as required skills and academic performance. The results of the user acceptance test of LPRS indicates that the system is useful in finding peers with compatible characteristics to form informal learning communities.

Dascalu et al. [32] develop a learning management system using Java called GrooPro. One of the features of GrooPro is grouping the students based on the required skills in a software engineering project. Lecturers identify the required skills for the project. In GrooPro, the lecturers will create a form that contains questions about the skills. These questions will capture the skills for each of the student and store in a skills

inventory. The authors conducted a user acceptance test on GrooPro. Their findings indicate that GrooPro is easy to use and efficient. A well-balanced group now can be formed faster.

Shih et al. [28] proposed a group formation system using a genetic algorithm. The adoption of artificial intelligence in group formation makes computation time short thus, makes it suitable when the size of the students is large. The grouping of students is based on the familiarity among the students within the group. The relationship among students is known as friendship values which are collected through questionnaire and complementary degree. Based on the input, the group formation system will generate a directed social network graph. The group formation system is integrated with a web-based e-Learning system. The students complete the questionnaire in the group formation system and upload assignments. The tutors or lecturers grade the assignments and give ratings to the groups. These generate the undirected social network graph. The students are grouped based on the directed and undirected social network graphs. The experiments indicate that group formation based on a complimentary degree of learning concepts and friendship values improved the students' learning status. The students also satisfied with the grouping.

Srba & Bielikova [7] proposed a group formation method that is not based on specified rules. The group formation is dynamic. This is achieved by reviewing the results that have been achieved in the current group. The method that the authors proposed begins with feedback from the previous collaboration activities. The feedback provides insights on how to create successful groups. Thus groups are actually created in real-time. The dynamic group method is based on the Group Technology approach considering students' characteristics which are learning styles and knowledge level that consider students' collaboration to improve group formation. The application of the method as a part of the collaborative platform is PopCorm. Proved in the research that students' collaboration can improve the group formation process as the groups created using the method

achieved higher collaboration quality with next iterations. Wijaya [33] also develop dynamic group formation tool for high school students. Unlike Srba & Bielikova [7], the system is based on the pot model system. Pot model system is a system that group the students based on ranking. The rank changes when a new assignment is given to the group. When the rank changes, so do the group. A simple performance assessment indicates that the tool improves student's attendance, student contribution in the groups and on-time assignment submission.

The work by Blowers [14] and Dascalu et al. [32] uses skills as the criteria to group formation while Christodoulopoulos et al. [30] uses students' learning style and knowledge level as the group formation criteria. Nonetheless, all three previous work develop the group formation application as part of a learning management system. With regards to the groups, Christodoulopoulos et al. [30] form groups that are both heterogeneous and homogeneous. Dascalu et al. [32] and Srba & Bielikova [7] forms an only heterogeneous group with skills and learning styles as the criteria as the basis of the group formation.

The Impact of Heterogeneous Group Members

Heterogeneous grouping is when a diverse group of students is put in the same cooperative learning groups [34]. The members within this group are different in terms of skills, personality, interests, educational levels and many others. Sagi [35] claimed that heterogeneous groups lead to better results. The heterogeneous group enables members to brainstorm a better range of views, producing fruitful solutions and creativity [36]. A study by Heltemes [37] indicates that grouping based on ability have distinct effects on academic achievements and student's behaviour towards learning. The results of the study show that students perform their tasks better, demonstrates signs of leadership qualities, had a greater quality discussion and demonstrates signs of increased self-esteem and self-efficacy than students in homogenous groups. Murphy et al. [38] conducted a study to see the influence of heterogeneous and homogenous ability grouping on the level of student's discussion and comprehension. Their findings revealed

that students in heterogeneous groups perform better than the students in homogenous groups in level of comprehension. Wang [39] studied the effects of heterogenous and homogenous grouping on student learning. The author's results indicate that heterogeneous grouping enhances a student's achievement and satisfaction. The results also show that students with a high and medium level of ability benefit more in homogenous groups while low-level ability students benefit more in the heterogeneous groups. In organizational settings, grouping workers based on different employment arrangements adds a variety of experience, information and approaches to problem-solving, which facilitates the process of decision making effectively. This corroborates the perception that different work arrangements result in improved performance by having the synergy within the group work.

METHODOLOGY

Figure 1 shows the methodology of this study. The methodology of this study consists of two parts: Part I and Part II.

The activities in Part 1 provides insights into the requirements for GroupPro. The requirements were gathered using two methods, namely analyzing existing literature and user observation. Existing literature that has been published in Google Scholar, IEEE and ScienceDirect on group formation system have been reviewed to see the functionalities of the applications. This activity is meant to see the basic functionality of a group formation system and to review the criteria used to form the group. Related work by Srba & Bielikova [7], Dascalu et al. [32] and Christodoulopoulos et al. [30] provide insights on system requirements from the aspects of the functionality of the system and also the criteria that were used to group students in the system. The review of other group formation applications is complemented by the observation of the lecturers and students in the class. This was adopted to understand how groups were formed in information systems classes. Four classes were observed, namely Enterprise Architecture, Knowledge Management Strategies,

Introduction to Enterprise Resource Planning, and International Business. These classes are non-technical classes which do not involve any hardware or software developments. The observation of the class provides some insights on how groups are normally formed in a class.

Part II is the system development phase. The development of the group formation system follows the waterfall development model. The user requirements gathered in Part 1 were finalized, and an activity diagram was developed to demonstrate the system flow. The system design phase involves the program design, which includes the grouping algorithm, database design and user interface design. The tools used to develop the group formation system are Laravel Web Framework, Heidi SQL, and XAMPP. A usability testing is carried out for both lecturers and students, particularly on how they perceive the usability and effectiveness of the system. A number of 8 lecturers and 10 students participated in the test.

Table 1 shows the user functional requirements for the system. Lecturers and students are the two users of the system.

Figure 2 shows the activity diagram for the group formation system. Registration is required for both users.

The process begins with the lecturers to create a course and set the project settings. The project settings include the number of members in each group. Lecturers will then determine the threshold value for personality, skills and CGPA for each member in a group. Students, on the other hand, enrol to the class created by the lecturer, perform the Big Five Personality Test at any Big Five Personality test websites and input the personality results on GrouPro. The last step for the student is to self-assess their skills and input their CGPA to GrouPro. During self-assessment, students will rate their skills, input the grade point average and personality test results. During the self-

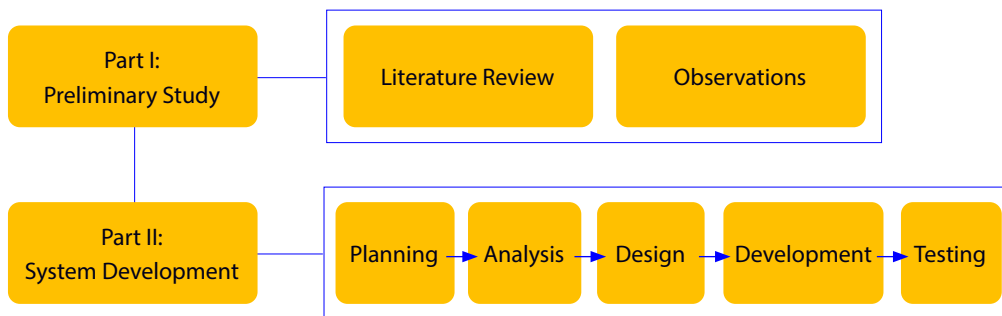


Figure 1 Project methodology

GROUPRO Prototype Development

Analysis

The proposed group formation system is called GrouPro. GrouPro uses three criteria: personality, skills, and grade point average. Firstly, students need to conduct their self-assessment. The lecturers will be determined what the important skills for the project are. Based on this information, the system is able to group the students to achieve a well-balanced group for the project.

assessment activity, GrouPro captures the student’s skills, academic performance and personality. Based on each student’s criteria assessment results and the threshold value set by the lecturer, GrouPro can group the students by comparing the student’s skills, academic performance and personality test results with the criteria set by the lecturer. Table 2 shows an example of information for Knowledge Management Systems (KMS) course. It assumes that the course has nine students and the lecturer wants 3 members in a group for the project.

Table 1 Functional user requirement

User	Functional Requirements
Lecturer	<input type="checkbox"/> Register <input type="checkbox"/> Create a course <input type="checkbox"/> View Student enrolled in the class <input type="checkbox"/> Set projects settings <ul style="list-style-type: none"> <input type="radio"/> Determine the number of groups and members in each group <input type="radio"/> Set the criteria threshold (i.e. personality, skills and CGPA) for the members in a group <input type="checkbox"/> View group formation
Student	<input type="checkbox"/> Register <input type="checkbox"/> Enrol to class <input type="checkbox"/> Conduct criteria self-assessment

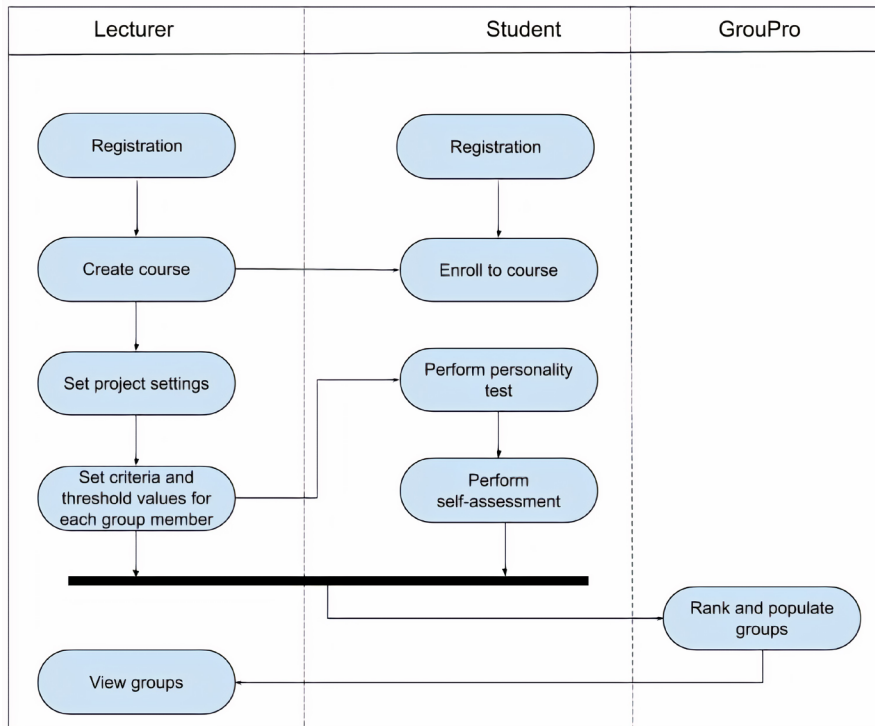


Figure 2 Group formation activity diagram

Table 2 An example of a knowledge management systems students

Course	Knowledge Management Systems
Total Number of Students	9
Total Number of Students per Group	3

The criteria for the group that is set by the KMS lecturer shown in Table 3. From Table 3, it shows that in a group, regardless of the number of members in a group, at least one of the members should satisfy the first criteria (C1) and another member satisfies the second criteria (C2).

System Design

Figure 3 shows a snippet of the algorithm of the grouping student program based on the criteria in Table 2. Lecturers execute the grouping program after the students have conducted their self-assessment on their personality, skills and CGPA and the lecturer

Table 3 Example of criteria for the group member

Criteria	Domain	Element	Score
C1	Personality	Extraverted	$\geq 75\%$
	Skills	Leadership	≥ 3
	Academic	CGPA	≥ 3.50
C2	Personality	Experience	≥ 50
	Skills	Communication	≥ 3
	Academic	CGPA	≥ 3

Table 4 Example of groups in KMS

Group 1	Group 2	Group 3
Student 1 fulfilled C1	Student 2 fulfilled C1	Student 3 fulfilled C1
Student 1 fulfilled C2	Student 2 fulfilled C2	Student 3 fulfilled C2
Random student	Random student	Random student

KMS students took the Big Five personality test and performed the self-assessment. GrouPro will sort the students based on the first criteria, take the top three students from the sorted list and populate the three groups. GrouPro sorts and populates the groups with the remaining students who fulfilled criteria C2. The remaining students after criteria C2 are assigned randomly to any of the three groups. Table 4 shows the groupings for KMS course.

has set up the number of members in the group and the criteria required for the project. The first part of the algorithm is to determine the entire group. This is obtained by dividing the total number of students in the class by the number of students per group set by the lecturer.

```

//Determine the number of groups
Lecturer input number of students per group.
Get TOTAL_NUMBER_OF STUDENTS from database
n = TOTAL_NUMBER_OF_STUDENTS divide by number of students
per group.
Assign id to groups formed

//Group the student
MOVE student_master table to temp_student table
LOOP based on entries in criteria table
Retrieve criteria from criteria table
SELECT ALL students that conforms to criteria FROM temp_student
table
IF result < n THEN send message to lecturer to lower the criteria ELSE
    {select the top n students
    assign students into Group 1, Group 2, Group 3.....Group n
    APPEND to group table}
ENDIF
REMOVE students already assigned to the group from temp_student
ENDLOOP
//Grouping for students who does not satisfy the criteria
SELECT ALL students FROM temp_student
LOOP
Assign students to Group 1, Group 2, Group 3....Group n
ENDLOOP

//Display groups
DISPLAY ALL groups
    
```

Figure 3 Grouping program algorithm

The second part of the algorithm is to group the students based on the criteria set by the lecturer. From Table 2, the lecturer only set the criteria for two members in a group, namely C1 and C2. This means that for all groups, two of its members need to have the specified personality, skills and CGPA. The system will check whether the number of students that fulfil a set of criteria is greater than the number of groups set by the lecturer. If the number of students that fulfil a criterion is less than the number of groups, GrouPro will display a message that informs the lecturer to reduce values of the criteria and run the program again. Based on Fig 3, the program will retrieve the first criteria and rank the students based on the first criteria. Given, the number of groups is n , and the program will select the top n students as the first member of the

groups. These students will be removed from the list, and the process continues for the second criteria with the remaining students. The process will repeat until there are no criteria to be used. If all members that satisfy the criteria have been placed in groups, the system will randomly assign the remaining students to any of the groups.

User Interface Design

The user interface design presented in this section is the group project settings and the self-criteria assessment. The group project settings screen is viewed by the lecturers. The lecturer uses this screen to determine the number of members in a group and set the required criteria for the group members. Figure 4 shows the user interface of the group criteria form. In

this form, the lecturer set the number of members in a group and the required personality, skills and CGPA for the group members. The lecturer may click the 'Add Member' button to set the required personality, skills and CGPA for additional members.

Figure 5 shows a snippet of the criteria assessment form for the students need to input their personality results and self-assess their skills. The students also need to enter their CGPA in this form. The information from this form will be captured and stored in the database.

Figure 4 Group criteria form

Figure 5 Self-assessment criteria form

Usability Testing

Usability testing was conducted to ensure the GrouPro is usable as to what the user expected. A total of eight lecturers and ten students participated in the usability testing session. The participants were given a questionnaire after navigating the system. The participants evaluate the system based on their usability and effectiveness. Figure 6 shows the results of GrouPro usability from the lecturer's perspective.

From Figure 6, the lecturers feel that the system is easy to use and will assist them to achieve a well-balanced group for the student's project. Figure 7 shows the result of GrouPro perceived effectiveness from the lecturer's perspective.

From Figure 7, the lecturers perceived that the system is effective in grouping the students accordingly. This also indicates that the lecturers have no concerns in the way the students are grouped. Fig. 8 shows the results of GrouPro usability from the student's perspective.

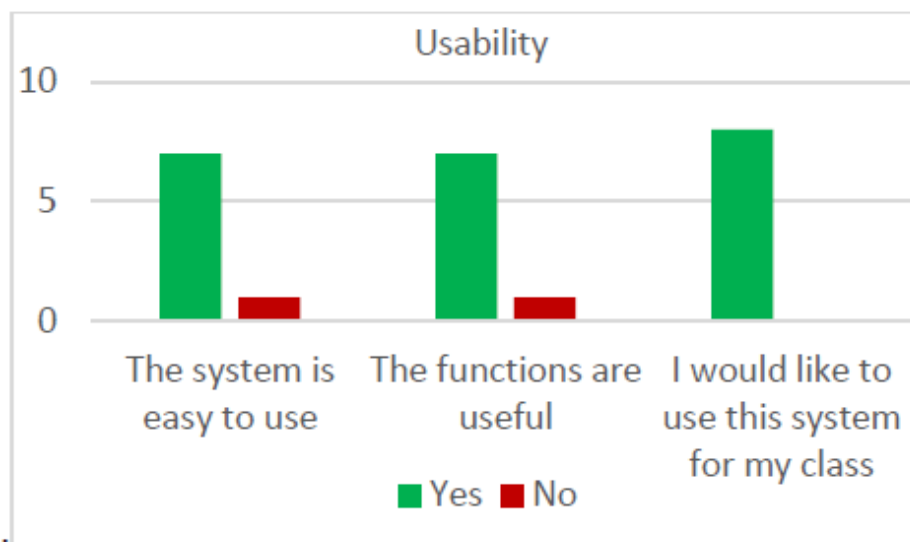


Figure 6 Usability from lecturer's perspective

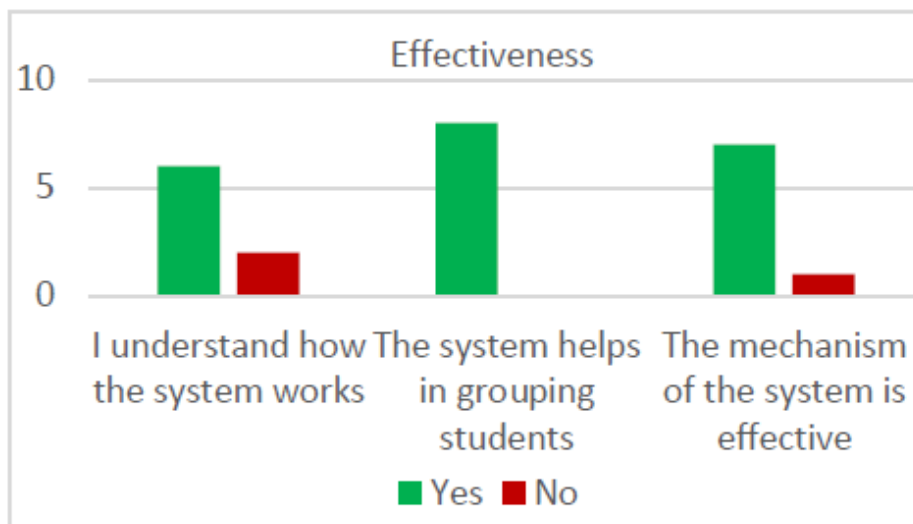


Figure 7 Effectiveness from lecturer's perspective

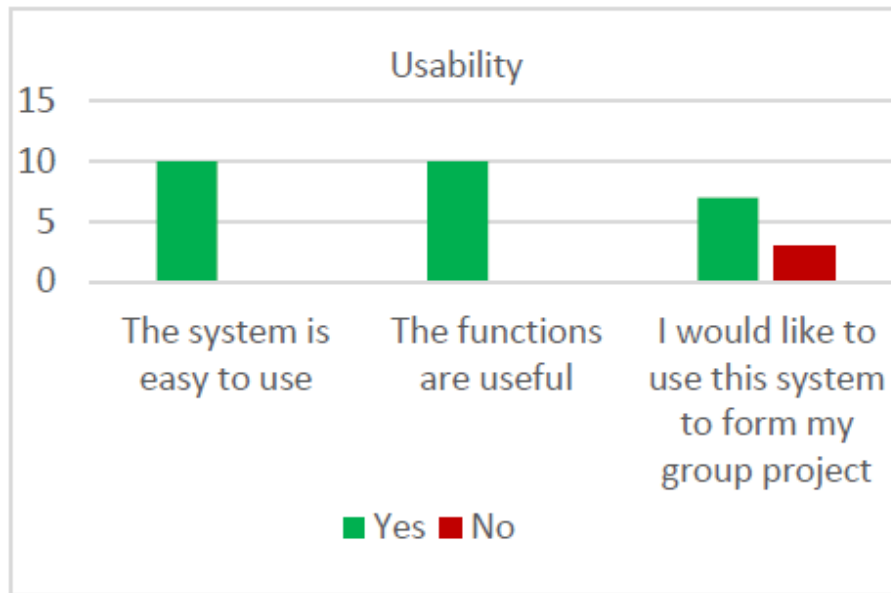


Figure 8 Usability from the student’s perspective

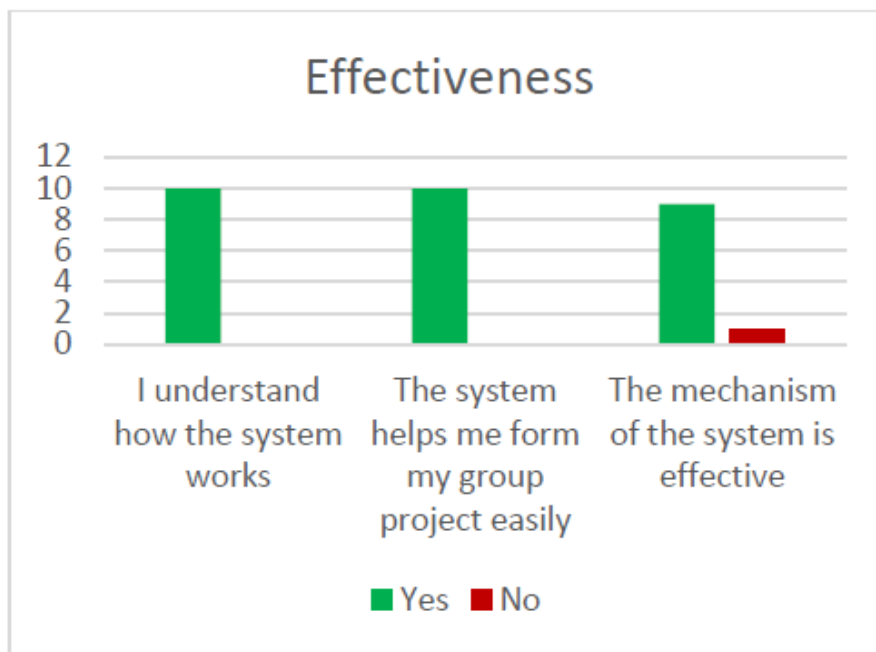


Figure 9 Effectiveness from the student’s perspective

From Figure 8, students agree that the system is useful for in grouping them for the class project. However, there seem to be certain students who prefer the self-selection approach.

Figure 9 shows the result of GrouPro perceived effectiveness from the student’s perspective. Majority of the students feel that the system is effective in grouping them for their project. Some students have difficulties in finding a group, thus having this system would minimize those difficulties.

Overall, the system is perceived to be usable and effective. The lecturers are quite satisfied and positive about the system in term of usability and effectiveness. The students also perceived that the system is very usable and effective in assigning in groups. However, there seems to be an element of unwillingness for the students to use the group formation.

FUTURE WORK

Firstly, the future work of this study is to enhance the usability and user acceptance test by including more participants from non-technical courses to use GrouPro. The second future work can focus on group's compatibility and performance. From the usability testing session, it was observed that the students seemed to be not preferring their lecturers to use GrouPro. Groups are formed because the team members stay in the same dormitories or the team members come from the same state, religion or race. This indicates that students prefer to be in a group of their choice because of compatibility. This study uses personality type as the criteria compatibility. However, it is not certain how effective personality type is to address compatibility among team members. Future study can investigate the approach in balancing academic performance, skills, personality and compatibility. Thirdly, this study can be extended to technical courses such as programming, system development and engineering as the group requirements for these courses are different from non-technical courses. Finally, this system can be extended to the mobile environment. The development of a group formation mobile application would give the users flexibility.

CONCLUSION

Groupwork is an integral element in teaching and learning. Putting students into groups will not only enhances student's understanding of a subject but also improves social skills such as presentation and communication skills. Studies have shown that a well-balanced group could improve group work quality

and performance. The group that consists of members with diverse skills set have some advantages. Firstly, group members complement each other in terms of technical skills, soft skills and overall capabilities. Secondly, students with poor academic standing can acquire knowledge from students with excellent academic standing. They can exchange knowledge and thoughts when they work together. These diverse criteria will help students to work more effectively and efficiently. However, forming groups consists of members with diverse skills can be daunting if it is done manually. This paper presents a group formation system that can form groups that consist of members with diverse skills to complete a task. The lecturer set the project's details and the skills required in a group to complete the project's tasks. Students enrol in the class and perform self-assessment on their skills, personality and CGPA. Usability testing of GrouPro was performed with students and lecturers, and the findings indicate that system is usable and effective in group formation. However, there exists an element of reluctance among students to use the system to form a group.

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