Guide to Effective and Inclusive Group Work

Introduction

The purpose of this guide is to provide instructors recommendations about how to support students to engage in effective and equitable group work. These recommendations are based on physics education research literature (cited throughout) and the experiences of the authors implementing group work in their courses. We suggest that instructors iteratively implement the strategies over time rather than implementing them all at once.

Recommendations

In this section, we present best practices curated from the physics education research literature about how to support students to engage in effective and equitable group work. The links head to detailed descriptions of the recommendations.

Creating Group Work Activities

1. Avoid tasks that can be easily completed by a single student.
2. Align group work activities with course learning goals.
3. Design assignments to support development of higher-order cognitive skills.
4. Scaffold activities to support students to engage in metacognition and self-regulation.
5. Effective group activities:
    a. Are engaging, interesting, and relevant (e.g., use real world problems).
    b. Require assumptions and estimates
    c. Have no one right answer
    d. Require information from outside sources
    e. Draw on real-world events
    f. Include hands-on activities
    g. Support lab skill development.
6. Use multiple problem types.

Creating Groups of Students

7. Intentionally create groups of students, and be flexible to individual student requests. Consider the following when creating groups:
    a. Group size
    b. Students' academic background/performance
    c. Students' identity aspects such as gender, race/ethnicity, English language learners, disability, LGBTQ+[1]
    d. Group work is not for everybody.

[1] LGBTQ+ stands for lesbian, gay, bisexual, transgender, queer+.

e. Change group membership frequently (3-4 times per semester)

First Day Framing

8. Be clear about the course and group work expectations.
9. Discuss the value of group work.
10. Emphasize building an inclusive community and valuing others.
11. Talk about inequity and the importance of diversity when framing group work.

Supporting Students to Engage in Group Work

12. Support students to create group norms and/or group contracts.
13. Use and enforce group roles.
14. Use name tags or name tents, and encourage inclusion of pronouns.
15. Use the jigsaw cooperative technique.
16. Instructors explicitly and regularly encourage students to work within and among groups.
17. Instructors walk around and listen to and engage with student groups.

Classroom Culture, Norms, and Practices

18. Minimize instructor and students lecturing during class.
19. Create a pattern of expected student and instructor behaviors.
20. Switch types of activities based on the needs of students in the moment.
21. Call on groups of students, rather than cold calling individual students.
22. Instructor emphasizes student groups sharing out key aspects of problem-solving, rather than describing the entire process.
23. Ethically solicit information from marginalized students about their experiences.

Grading Group Work

24. Throughout the course, grade students based on their group functioning, the products their groups create, and individually.
25. Make group work a course outcome.
26. Do not require group work outside of class time.
27. Do not grade on a curve.
28. Give teamsmanship bonuses on exams.
29. Allow students to provide feedback to each other.

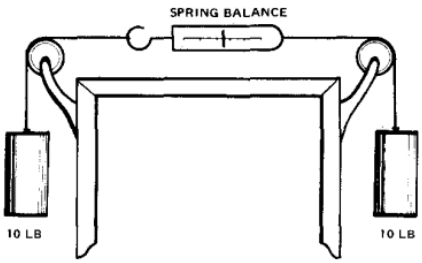
Detailed Descriptions of Recommendations

This section includes more detailed explanations of the recommendations above. Each recommendation includes: 1) a description of the recommendation; 2) example(s) of what the practice in a physics course; and 3) citations to relevant literature and/or examples.

Creating Group Work Activities - Detailed Descriptions

1. Avoid tasks that can be easily completed by a single student [1, 2, 3].
    a. The purpose of group work is to facilitate student learning. Students passively listening to an explanation (i.e. lecture from an instructor or peer) has a minimal effect compared to having to synthesize the information, organize a presentation, and present the information to a group of peers [4].
    b. To facilitate and encourage group work, instructors should avoid problems and activities that can be completed without input from their group members [2, 5].
2. Align group work activities with course learning goals [2].
    a. Problems should require understanding of the basic course concepts, otherwise the activity may be perceived as irrelevant.
    b. Instructors should clearly explicate the learning goal for each segment of the course and ensure that completion of the activity will aid in the completion of the course's learning goals. This could be achieved by listing the learning goals that are targeted for each problem, assignment, lesson, etc. Instructors should also critically examine the problems/questions they assign to make sure they are directly aligned with the learning goals and remove or revise problems/questions that are not aligned.
3. Design assignments to support the development of higher-order cognitive skills [2].
    a. In order to engage groups, instructors should utilize questions that can be answered using a variety of techniques, include the diversity of group members' experiences, are inquiry-based, require predictions, and/or data interpretation. During group work, instructors should challenge students to engage in analyzing, evaluating, synthesizing, and/or questioning the problem's premise or assumptions. For example, ask students to identify and defend a specific method for solving a problem. Restrictive, closed-ended problems should be difficult enough so that individuals cannot solve them easily.
4. Scaffold activities to support students to engage in metacognition and self-regulation [1, 6, 7].
    a. Instructors should do everything they can to discourage the lecture mode of group sharing (i.e., a series of group presentations). Keep the groups' output for class discussion simple and focused on the essential group task. For example, ask students to choose the most important reason or the best solution.
    b. Instructors should include problems/questions that encourage students to monitor and reflect on their progress and performance [8]. Ref [8] contains some excellent examples of these kinds of problems in several physics fields.

Since the net force on the spring scale shown in Fig. 1 is zero how can the scale register a non-zero reading? What does the scale register? Why isn't it 20 since it is pulled by 10 lbs at each end?



c. Metacognition is an awareness of one's own thought processes and self-regulation enables students to control how they interact with their environment. To assist students in these processes, instructors should provide clear instructions to students to communicate:
    i. the task (e.g., brainstorming, strategies, choosing, solving);
    ii. the expected product (e.g., reporting back to the class on ideas, handing in a worksheet, presenting a solution to the class); and
    iii. the method of "debriefing" or "reporting out" (e.g., sharing group results, sharing pros/cons, discussing group ideas, noting consensus and diversity of ideas).
d. Instructors should set a time limit for each group work activity and regularly make sure students know how much time is left. For example,
    i. give verbal announcements of the time remaining,
    ii. include a timer on the front projector screen,
    iii. provide individual reminders for groups.

    There is a careful balance that needs to be struck in order to ensure students are aware of the time they have to complete the assignment while also not stressing students out and triggering anxiety about the limited amount of time.

5. Effective group activities are engaging, interesting, and relevant [2, 7, 9, 10].
    a. Instructors should consider if the problems can lead to an engaging group discussion. Good group problems require justifying assumptions and estimates, have no single correct solutions, require information from outside sources, draw on real-world events, and can incorporate hands-on activities and building lab skills. Typically, end-of-chapter physics problems do not meet these criteria and thus, are not appropriate for group work. For example, instead of asking students to only calculate the inductance of a solenoid, ask them to design a solenoid to fit certain required parameters and produce a required magnetic field.
6. Use multiple problem types [10].
    a. To help students stay interested and engaged in group work as well as to prepare them for problems they may see on future assessments and in their future

careers, instructors should use multiple problem types. For example ill-structured problems (ill-structured problems prompt students to ask themselves “How do I know this? Am I making any assumption while doing these steps?”) [11], flawed reasoning (Example: two students are having a discussion about a series circuit. The first student says that the current from the battery is equally shared by the two bulbs, with half of the current used by the first bulb and the other half used by the second bulb. The second student claims that current from the battery all passes through the first bulb and all passes through the second bulb and then back to the battery. Which student do you agree with and why?), require explanation of thought process, word problems, problems that emphasize conceptual understanding, and problems that require groups to collaborate. Instructors do not need to include each of these types of problems in each assignment, but instead include a variety of problem types over the course of the semester.

Creating Groups of Students - Detailed Descriptions

7. Intentionally create groups of students, and be flexible to individual student requests [12, 13, 14, 15, 16, 17]. Consider the following when creating groups:
    a. Group Size: Instructors should create groups of three to four students. Prior research [2, 18] has shown that groups of three to four students are optimal to engage all students in group work.
    b. Students’ Academic Background/Performance: Instructors should create heterogeneous groups in terms of students’ academic background and/or performance (e.g., students from top, middle, bottom of class). This means that instructors need to know about the students’ academic background at the beginning of the semester via some pretest or grade in a previous course. Heterogeneity allows for the possibility to obtain new information from group members. Therefore, for students with little prior knowledge heterogeneous groups are most beneficial, whereas for students with high prior knowledge no difference is found [19].
    c. Students’ Identities: Instructors should not form groups where there is only one student from a marginalized group (consider identity aspects such as gender, race/ethnicity, English language learners, disability, LGBTQ+). This can be achieved by forming groups only containing students from one marginalized group (e.g., a group of four People of Color) or groups with two students from one marginalized group and one from the dominant group. For example, a study showed that homogeneous gender groups and mixed gender groups of two females and one male performed better than groups with two males and one female [2]. Instructors should be careful not to assume a students’ identity (e.g., assuming a feminine-presenting person is a woman, or that a white-passing person is not a Person of Color). Instructors can instead survey students at the beginning of the semester about how they identify and prefer to be described.

d. Changing Groups [10, 17]: Prior research [10] indicates that changing groups multiple times throughout the semester will benefit student learning performance because the groups can become so comfortable with each other that their in-class discussion topics are no longer about physics. However, another study [17] showed that changing groups presents additional challenges, especially to students from marginalized groups. Changing groups only once in the middle of the semester can be traumatic because, for example, the students have formed strong friendship bonds that are now severed, disabled students have learned how to function with their group mates and now need to get used to another group, LGBTQ+ students may have come out to their peers and now have to make the decision to come out again or not, etc. Instructors should announce the number of group changes at the beginning of the semester. Each time new groups are formed, there should be a brief training in group functioning to reduce the resistance.

First Day Framing - Detailed Descriptions

8. Be clear about course and group work expectations [14, 20, 21].
    a. Instructors should carefully describe their expectations for how students should engage with group work. The expectations should include aspects such as when students will work in groups (e.g., only one day per week, every class period, or specific times), if and how they will be graded on the group work (e.g., ungraded work, graded individually or as a group, graded on participation or correctness), how groups will be formed, whether groups will be changed or not, the instructors' expectations for participation and distribution of work, and discussion norms for students to follow. Instructors should include this information in the syllabus, learning management system, and possibly posted in the classroom (e.g., poster with discussion norms) as well as reinforce the expectations throughout the semester.
9. Discuss the value of group work [15].
    a. Throughout the semester, instructors should discuss and point out instances of the value of group work. For example, group work promotes a diversity of ideas, matches the real-world practice of science where most scientists work with others (and sometimes in very large collaborations), allows for students to share the workload, etc. This could be done during a whole class discussion, with individual groups or students, etc.
10. Emphasize building an inclusive community and valuing others [22].
    a. In the physics community (and in the U.S. context specifically) there is typically an emphasis on individualism (i.e., the mindset that a person must be self-reliant and independent to be successful). To counteract this idea, instructors should emphasize building an inclusive community of learners within the classroom. This involves creating, supporting, and reinforcing group work structures, ensuring that students are working equitably with each other, and being open and welcoming with students. Instructors should also emphasize that students and

instructors are all humans who have intrinsic value regardless of their work in the course.

11. Talk about inequity and the importance of diversity when framing group work [22, 23].
    a. Physics courses are taught at institutions which are housed within societies in which systems of oppression (e.g., racism, sexism, ableism) are endemic. Therefore, without intentional effort these systems of oppression will seep into the physics classrooms and students' interactions during group work. Instructors should talk about these systems of oppression, how they shape science (and its histories), and how they can come into play during group work. Additionally, all people have different identities and experiences which contribute positively to group work.

Supporting Students to Engage in Group Work[2] - Detailed Descriptions

12. Support students to create group norms and/or group contracts [24, 25].
    a. Instructors should prompt students to create group norms and/or group contracts. Group norms are a list of norms, policies, and practices for students to follow while they engage with group work. See the STEP-UP project's discussion norms for an example [26]. Group contracts are a set of rules (and sometimes consequences) that student groups create and agree upon. The value of adding group contracts is that they can motivate students to keep up with their ideals for group work included in their group norms throughout the entire semester. Group contracts can also provide a mechanism for recourse for students who are not enacting their agreed upon group norms. See an example from Havard [27].
13. Use and enforce group roles [18, 20, 28, 29].
    a. To support students to engage in group work and to equitably divide the work, instructors should use and enforce group roles. Group roles are named roles for students to espouse during group work including a manager (leader of the group and timekeeper), recorder (person who takes notes and documents the group's progress and findings), and skeptic (person who questions the assumptions and process of the group to allow for a more thorough discussion and consideration of possible processes/solutions). Prior research [29] has shown that without formal group role structures, there is an inequitable gender divide in roles and labor. See the Cooperative Group Problem-Solving from University of Minnesota for a further description of group roles [30].
14. Use name tags or name tents and encourage inclusion of pronouns [10, 17].
    a. Instructors should use name tags or name tents during class. Name tags/tents allow the instructor to use students' names (which may differ from their name

[2] One thing to keep in mind is not all students have the same comfort level, experience, and/or expertise in engaging in group work. For example, students from outside of the U.S. may not have been asked to engage in group work earlier in their schooling; or students with particular disabilities, Autistic students for example, may not be comfortable engaging in group work to the level that it would detract from their learning. Instructors should be on the lookout for students who are struggling with group work to provide them extra support or even, in situations where engaging in group work is significantly negatively affecting the student's learning, find an alternative to group work for individual students.

listed in the course roster) and it also encourages students to get to know each other and use their peers' names. This can be done in a busy classroom by providing students with a piece of cardstock at the beginning of the semester to create the name tent and then either have the students be responsible for bringing the name tent to each class, or the instructor/teaching assistants could collect and redistribute the name tents for each class. Instructors should also welcome and encourage students to include their pronouns on their name tags/tents if they are comfortable. Instructors should NEVER require students to include their pronouns as some students may not be comfortable sharing their pronouns in the classroom setting, while others may be on a journey to find/solidify their pronouns and forcing them to list the pronouns could be distressing. However, encouraging pronoun usage helps to create a welcoming and inclusive classroom culture. If they are comfortable, instructors could also list their pronouns in the course syllabus and use their pronouns when introducing themselves to the class (e.g., "Hello class! My name is ### and I use she/her – he/him – they/them – ze/zir, … pronouns.")

15. Use the jigsaw cooperative technique [20, 31].
    a. Many studies showed that collaborative learning is better than individual learning when students can share/teach information to their colleagues through the use of a jigsaw cooperative technique. Students with complementary information can be induced by the jigsaw cooperative technique [32]. It can be adapted to different learning environments (i.e., course contents, group compositions, etc.). The first step to set up a jigsaw is to divide the intervention or the mini-lecture into two or three segments and make each student the expert of one segment by reading over the segment or work on it by themselves. The number of segments should be no more than the number of students in each group so that each group can contain experts of all segments. Then form temporary "expert groups" by having students assigned to the same segment sit together to discuss the main points, resolve questions, and rehearse the presentations they will give to their own groups. TAs and instructors can join "expert groups" and act as the leader. When ready, bring students back into their own groups and make each student teach the segment to the group. TAs and instructors should float from group to group to make sure the whole process goes smoothly.
16. Instructors explicitly and regularly encourage students to work within and among groups [10].
    a. Students without prior group working experience in class simply do not know what they can do in a collaborative learning class. TAs and instructors should encourage students to talk to each other and move their seats to be closer to participate, rather than overwatch the discussion or activity.
17. Instructors walk around and listen to and engage with student groups [10].
    a. Regularly circulating through the room, sitting together with students, and engaging with student groups can shorten the instructor's distance away from students. Some students are reluctant to talk to instructors since they do not want to be caught doing/saying something incorrect. Instructors should be kind and

reinforce that the role as instructor is to support students to succeed in the course.

Classroom Culture, Norms, and Practices - Detailed Descriptions

18. Minimize instructor and students lecturing during class [10].
    a. Instructors should minimize the amount of time they spend lecturing as well as the time students spend presenting long explanations to the rest of the class. Instead, instructors should engage students in active learning activities such as group work, whole class/small group discussion, demonstrations, hands-on activities, etc. See the Freedman et al. for a meta-analysis showing that students engaging with group work better supports student learning and attitudes [33].
19. Create a pattern of expected student and instructor behaviors [14].
    a. Typically, students have extensive experience with traditional lecture style courses (i.e., composed of separate lecture and laboratory meetings, where the instructor lectures for most of the lecture sections and students are expected to passively engage with the course). Therefore, transitioning to a course that incorporates group work can be startling or confusing. To support students to engage with group work, instructors should create a pattern of expected student and instructor behaviors including set cues for students to start and stop engaging with group work, norms of how instructors engage with students during group work (e.g., circulating the room, checking in on students' work, instead of providing students with the answers to the discussion problems engaging with Socratic questioning), what kinds of questions/discussion topics are appropriate for students to engage with during group work, and how students can/should communicate that they have completed the group work task.
20. Switch types of activities based on the needs of students in the moment [10].
    a. One of the values of courses that are not traditional lecture style is the ability of instructors to be responsive to the needs of students. Instructors should continually monitor the progress and learning of students during class and be flexible to switch between types of activities based on the needs of students. For example, if an instructor notices that students are having difficulties paying attention during a lecture presentation, the instructor could switch to having students discuss one of the topics they learned from the pre-class reading and one thing they have an outstanding question or concern about. Or if an instructor notices many student groups are stuck at the same point in a group problem, the instructor could switch to a group discussion about the sticking point or could present/re-present the content relevant to the sticking point.
21. Call on groups of students, rather than cold calling individual students [14].
    a. Previous research [34] has shown that students can feel a lot of anxiety in a course when the instructor utilizes traditional cold calls (i.e., calling on a student during class to present their answer, ideas, or thoughts about a topic without advance warning to the student). However, cold calling can motivate students to meaningfully engage with group work and to remain focused on the class. As a

compromise, instructors should call on groups of students to share their answers, ideas, or thoughts about a topic they discussed in their groups, rather than calling on individuals. Instructors should also engage with error framing [34] (i.e., emphasizing that errors are an important and normal part of the learning process and help us to learn) when student groups do not share out the correct answer.

22. Instructor emphasizes student groups sharing out key aspects of problem-solving, rather than describing the entire process [9].
    a. When an instructor calls on a student group to share their answers, process, and/or reasoning for a group problem, the instructor should emphasize sharing out key information rather than the entirety of the process to minimize the amount of student lecturing. This could be done by asking student groups to share out the final answer, a step in the problem-solving process (e.g., equation of motion, free-body diagram, physics concept utilized), the part of the problem that was the sticking point for their group, and/or one thing they learned from solving the problem.
    b. Select a mechanism whereby groups share their essential results simultaneously in a highly visible way. Provide time for groups to digest, process, compare and contrast, and evaluate the output of other groups prior to the whole class discussion.
23. Ethically solicit information from marginalized students about their experiences [22].
    a. As described above, the systems of oppression endemic in society often percolate into the physics classroom. Students from dominant groups (e.g., white, cisgender, heterosexual, able-bodied, affluent, men) are typically centered, planned for, and expected in higher education and will likely have different experiences than students from marginalized groups (e.g., People of Color, LGBTQ+, disabled, lower socioeconomic status, women and gender minorities). Therefore, it is important to elicit information from students from marginalized groups about their experiences in the course. Instructors should be purposely and use caution about the ways in which they solicit, use, and disseminate this information. Instructors should be aware to not trigger trauma or memories of traumatic experiences, expect students from marginalized groups to educate instructors about their identity and associated systems of oppression, break confidentiality of students by including their name or identifying information when sharing findings with others, or to disseminate findings for the personal gain of the instructor without credit and compensation for the participants. We suggest instructors work with marginalized students, staff, and faculty are their institution to develop best practices for their local context.

Grading Group Work - Detailed Descriptions

24. Throughout the course, grade students based on their group functioning, the products their groups create, and individually [1, 13].
    a. For a course emphasizing group work, it makes sense to grade group functioning and performance. However, it is equally important to grade on group participation

and group contributions. Instructors should track and grade student attendance/class participation, group participation, and individual students' contributions to their group. These activities can be tracked by many computer and/or smartphone-based software (e.g., Slack, Microsoft Teams, Google Doc) to make grading on those factors possible. Instructors should also ensure students are responsible for doing their own share of the work and for mastering the material by having a portion of their grade be individual.

25. Make group work a course outcome [15, 21, 35].
    a. When designing a course, it is important to have learning objectives explicitly relating to the improvement of interaction and learning through class activities. For example, instructors should make it clear to students that all group members mastering the content and helping each other during group work are course outcomes. When students are collaboratively solving a problem, instructors can make each group member use a different color pen to motivate individual accountability. Furthermore, lecture content, activities, readings, homework, and assessments could be planned and broken into smaller steps to help students to achieve these outcomes.
26. Do not require group work outside of class time [36].
    a. While group work can be an important part of a course and can improve student learning, instructors should not require group work outside of class. A study showed that scheduling group work outside of class time is hard for students who are raising children to attend. Additionally, students with jobs, familial obligations, etc. can also have a difficult time meeting with other students outside of class.
27. Do not grade on a curve [10].
    a. Students and instructors typically have different interpretations of what counts as "curving grades". To students, any unjustified bonus points might be "curving" or that curving exam scores means the exam was impossibly difficult. Therefore, instructors should carefully justify every bonus point opportunity to avoid students to interpret it as "curving". It should be avoided for an effective classroom.
    b. Imposing a curve to final grades (i.e., fitting the grade distribution to a normal curve) greatly affects the overall classroom dynamic. In this case, a student helping another student get a better grade may mean a decrease in their own grade. To effectively encourage group collaboration, instructors should not curve final grades in this way and should communicate to students at the start of the semester that this type of curving will not be used.
28. Give teamsmanship bonuses on exams [10].
    a. To encourage students to work in groups, instructors should consider giving teamsmanship bonuses for groups that work particularly well together. For example, if the team average on any given test is "B" or better, each team member has 5 percent added to their score. It is in the best interest of the top students to teach the others in their group. Since the top students are often highly motivated by grades, this has been quite successful.
29. Allow students to provide feedback to each other [10].

a. Students need to evaluate how well their team is functioning, where they could improve, and what they should do differently in the future. The feedback can be given anonymously and related to the grade of the course. It also can be a face-to-face discussion in the spirit of continuous improvement.

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