Group Selection in a Senior/Graduate Level Digital Circuit Design Course

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Abstract

It is always a difficult task to decide how to select the members for group projects. There are many different approaches to this problem, including selecting the members to diversify their skill sets, randomly selecting the members, or letting the students form their own groups. This paper will present the pros and cons of the different approaches to determine if one is significantly better than the others, as applied to a senior/graduate level digital circuit design course.

Introduction

Many different approaches exist for selecting members for group projects, including selecting the members to diversify their skill sets, randomly selecting the members, or letting the students form their own groups[1]. Diversifying a group's skill sets is much more important for introductory courses, where the students may come from a variety of different backgrounds and may therefore have extremely varied skill sets. For a senior/graduate level engineering course, the students have all taken the same prerequisite courses and should therefore all have the basic skill set necessary to complete the projects assigned in the course. Hence, assigning groups to diversify their skill sets would not be necessary in this type of course. Groups could be selected based on ethnicity, gender, or GPA, but this would not be expected to significantly differ from random selection. Therefore, two main approaches for forming groups remain: self-selection and random selection. This paper will detail the pros and cons of these two approaches in order to determine if one is significantly better than the other, in the context of a senior/graduate level digital circuit design course, *Digital System Modeling*.

Course Overview

The number of students in Digital System Modeling (CpE 318) normally ranges from 20 – 40, with the previous semester, on which this paper is based, having 20. This course contains two separate digital circuit design group projects: one due at mid semester and the other due at the

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end of the semester. These projects are very suitable to being done in groups for a number of reasons: they are large design efforts that would be difficult for a single person to complete in the time allotted; the designs can easily be partitioned into subsystems, such that each member can work somewhat independently on their specific portion; and the subsystems must be designed in such a way that they will work together correctly when integrated, thus requiring group planning and a cooperative effort. The projects are also very similar to industrial digital design projects, where a group of people design some complex chip in a hierarchical fashion by partitioning the design into smaller subsystems that are developed by individuals or smaller groups, and are later integrated together to complete the overall design. Hence, the course projects include both individual and group components and are based on real-world problems, making them extremely valuable tools for enhancing student learning on multiple levels.

Experiment Design

Since there are two group projects in the course, the students formed their own groups for the first project, and the groups were randomly assigned for the second project. This order was chosen because if groups were randomly assigned for the first project, the groups for the two projects would likely be correlated. For example, if the randomly selected group performed well together, they would be likely to keep the same members for the second project when they were able to choose groups themselves. However, if the groups form themselves for the first project and are randomly assigned for the second project, the first and second project groups will not be correlated.

A number of different assessment methods were used to determine the pros and cons of each group selection approach and to determine if one approach is significantly better than the other. These methods included group self-assessment, where each member of the group rated the others in the group and rated the performance of the group as a whole, using an assessment form developed to include both numerical ratings and free response questions; the author’s assessment of the groups’ success, based on how well their project designs worked; a written assignment at the end of the course, where the students could compare, contrast, and rate the two different approaches to group formation, from their perspective; and the author’s assessment of how successful each group selection method was. The collected information was then examined and the pros and cons of each approach were tabulated to form an opinion of which, if either, of the two group selection methods is significantly better than the other.

Project #1

The first project entailed designing a Huffman Decoder Chip, which was to be done in groups of up to 3. The class divided itself into 9 groups, including 3 groups of 1 student, 1 group with 2 members, and 5 groups of 3. The overall average on the project was 85%-87%, depending on how the average was calculated, which was a mid to high B. Table 1 shows the grade distribution broken down by group size.

Of the 9 groups, 6 did very well, designing Huffman Decoders that were completely correct, or only had very minor errors. One group did pretty well, designing a Huffman Decoder that only had minor mistakes, but lost some credit due to poor documentation because of running out of time. This was the group of two, of which one student was struggling with the class. Another group did OK, but had a major flaw in their design, which was not detected because of minimal testing effort due to their running out of time. The final group, consisting of only 1 student, did a very poor job on the project. This student was having major problems with the class.

Table I: Group Size vs. Grades for Project #1

Group Size	Average	As	Bs	Cs	Fs
1	80%	2	0	0	1
2	83%	0	1	0	0
3	88%	4	0	1	0

To have the students assess themselves, they were given a questionnaire to rate and discuss the participation and ability of each of the group members and of the group as a whole, after they turned in the project and before they received their grade. The numerical results are tabulated below. The students also rated the project a 3.5 on how well it helped them to better understand the class material, and gave it an overall rating of 3.5.

Table II: Student Evaluation for Project #1

	Rating
Participation of Group Member	3.83
Ability of Group Member	3.55
How well group worked together	3.57
Ability of group to complete task	3.41

* 4 = excellent; 3 = pretty good; 2 = average; 1 = OK/fair; 0 = poor
* you may use a tenth: (i.e. 3.7)

Project #2

The second project required the students to augment a simple 4-bit RISC microprocessor that was overviewed in class, which entailed adding additional instructions, including conditional branches, and adding instruction prefetch capability so that the branch instructions were able to be executed in one clock cycle. Furthermore, the students were required to write an assembly language program to perform a sign magnitude multiplication using the microprocessor, and write a testbench, which initially loads the program from a text file into the microprocessor's program memory, executes the multiplication program and writes the resulting product to the microprocessor's data memory, and then writes the contents of the data memory to a text file and checks the calculated product to ensure that it's correct. The project was performed in 5 randomly selected groups of 4 members each. Groups of 4 were chosen because the project could be easily partitioned into 4 main parts: 1) adding branching instructions and prefetching capability, 2) adding additional instructions and coding the microprocessor in VHDL, 3) writing the assembly language program for signed magnitude multiplication and converting it into microcode, and 4) writing the VHDL testbench.

The overall average on the project was 88%, which was a high B. There were 3 low to mid As, 1 mid B, and 1 low B. All groups did pretty well, resulting in projects with only a few minor mistakes. Again, the students assessed themselves with the same questionnaire used for Project #1, after they turned in the project and before they received their grade. The numerical results are shown in Table III. The students also rated the project a 3.4 on how well it helped them to better understand the class material, and gave it an overall rating of 3.6.

Table III: Student Evaluation for Project #2

	Rating
Participation of Group Member	3.61
Ability of Group Member	3.60
How well group worked together	3.57
Ability of group to complete task	3.72

* 4 = excellent; 3 = pretty good; 2 = average; 1 = OK/fair; 0 = poor
* you may use a tenth: i.e. 3.7

Comparison

Comparing the two projects shows that the students did slightly better on average on the second project, and that there was a much smaller standard deviation in performance on the second project. This is believed to be because everyone was required to work in a group on the second project, which benefited the poorer students and helped keep the project on track and on time. It is not believed that this difference in performance had anything to do with the way the groups were formed.

Comparing Tables II and III shows that: 1) The member participation decreased when the groups were randomly assigned. By reading the students' free responses to this question, it is the author's opinion that this was mostly caused due to incompatible schedules, whereas the self-assembled groups had better coordinated schedules; 2) The ability of the group members increased slightly from Project #1 to Project #2, in the author's opinion because of the increased knowledge gained by learning an extra month's worth of class material between the end of Project #1 and the end of Project #2; 3) The groups worked equally well together on the two projects; and 4) The ability of the group to complete the task increased from Project #1 to Project #2, in the author's opinion because of the students' increased knowledge in the subject matter and because all projects were required to be performed in groups, as explained previously.

Furthermore, the students were asked to rate which group selection method they preferred, using the following scale (4 = strongly preferred self-selection; 3 = somewhat preferred self-selection; 2 = doesn't matter; 1 = somewhat preferred random selection; 0 = strongly preferred random selection; you may use a tenth: (i.e. 3.7)), and were asked to write a detailed explanation of the pros and cons of each and why they preferred one over the other. The average was 2.3, showing that the students only slightly preferred self-selection. The most recurring comment was that "self-selection yielded more compatible schedules." Other reoccurring comments included: "with self-selection you got to work with those you knew, however random selection better mimicked a realistic work environment;" and "random selection forced the project to keep on schedule better than self-selection." However, most students stated that they "didn't significantly prefer one method over the other."

Conclusions

This study found that selecting groups for team-based design projects in the context of a senior/graduate level digital circuit design course by either random selection or self-selection didn't make much difference in terms of the project grades, the members' ability, how well the group worked together, or the groups' ability to complete the project. Random selection did however tend to slightly decrease group member participation due mostly to incompatible schedules. Furthermore, the students did not significantly prefer one group selection method over the other. Therefore, the author suggests using both group selection methods, and will continue to do so in future offerings of UMR's Digital System Modeling class.

Future Work

The author plans to continue this study in subsequent semesters in order to collect more data to validate the conclusions. It is also planned to add the following two questions to the project survey: 1) rate your own participation, and 2) rate your own ability, in order to determine if students' assessment of themselves is in agreement with their peers' assessments. Furthermore, it would be interesting to see if the groups were actually correlated if the first project group was randomly selected and the second project group was self-selected.

Bibliography

1) J. L. Brickell, D. B. Porter, M. F. Reynolds, and R. D. Cosgrove, "Assigning Students to Groups for Engineering Design Projects: A Comparison of Five Methods," Journal of Engineering Education, pp. 259 – 262, July 1994.

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