ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

2017 Pacific Southwest Section
Meeting: Tempe, Arizona Apr 20 Paper ID #20664

# Group Work Versus Informal Collaborations: Student Perspectives

**Dr. Andrew Danowitz, California Polytechnic State University, San Luis Obispo**

Andrew Danowitz received his PhD in Electrical Engineering from Stanford University in 2014, and is currently an Assistant Professor of Computer Engineering at California Polytechnic State University in San Luis Obispo. His engineering education interests include student mental health, retention, and motivation.

# Group Work Versus Informal Collaborations: Student Perspectives


## Abstract

A substantial body of research exists showing that, when implemented correctly, the use of group work in a class can improve student learning outcomes. When implemented incorrectly, however, group-based assignments can lead to dysfunction and inter-personal conflicts that can hamper overall student success. This problem can be especially acute in first and second year engineering fundamentals courses where advanced students who learn the concepts faster may end up completing—and reaping the benefits of—a lions-share of the group work. As the course material starts to build on itself, those students who initially underperformed in their group may lack the understanding to keep up with new material, and find themselves falling ever further behind. To avoid this issue, my study looks to the use of informal collaborations—where students are encouraged to seek help from and work with their classmates on an assignment, but are ultimately responsible for their own submission—as potential alternative to formal group assignments.

I conducted my experiment in a sophomore-level Introductory Digital Design, a course that has traditionally required students to work in fixed pairs to complete a number of VHDL circuit modeling and design labs. For each lab, I required students to submit their own work, but I also encouraged students to seek help from and form informal collaborations with their classmates to model and verify their circuits. To further encourage students to form collaborations, I did not alter or reduce the scope of the lab assignments to account for the fact that students were no longer necessarily working in pairs. At the end of the course, I conducted an anonymous survey to measure student reactions to the use of informal collaborations versus traditional group work, and whether students still chose to work with their classmates to complete the labs. The survey also measured whether shifting from a group-submission model to an individual-assignment model produces undue strain on students.

Data collected from my pilot course shows promising results. All respondents agreed that being responsible for each lab helped them to learn the material better. Additionally, 77% of respondents reported that being responsible for the lab increased their confidence in their ability to learn the material. All but one respondent either agreed or strongly agreed that they *often* collaborated with classmates to complete the assignment, indicating that students are still developing some of the interpersonal skills and peer learning techniques provided by formal group work.


## Introduction

Teaching students to work effectively in groups and teams has become a learning objective in many engineering programs. ABET requires engineering programs to develop a student's "ability to function on multidisciplinary teams" as part of its accreditation criteria[1]. Beyond accreditation considerations, training students in effective teamwork offers many benefits to engineering students. According to the National Academy of Engineering, engineers will increasingly be required to work in "interdisciplinary, globally diverse" teams as part of their careers[2], necessitating that team-work and communication skills be taught as part of their formal training. Additionally, a substantial body of research exists showing that, when implemented

correctly, the use of group and team work in a class can improve student learning outcomes[3,4]. The danger is that, when implemented sub-optimally, even in a single group, group work can lead to lower performance and worse learning outcomes for individuals than if students had been asked to work alone[4].

To avoid the issues associated with suboptimal group-work while still encouraging the development of strong collaboration and peer learning skills, my study looks to the use of informal collaborations (IC)—where students are encouraged to seek help from and work with their classmates on an assignment, but are ultimately responsible for their own submission. While this mechanism is not intended as a replacement for formal group-work throughout the engineering curriculum, it may offer a safer alternative for faculty with little formal experience in facilitating group work looking for a low-risk way to nurture collaboration skills and improve student outcomes in engineering fundamentals courses.

The rest of this paper is organized as follows. First, I discuss some of the background and motivation for performing this study. I then discuss my efforts to study student impressions of informal collaboration versus formalized group work in a sophomore level digital design course. Finally, I discuss the measured results, and implications for future work.

**Motivation and Background**

While well managed team-based assignments can have positive effects on student outcomes, if not implemented properly, team-based assignments can have a negative effect on student learning[4]. In these scenarios, team performance can be hampered by intra-team competition, mutual distrust, differing work ethics, and uneven distributions of labor among group members.

The danger of suboptimal groups can be especially acute for students in engineering fundamentals courses. In these courses, more advanced students who learn the concepts faster may end up completing—and reaping the benefits of—a lions-share of the group work. As the course material starts to build on itself, those students who initially underperformed in their group may lack the foundation to keep up with new material and find themselves falling ever further behind. In some cases, this condition can persist across an entire pre-requisite chain of courses, where students who underperform in one course remain behind the curve in follow-on courses, eventually leading to failing grades and potential dismissal from the program.

This danger is far from theoretical. In the summer of 2016, I taught a required Introduction to Computer Design and Assembly course. This course, CPE 233, leans heavily on the materials and digital design tools (Vivado) taught through pair-based lab assignments in the pre-requisite Digital Design course, CPE 133.

Of the fourteen students enrolled in the summer CPE 233 course, roughly half of the students had already attempted and failed the course at least once. Of these students, only one appeared to have an advantage in knowledge over the students who were taking the course for the first time. Several of the students taking CPE 233 remedially lacked a basic understanding of how to use the Vivado software package that they had been required to use for the pair-based lab assignments in both CPE 233 and CPE 133. Several reported that they had no personal experience working with the tools, and that they had relied on their lab mates to do the bulk of the technical work. These observations led me to look into alternative methods for encouraging

students to work together, while still ensuring that each individual group member is held accountable for acquiring the knowledge.

While there are many potential methods for addressing poor group results and improving student outcomes, the focus of this study is on the use of Informal Collaborations (IC) to achieve these ends. For IC, the instructor requires all students to be individually responsible for the lab assignment. The instructor then strongly encourages students to seek help from their peers and work with others to complete their assignment. The idea is that since all collaborations are purely voluntary, no student has an incentive to allow another student to become a free-rider. Conversely, no advanced student has an incentive to sideline or freeze-out a partner in the interest of completing the assignment as quickly as possible. Additionally, since informal collaborations can be ephemeral, and since everyone is free to progress on the lab assignment at their own pace, ideally, the use of IC-based labs encourages students to work with a wide variety of classmates on each lab, helping to improve communication and peer learning skills.

The other benefit of IC is that it is relatively simple to implement, requiring no special training or advanced experience in managing collaborative work on the part of the instructor. For engineering fundamentals courses, where sections can be quite large, and where teaching responsibilities can fall to a variety of instructors and even graduate students, all with varying backgrounds and experience levels in engineering pedagogy, following a simple teaching mechanism that provides some of the benefits of formal group work while limiting the risk from dysfunctional groups can be quite beneficial.

**Testing the Effectiveness of IC**

I used a fall 2016 section of Digital Design to pilot IC at Cal Poly SLO. I kept all of the laboratory assignments from my previous offering of the course, and presented them to students as individual assignments. I directly encouraged students to seek help from and work with their peers on the assignments. To further promote student collaboration, I required students to abide by a set of debugging and troubleshooting guidelines, where, during lab time, students were required to seek help from another student before asking questions to the instructor.

While there was a risk that by keeping the lab coursework the same while moving from pair work to individual assignments I would overwhelm my students, I hoped that the procedures in place would encourage students to work together to solve lab challenges. Additionally, from past experience in teaching the course, I had witnessed cases where a student would choose to work alone, or where both partners would complete the lab independently, so I was confident that even students who did not take advantage of informal collaborations would be able to complete the work.

To test student reaction to this setup, I created and distributed an online survey instrument. The survey questions are reproduced in Tables Table *1*-Table *3*.

The questions in Table 1 are designed to act as an assessment of how students have experienced traditional group work. Questions 1 and 2 try to determine whether students experience what they consider to be a fair distribution of labor from group work. Questions 3d-e are designed to see whether students report taking full advantage of peer learning in groups, or whether they

choose depend on their peers' expertise to get a good grade. 3a-c try to extract students' grade-based motivation for actively learning and participating in group work. Finally, question 4 is intended to compare students' impressions of learning alone versus learning in groups.

Table 1. Questions about student experiences with and attitudes towards learning in a formal group setting.

| **Question** | **Type** |
|---|---|
| 1) When working on assignments in groups of 2, what percent of the technical work do you usually do? | Multiple choice |
| 2) When working on assignments in groups of 2, what percent of the communication-type work do you usually do? | Multiple choice |
| 3) On a scale of 1 to 5, please rate your level of agreement with each of the following statements: | 5-point Likert scale |
| a) I fully participate in group work when all group members will receive the same grade | |
| b) I fully participate in group work when I will be evaluated primarily on my individual contributions to the project. | |
| c) I fully participate in group work when I will be evaluated both on my individual contributions and the group's overall product. | |
| d) If I do not understand what my group member is doing or why a solution works, I get my group member to teach me. | |
| e) If I do not understand what my group member is doing or why a solution works, I always figure it out before the project is submitted. | |
| 4) On a scale of 1 to 5, please rate your level of agreement with the following statement: I generally learn more when I am required to work in groups than when I work alone. | 5-point Likert scale |

The question in Table 2 ask students to compare their impressions of learning outcomes with a group work approach to the learning outcomes through IC. While I recognize that IC may not provide all of the benefits of optimally implemented group work, this question was designed as a sanity check to ensure that students did not find IC detrimental to their learning.

Table 2. Question directly comparing formal group work with IC

| | |
|---|---|
| 5) On a scale of 1 to 5, please rate your level of agreement with the following statement: I learn more working in a formal group setting than when I am allowed to form informal collaborations with my classmates. | 5-point Likert scale |

Finally, the questions in Table 3 were designed to assess whether my implementation of IC was meeting my educational goals. These included ensuring that students were still working with peers to solve lab problems, and that students were still able to complete the lab work on-time without being overburdened.

Table 3. Questions about how IC was implemented.

| | |
|---|---|
| 6) On a scale of 1 to 5, please rate your level of agreement with the following statements. | 5-point Likert scale |
| a) Being responsible for the entire lab helped me learn the material better. | |
| b) Being responsible for the entire lab made me more likely to attend office hours. | |
| c) To successfully complete the labs, I often had to work informally with classmates. | |
| d) To successfully complete the labs, I sought help from a wide range of classmates. | |
| e) I helped my classmates as much as they helped me in completing lab assignments. | |
| f) Between the professor and my classmates, I was able to get the level of help I needed. | |
| g) Knowing that my final project partners had completed labs 1-4 increased my confidence in their abilities. | |
| h) All of my labmates were able to make contributions to the digital design portions of the final project. | |
| i) I was able to access development boards when I needed one. | |
| j) I had sufficient time to complete the labs. | |
| k) I found the lab workload to be overwhelming. | |
| l) Completing the lab by myself increased my confidence in my ability to learn the material. | |
| m) I prefer this way of working on labs to working on the labs in fixed pairs. | |
| n) After completing the labs in this course, I will approach future labs with more confidence. | |
| 7) Professor Danowitz requires each student to be responsible for their own lab submission (as opposed to working in pairs) to ensure that all students gained a basic proficiency in circuit design and were better prepared for the final and follow on courses. Do you feel this worked? Do you agree with this requirement? Please explain. | Free Response |

While the results captured by this instrument are limited in that they rely on student self-report rather than direct measures of student performance, I believe the survey instrument is thorough enough to assess the basic fitness of IC as a limited replacement for formal group work.

**Testing the Effectiveness of IC**

I administered my survey instrument to my test course after students had completed the lab portion of the class and moved into a team-based final project. Out of 34 students enrolled, 15 responded. Due to Institutional Review Board constraints, no individual survey question could be required, so certain questions had as few as 13 responses.

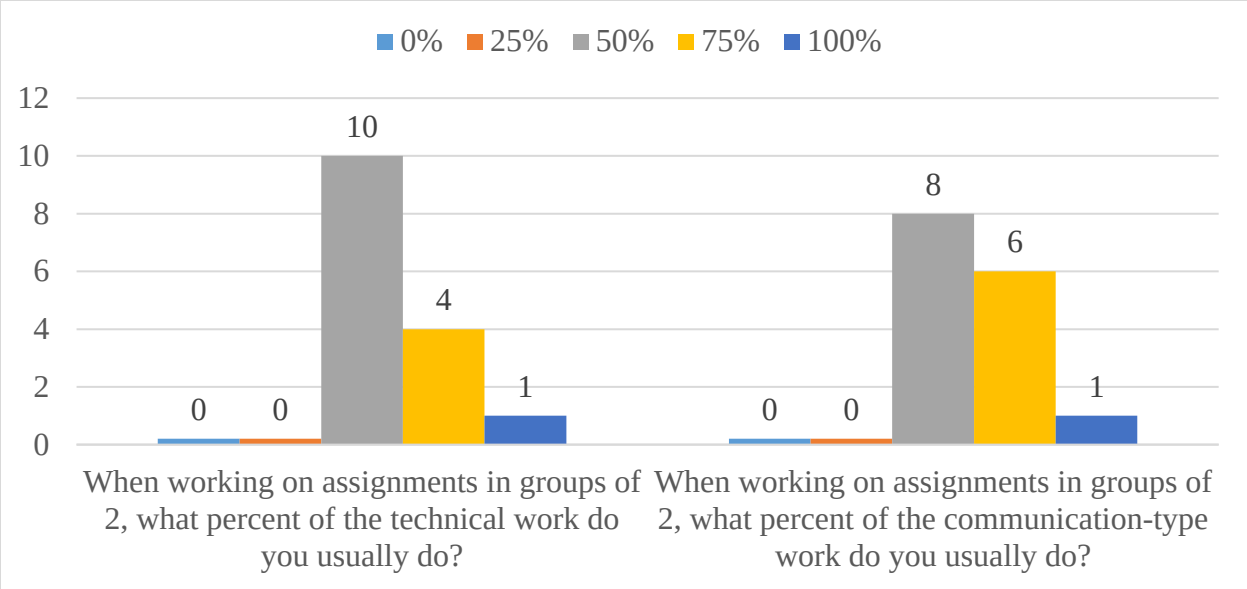


Figure 1. Student responses to questions about how much of the work they usually complete when working in groups of two. This data corresponds to survey questions 1 and 2.

Student responses to questions about formal group work are shown in Figure 1 and Figure *2*. More than half report that working in pairs results in a fair distribution of labor, and the majority either agree or strongly agree that they fully participate in group work, regardless of whether the work is evaluated only at the group level, or if individual contributions are taken into account. Finally, a full 60% of respondents either agree or strongly agree with the statement that they learn better in formal group settings than they do on their own. These results indicate that most students tend to work together effectively in a group setting, and may not need the added accountability provided by IC to engage in learning.

For a sub-population of students, however, the results are not as promising. Roughly 13% of respondents neither agreed nor disagreed that they fully engage in group work when they are not being individually evaluated. Additionally, nearly 45% of respondents either disagreed or neither agreed nor disagreed with the statement “If I do not understand what my group member is doing or why a solution works, I always figure it out before the project is submitted.” This indicates that some students may be engaged in either free-riding, or a divide-and-conquer mentality to group work.

The “please explain” responses for question 4 confirm the existence of the free-rider and divide-and-conquer mentalities. One identified that if another group member comes up with a solution, they would “only sometimes recreate it to learn it myself.” Another reported that “I personally don't like group work, unless it is […] an assignment with sections of clearly defined work, so that each member can contribute to one sections [sic].” For engineering fundamentals courses, where an instructor may wish for all students to engage with all of the material, this divide-and-conquer approach to group work can lead to negative student outcomes.

While, arguably, all students could be made into more effective group members and learners with the right instruction, in introductory engineering courses where there are a large number of

students and group work is only one component of the graded material, it can be difficult for instructors to promptly identify and intervene in cases of dysfunctional group work.

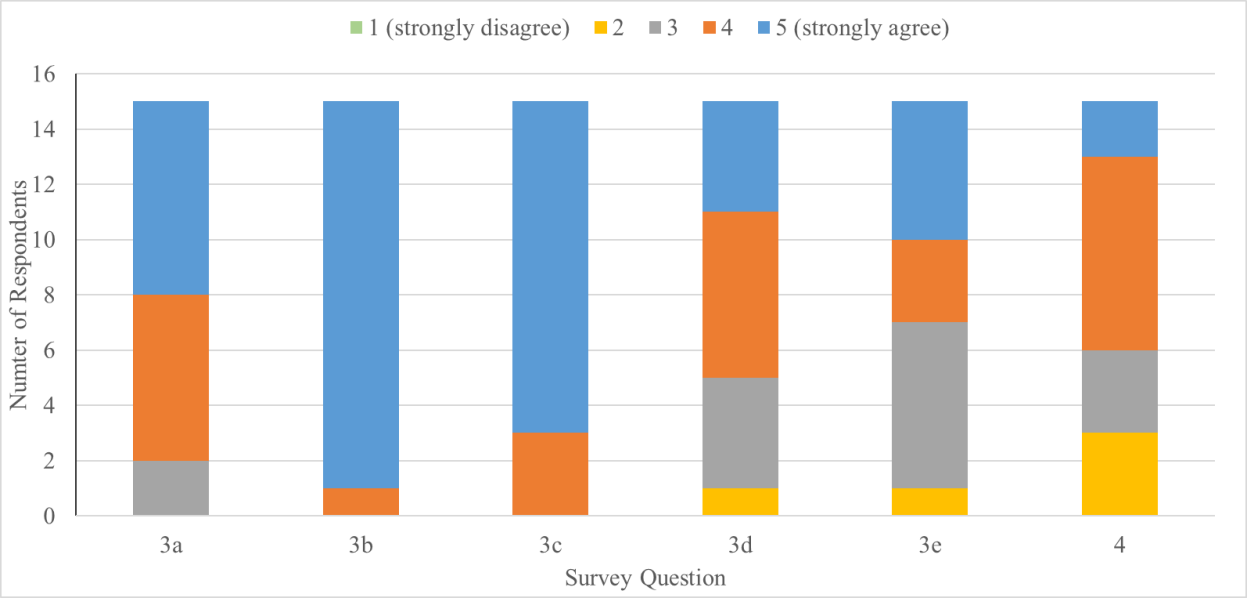


Figure 2. Questions about participation in group work. This data corresponds to survey questions 3 and 4. Full question text is available in Table *1*.

To determine the appropriateness of IC as a potential low-risk substitute for formal group work, the survey first asked about student learning when engaging formal group work versus engaging in IC. This question was designed to serve as a "sanity check" to ensure that IC is not detrimental to student learning.

As seen in Figure 3, exactly half of all respondents either disagreed or strongly disagreed with the statement "I learn more working in a formal group setting than when I am allowed to form informal collaborations with my classmates." An additional 27% of respondents neither agreed nor disagreed with the statement. These results confirm that IC does not hurt student learning relative to group work.

With IC as a viable alternative to formal group work, the next question is whether it was successful at holding individual students accountable for the material while still encouraging collaboration.

As illustrated in Figure 4, the use of IC seemed to improve student performance on a number of metrics. All respondents to question five agreed that being responsible for each lab helped them to learn the material better. Additionally, 77% of respondents reported that being responsible for the lab increased their confidence in their ability to learn the material.

While an IC-based collaboration mechanism presents a risk that students could choose not to collaborate and miss out on valuable peer-learning and collaboration, the data shows that this largely did not happen. All but one respondent either agreed or strongly agreed that they often

collaborated with classmates to complete the assignment. Additionally, over 70% of students report working with a wide range of classmates on the labs and giving as much help as they provided. The latter result is especially encouraging, since it provides a second indication that students are not engaging in imbalanced partnership where one partner completes a majority of the work.

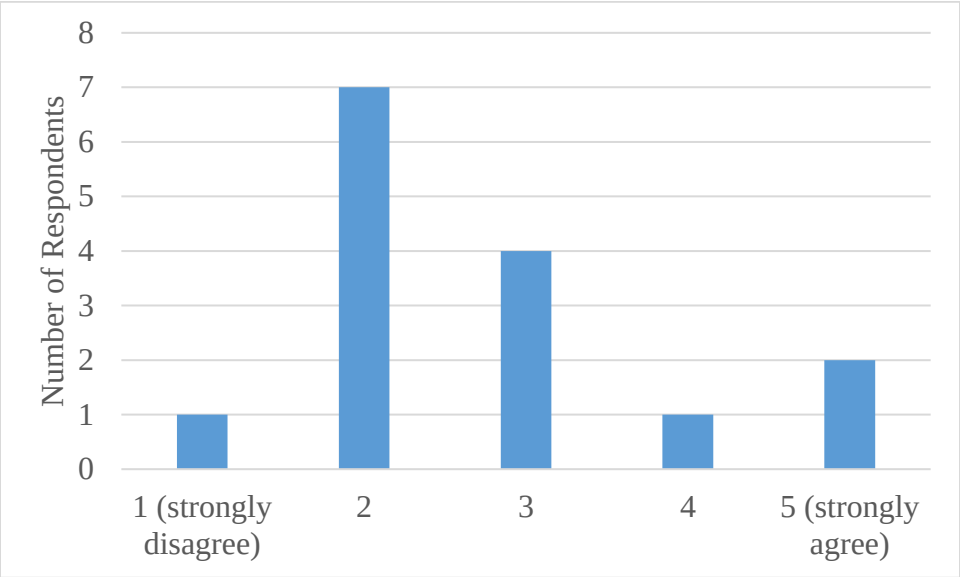


Figure 3. Responses to question 5: “I learn more working in a formal group setting than when I am allowed to form informal collaborations with my classmates.”

At the same time, despite being individually responsible for work that had formerly been assigned to teams of two, the respondents largely reported that the workload was not overly burdensome. Only one respondent reported not having enough time to complete the labs, and about 16% agreed that the workload was overwhelming. While I do not have hard data to support this, anecdotally, these results are in line with what I observe when teaching the course in traditional pair configuration.

Finally, over half of the respondents reported that they prefer IC to traditional group work (question 6m), with only 15% percent preferring traditional group work. The free responses to question 7 provides some insight into why this might be the case.

Six of the thirteen responses to question 7 explicitly stated that working in an IC modality made them take responsibility for learning the material. According to one student “I liked the lab setup, I was able to get help from other people but was still doing all the aspects of the lab.” Another student noted “Yes, this worked very well […] I learn the material by actually doing everything and learning from every classmates.” Additionally, five of the thirteen respondents observed that IC avoids the unequal division of labor and learning pitfalls that can occur during formal group work: “Often in pairs, one group member may take on more of the workload, meaning the other person takes advantage of them or doesn't learn as much.” These students approved of IC because it prevented this from happening.

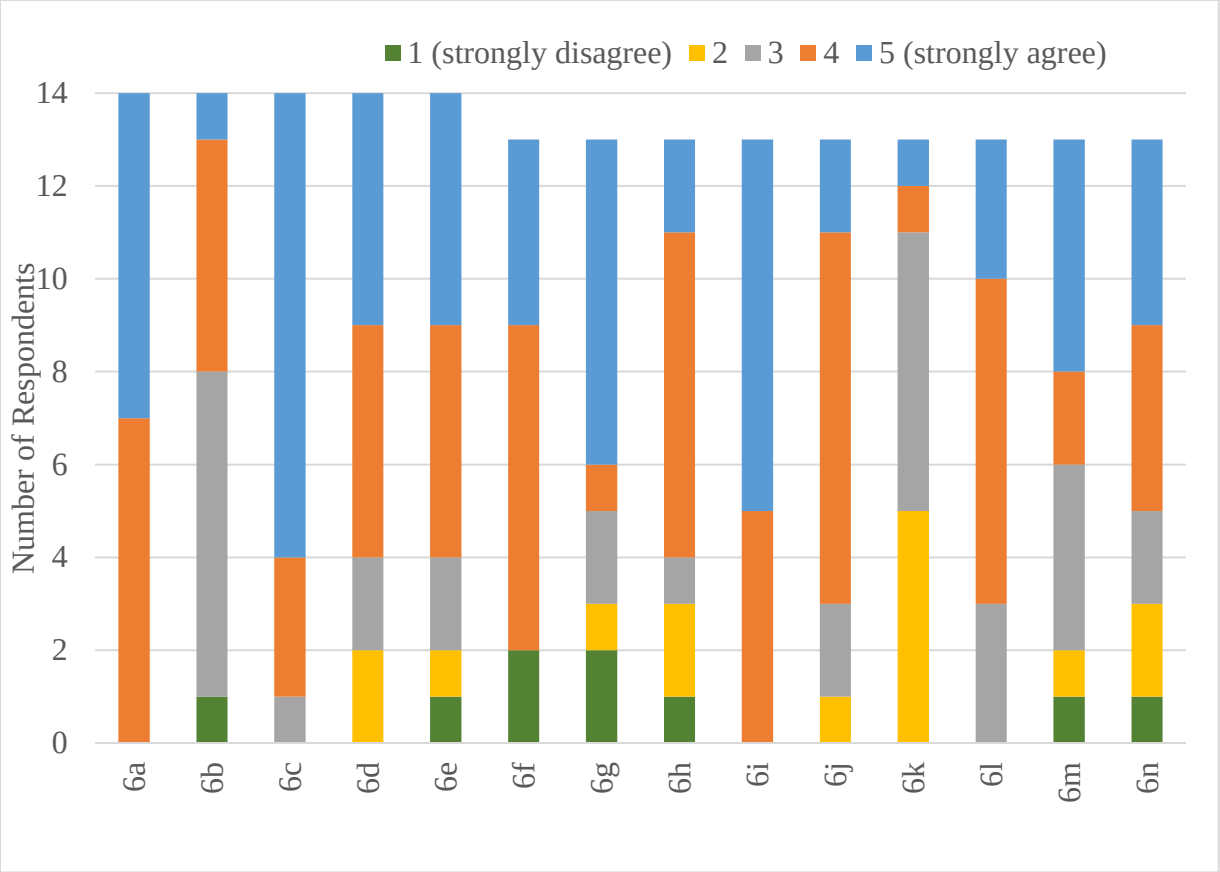


Figure 4. Questions about participation in group work. This data corresponds to survey question 6. Full question text is available in Table 1.

Not all of the feedback was positive, however. On Question 7, one student reported an overreliance on other students to complete the labs. This is especially troubling since I introduced IC in large part as a way to prevent students from relying too much on others to complete a lab. Given the large number of students who mentioned that IC prevented overreliance, however, it is still likely that IC is better at ensuring individual accountability than formal group work.

Two other students commented that, with IC, it could be frustrating trying to find other people working on the lab at their same pace. This issue likely affects struggling students the most, since students working ahead who get stuck can wait for others to catch up. If these struggling students could be identified—perhaps by periodically polling students on their progress in lab—and given some personalized instruction, they may see better learning outcomes than if they were operating in a formal group environment with peers who are primarily concerned with completing and submitting the assignment.

**Conclusions**

While a wide body of work has confirmed that formal group work can enhance student learning, when implemented incorrectly, group-based assignments can lead to dysfunction and inter-

personal conflicts that hamper student success. This problem can be especially acute in first and second year engineering fundamentals courses where advanced students who learn the concepts faster may end up completing—and reaping the benefits of—a lions-share of the group work. To address this problem, this work explored the use Informal Collaborations as a means of ensuring student accountability while still providing some of the peer-learning and team-work experience found in traditional group work.

After piloting IC in an introductory Digital Design class, it appears that IC is largely up to the task. All respondents agreed that being responsible for each lab helped them to learn the material better. All but one of the students surveyed from the course either agreed or strongly agreed that they often collaborated with classmates to complete the assignment. Additionally, over half of the respondents reported that they prefer IC to traditional group work.

I believe these initial results are promising enough to recommend the use of IC to instructors with limited experience in facilitating group work and to those instructors teaching large fundamentals courses where engaging in dysfunctional group work could have a severely negative impact on student learning. I also believe that the positive results presented here justify future research to directly measure how IC compares with well-implemented group-work in terms of promoting student learning.

## Bibliography


1. ABET. *Criteria for Accrediting Engineering Programs, 2017 – 2018;* ABET: Baltimore, 2017.

2. National Academy of Engineering. *Educating the Engineer of 2020: Adapting Engineering Education to the New Century;* National Academy of Engineering, 2005.

3. Oakley, B. A.; Hanna, D. M.; Kuzmyn, Z.; Felder, R. M. Best Practices Involving Teamwork in the Classroom: Results from a Survey of 6435 Engineering Students Respondents. *IEEE Transactions on Education* 2007**,** *50* (3), 266--272.

4. Smith, K. A. Cooperative learning: Effective Teamwork for Engineering Classrooms. *Frontiers in Education Conference*, 1995.