Designing Group Work in Science Classrooms

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Group work is a chance for students to work independently and in social settings without the teacher's overt guidance. If designed properly, group work gives students many rich opportunities to engage in "science talk", to learn from others, and to develop pro-social behaviors.

Group work is a designed event. Teachers must use forethought to effectively construct learning situations for groups of students. In this paper, we look at the design of group work through five "lenses":

1. Nature of the tasks assigned
2. Assigning students to groups
3. Fostering student ownership
4. Interpersonal considerations
5. Assessment and accountability

1. Nature of the tasks assigned

There are two broad categories of tasks. One is the short term task which generally brings a group of students together for only one or two class periods. The other is a long term task, in which a group of students work together for weeks.

Short term work: activity

For short term group work, the tasks are usually clearly defined. The teacher may ask students to do any one of the following tasks and give one class period or less to complete these. These are ***authentic tasks***, in that real scientists do these things as part of their work:

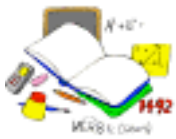
- Make sense of something they have read
- Co-construct a representation of an idea (model)
- Solve a small-scale problem
- Apply existing knowledge to a new situation
- Design an investigation
- Critique an investigation
- Collect, organize, and graph data
- Interpret graphs
- Develop hypotheses based on background reading
- Examine and weigh out various forms of evidence
- Develop an argument for or against a position.
- Others…

Acid test for group work activity: Too often students can "go through the motions" of group exercises without needing to use scientific knowledge or skills. Make sure that tasks require the use of scientific knowledge or skills.

Short term work: keeping on task

At the beginning of group work make it clear to your students why they are doing this activity (so it's not some disconnected, meaningless exercise) and what the product is that they are responsible for (a concept map, a "solution" statement, a graph, a set of arguments, etc.). Write these on the board *and* provide a handout. You don't have to specify *exactly* how to arrive at the final product, but make sure the students have a goal and they know exactly what is expected of them. How much you structure this activity depends on the levels of skill your students have currently.

To keep students on task and on schedule, you can have a mid-point product that they are responsible for, perhaps half-way through the class period (if the group work lasts only one period). If, for example students are supposed to collect data, organize it, and graph it, you may ask that after about 15 minutes they produce an outline for how they will accomplish these tasks.



Within the first 10 minutes of the group work, you should make "the rounds" of your groups and monitor their progress. Don't *just* see if they are "on schedule to finish" or "following directions"— be prepared to listen for clues to their thinking, be prepared to ask probing questions. You also should be able to spot groups who are working themselves into a dead end, that misunderstand what the group is supposed to do, or who exhibit interpersonal problems.

Longer term work

Sometimes you want students to work together on major projects which last weeks. This is generally to produce a complex product (like a full inquiry and report) or performance (like producing a video that shows how invasive species have influenced local ecosystems). As with short term group work, you want to use ***authentic tasks***: these are activities that scientists actually do. In these cases, you cannot specify *exactly* what students should do over this long period. You should, however, suggest stages of progress that students should pass though on their way to this final product or performance. Students should have some way of monitoring their own progress, and it helps to make clear what the intermediate steps should be on the way to the big goal. For these longer projects it helps to have students turn in a proposal for how they are going to organize themselves or a proposal for how they will have different stages in accomplishing the overall task. Students are not naturally adept at organizing themselves, this has to be purposefully fostered by the teacher!

As always, for any works in progress it is vital to give students feedback on their thinking and their activity.

Long term work: an ideal task design

A note about what has been referred to as "true group tasks." True group tasks require resources (information, problem-solving strategies, materials, and skills) that *no single* individual could possess so that no single individual is likely to solve the problem or accomplish the task objective without at least some input from the others. Each member must *exchange resources* with others during the project. True group tasks are not always feasible in the classroom, especially for short term tasks, but for longer term work, this kind of structure is a goal to shoot for.

Science specific task-oriented group work for any duration

Here are some tasks science teachers in particular should shoot for:

- *Encourage students to grapple with data*. Encouraging groups to grapple with data requires that students make sense of what they are learning. When this is done in collaborative settings, students can struggle together with the ultimate goal of understanding.
- *Assist students to focus on science concepts and processes, not on procedures.* Some studies have shown that collaboration in science classrooms can be overly focused on observational or procedural issues i.e. "following directions" and overlook the development of scientific knowledge (Bianchini, 1997). While focus on mastering procedures may be significant to understanding how science is done, it is arguably more important to understand basic scientific principles. In this way, students can focus on learning ***why*** certain procedures are done, not just how. For example, to achieve scientific argumentation in groups, teachers need to challenge groups to develop and present scientific justification and verification, not just answers or summaries.
- *Establish science and group mastery criteria.* Because students are not familiar with the inquiry process, providing clear mastery criteria is important. The types of criteria needed include criteria for what science concepts must be mastered, criteria for mastering how to do science, and criteria for mastering cohesive group work. In addition to providing the criteria for mastery, students also need assistance in learning to use the criteria and take steps to work toward the criteria. If this is coupled with an atmosphere that actively encourages students to rework problems or experiments then students will be more likely to pursue higher levels of mastery.
- *Provide science tasks with choice.* Crawford (Crawford et al., 1999) suggests that some scientific inquiry tasks tend to promote more choice for the students. For example creating situations that promote student-initiated questioning or that allow students to devise their own strategies for experiments tend to increase project ownership *and* collaboration. These tasks differed in comparison to teacher-initiated questions and experiments that did not qualitatively show ownership and collaboration in a focus group. Additionally, Crawford and her colleagues (1999) found that students were more likely to collaborate with peers when inquiry tasks were connected to real world questions, compared to topic-bound tasks.

Some things to avoid in group work of any duration

Don't have students sit in groups and complete worksheets. This is simply "exchanging answers" and does not foster any scientific discourse. Also, don't divide labor so each person does their part of task separately, and the parts only have to be drawn together in the end. There is no basis to expect the pro-social outcomes from the situations described above.

2. Assigning students to groups.

The ideal number of students in a group is 3 or 4. If the group size gets too big, it becomes easy for one or more students to "hide," take on passive roles, and feel less accountability to the group. If the group size is too big then the material resources cannot be utilized by everyone. This can happen even with a group of 3, but it is almost guaranteed with groups of 5 or larger.

It is best to have groups with mixed ability, gender, and cultural background, but try not to place "token" kids in each group. Do not have quotas for each group-- students are able to pick up on that strategy right away and are offended by it.

When the groups are of mixed ability, the more accomplished students benefit by explaining their ideas to others and the kids who usually struggle can get access to the thinking of more advanced students. They can hear how other students organize themselves, how they approach complex problems, and how they seek out relevant resources. This is one of the characteristics of students who usually struggle in class, they do not yet have ways of self-monitoring their own understanding and progress towards a goal and they lack the disposition to self-organize. These are *not* "stupid" kids.

Don't have students self-select into groups, otherwise they will fall along friendship lines and inevitably ostracize those who are less popular or less able. You take charge of putting them into groups.

3. Fostering student ownership through socio-cognitive roles

One of the hallmarks of good group work is that students are *engaged in productive dialogue with each other over science ideas*. It is up to you to come up with a compelling problem for them to solve and to have clear goals for their work together.

To foster group participation, it is helpful to assign roles to students. Some teachers assign managerial roles, such as note-taker, supply-getter, procedure-reader, is associated with **less** focus on scientific concepts (Lumpe & Staver, 1995). Lumpe and Staver (1995) advocate the use of cognitive roles.

1) **Big ideas person**: The BI person pulls the group (occasionally) back to the scientific purpose of the activity (often a group will get too wrapped up in the rote execution of the directions).

- Asks "How does X (something we are studying, reading, investigating, observing, etc.) relate to The Big Idea?"
- Asks: "How does X change the way we're thinking about The Big Idea?"
- Asks: What is the big idea we are trying to understand? Why are we [watching ice melt]?

2) **Clarifier.** This is a role of monitoring comprehension—a check to see if group members at least share a common set of ideas and terms. This person can stop the group and ask: Do we know what the word ____ refers to? Do we all understand it the same way?

3) **Questioner**: This person asks probing questions during the activity. These folks listen for questions posed by other group members and then re-voice the questions to make sure that the whole group takes a moment to hear and entertain questions from everyone. This is not a role that students find easy, so it helps to provide them with question stems such as :

- Asks: "What does it mean that ____?"
- Asks: "How do we know that_____?"
- Asks: "What would happen if we changed ____?"
- Asks: "What's your evidence?"

4) **Summarizer/Explainer**: This person ask others to periodically take the measure of the group's progress.

- Asks: "Can we describe what we've done so far?"
- Paraphrases what other have said: "So, Santiago, what I think you are saying is…"
- When you stop by a table to listen in on a group, you should expect this person to be able to communicate the ideas of the group members AND attribute ideas to particular people (giving credit where it is due).

In larger groups (more than 3 kids) you can add a 5th role:

5) **Peacekeeper**: This person monitors airtime of people in the group— this person is allowed to control who has "the floor" with the goal of ensuring that everyone gets a chance to talk and that everyone takes time to listen.

As a teacher, you certainly don't need all of these roles in a group, perhaps just two or three. Sometimes students will play multiple roles and do so spontaneously. This would obviate the need for roles. But in lower grades you will often see kids who have no idea how to work socially within groups, particularly lacking the ability to self-organize individually or as a group. In this case, roles are good to structure their participation.

4. Interpersonal considerations

Students in middle and high school do not possess all the interpersonal skills necessary to support productive group work. Fostering pro-social behaviors should be a concurrent strategy with the design of productive group tasks. What kinds of behaviors are beneficial to group work?

• Making sure everyone has a significant role to play (both procedurally and cognitively) – this means giving everyone a chance to voice their ideas and opinions.
• Commenting on the ideas of others without commenting on them as people.
• Making ideas public and explicit without at first passing any judgement.
• Building on ideas of others (kids get to listen to the thinking process of others—extremely valuable!).
• Asking on-task questions that go beyond procedures and are about ideas.
• Asking peers to clarify what they mean.
• Peers answering the specific questions asked by their classmates.
• Keeping sarcasm out of the conversation.
• Others?…

As the teachers you should take the time to talk in very plain terms about these principles and give examples and counter examples of each through role play (kids are actually good at this, they do enjoy giving the good and bad examples). You should make a poster of these principles (make your own list, ours is not complete or perfect) and hang them in your classroom. Early in the year, you are really in the business of establishing norms of behavior-- what will and will not be acceptable in your classroom. The list above can pertain to whole group discussions as well as small group interaction.
Make students cognizant of these interactions as they happen in small groups. At the beginning of a day of group work, have students focus on one of the principles on your list. At the end of a day of group work, have them report out how they fared in maintaining that norm. Make the pro-social goals equal in importance to the intellectual goals.

Additionally teachers should actively discourage competition and ability comparisons between and within groups. To capitalize on student effort, teachers could design competitions that are more removed from the student groups. For example, teachers can structure a competition between different classes rather than among groups in the same class. Alternatively, the teacher could aim for an alternative goal, such as presenting group work to local officials or scientists (Crawford, 2000).

5. Assessment and accountability

As mentioned previously, you as the teacher should make informal and frequent assessments of who in the groups is involved. Involvement means not only in the handling of materials but in the intra-group dialogue as well.

In every class there will be students who will not contribute to the work of the group. Frequent monitoring of the group's activity is one way to head this off. You also can give the group an assessment sheet in which they self-assess their own contributions to the group and they assess the contributions of their peers. You will need to give them examples of what you mean by "contributing to the success of the group." Students can also give group and self-evaluations reflective feedback for specific scientific processes criteria (i.e. making scientific connections, being systematic, reasoning carefully, teamwork, etc.).

Teachers can also help students can take ownership for helping one another. For example, teachers can tell students that they do not know which members would be called upon to explain their scientific reasoning so group members need to make sure everyone in their group understands the material before they presented it to the class.

For group work that lasts only one class period, you may not have to give them any formal evaluation, as long as their work can be talked about in a whole group setting so that the teacher knows they have been engaged in productive work.

For longer term work however, you will want to have both group and individual accountability. For any major project you must have a rubric that you share with students at the outset of the project. This is used to give some feedback to them and is the basis for a group grade. This *group* grade may account for one third of their total final project grade. The students, as individuals, may be given some task or questions related to the final project. This *individual* grade may count as two-thirds of their total final project grade. In a perfect world, all students in a group contribute equally to a project and all can fairly receive the group grade as the total final score. But this is not a perfect world.

Other strategies that have been used are to give everyone a group grade based on the average improvement of every member of the group. What this requires is that a pre-assessment of student thinking is administered and a post assessment too. For cases where everyone in a group has improved, all members of the group are rewarded. This may encourage the more able members of the group to help the struggling students to improve.

Be forewarned that any grading scheme for group work is going to be open to criticism. There is no such thing as total, objective fairness in group assessment. The benefits to well-designed group work however, clearly outweigh the challenges to assessing student progress.

Establishing Socio-Scientific Norms & Maintaining Groups over Time

When group work is thoughtfully designed it can act as a catalyst for student learning as well as a model of collaborative work in science. While there are several factors to consider when establishing group work for tasks and activities, the success of these

groups depends on: 1) how teachers establish a classroom community that values group work and 2) how teachers maintain this focus over the course of a school year.

Before we consider how to establish and maintain groups over time we need to clarify the multiple types of group interactions within our classrooms. First we can consider how the entire class operates as a group. Second we can consider how members within small groups interact. And third we can consider how small groups interact with other small groups. Establishing and maintaining norms for each type of group of interaction is important for helping students see the value of group work.

Setting social norms (general ways that students participate in classrooms) and socio-scientific norms (specific ways that students participate in science activities & discourse) at the beginning of the year sets a tone for the year; indicating that you value (and the discipline values) people working together. Having students participate in the development and publishing of these norms is a first step in establishing the idea that group work will only be successful if everyone takes ownership.

Students are more likely to be able to articulate social norms, especially at the beginning of the year. Activities that promote this sharing might include:

- "Our best self": have students draw a picture of the group and write descriptions of what "their best self" looks and sounds like, on the boarder of the picture have students write distracters that work against their best self
- Strengths we bring to the group- have students describe one of the strengths they bring to the group (and place yourself as a group member as well)

Teachers can also explicitly promote socio-scientific norms including:

1) students' explanations consist of a scientific argument, not simply a procedural description
2) scientific thinking involves understanding and reconciling multiple theories
3) errors provide opportunities to reconceptualize a problem & explore contradictions
4) collaborative work involves individual accountability and reaching a consensus through scientific argumentation

Maintaining these norms is critical. Periodically revisit norms; this helps students focus on positive ways in which the group is developing. Students can revise norms and monitor positive ways in which the norms are exemplified.

In addition to developing and maintaining norms teachers can actively promote positive group relations by:

- Positively reinforce helpful group behaviors
- Reinforce trust and openness in communication in groups
- Negatively reinforce harmful group behavior
- Providing direction/redirection for "caring" group behaviors

- Developing or maintaining a format for solving problems in groups
- Reinforcing that group problems are an opportunity for growth
- Referring questions or problems to the group for their input (reflective toss- within or between groups)
- Communicate confidence that the students can do what needs to be done to maintain a positive working group
- Involving the group in processing group behavior and progress

Yet maintaining positive group functioning also requires that teachers gradually turn more of the leadership roles (although not disciplinary roles) over to the students. Examining the list above, we can think about how some of these teacher actions can be gradually turned over to the students. Additionally considering "phases" of group development can help determine what this scaffolding might look like (see table).

Summary

As mentioned earlier, being successful in group work can take the form of conventional academic achievement, engaging in productive discourse about science, and fostering pro-social behaviors. Your job as a teacher is to take those disciplined ways of thinking and pro-social ways of relating to one another as peers and get kids to "internalize" these behaviors. Your goal is to scaffold student's thinking and social actions so that they can eventually do this on their own, without your intervention. Remember, kids are not naturally organized, they do not spontaneously monitor their own progress, they do not naturally use scientifically disciplined ways of thinking, and they do not always know what pro-social behavior is. It is your responsibility to make these ways of thinking and acting explicit to them and to help them monitor their own efforts at thinking and acting this way.

Group Phases. Both the entire class as a group and small groups within the class will tend to move through phases. These phases are not necessarily linear. Identifying phases can help you problem-solve how to move students forward in learning and in working with one another.

	FORMING	STORMING	NORMING	WORKING	ENDING
	Setting norms	Testing norms	Common sense of purpose	Moving forward in learning	Transitioning
Student Behaviors	• Individuals in groups learn about one another, • Some students are hesitant • They establish ideas about how included/ excluded they will be	• Students test what is acceptable and test teacher expectations • Subgroups/ cliques form • Students may blame teacher for problems in classroom	• Group shares in maintaining norms • Cliques and subgroups are more tenuous	• Students have formed a strong cohesive clique-free group that embodies the established value system • Group relies less on adult leadership and places considerable demands on its members to face their problems, and help one another work together	• Students have formed a strong cohesive clique-free group that embodies the established value system • Students may show apathy or sadness that the class is ending
Teacher Responsibilities	• Establish, model and monitor group rules for whole and small group operations • Use group work daily • Establish that helping can come from the teacher and the group • Reinforce helping one another • Participate in discussions but refer questions to the group • Acknowledge each group member's comments • Begin to share the responsibility of monitoring group work	• Encourage candid expression • Invite students to participate in problem solving • Begin to teach the group how to analyze group processes • Challenge the group to share responsibility for group behavior • Reverse responsibility • Talk to individuals negatively influencing the group & appeal to their potential for being a positive group member • Revisit norms	• Help group distinguish between helpful and nonhelpful communication • Give group increasing responsibility to deal with problems in a helpful way • Continue to reach out to struggling participants; find ways in the group to give them recognition and respect for positive participation	• Help group distinguish between helpful and nonhelpful communication • Give group increasing responsibility to deal with problems in a helpful way • Continue to reach out to struggling participants; find ways in the group to give them recognition and respect for positive participation	• Acknowledge feelings of sadness/loss • Continue to emphasize norming and working but encourage moving on- with friendships and continued progress