Practical Advice for Small Group Learning in Undergraduate Mathematics

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What Is Small Group Learning?

In the following table, we give some different characteristics of small group learning activities, and a few examples. Typically a "small group" has 2-5 members.

Procedure	Formal (sometimes called *cooperative learning*) • "a structured, systematic instructional strategy" (Springer et al. 1999, p. 24) • "tasks which are specifically designed for, and assessed in, groups" (MacBean et al. 2004, p. 51)
	Informal (sometimes called *collaborative learning*) • "relatively unstructured processes through which participants negotiate goals, define problems, develop procedures, and produce socially constructed knowledge in small groups" (Springer et al. 1999, p. 24) • "when the students come together naturally to help each other" (MacBean et al. 2004, p. 51)
Setting	In-Class • e.g. tutorial groupwork (formal), or students talking in lecture (informal)
	Out-of-Class • e.g. group projects (formal), or students studying together for a test (informal)
Formation	Student-Selected Groups
	Teacher-Selected Groups • heterogeneous groups (mix of weak and strong students) yield best results

Why Use Small Group Learning?

Group work experience is valuable. Students should learn to work in groups because scientists and researchers function most effectively in groups. (AAAS, 1990)

More effective learning. Students get more done in groups. E.g. when individuals get stuck, their peers can quickly tell them if they see a common error or misunderstanding.

Social aspects. Working in groups helps students get to know their peers. This mitigates the stress of the university environment and helps them build a network of friends and colleagues.

Building mature skills. Verbalization of mathematics to peers improves proof-writing skills and conceptual understanding; teaching peers and planning group projects facilitate cognitive and meta-cognitive growth. These skills build *mathematical maturity*.

Shifting the centre of learning from teacher to student. Students can obtain multiple viewpoints on the same material. It is less intimidating for students to ask questions to peers rather than to the lecturer, especially if they are unsure if the answer is "obvious."

Students collaborate naturally. Working as a group on individual assignments is viewed as "trivial cheating" by 79% of undergrads vs. 27% of faculty in Canada; 45% of undergraduates have done so. Arguably, students see the benefits of working together. (Springer et al., 1999)

Sample Activities From Literature

- As an ice-breaker, have students interview each other in pairs and report a unique fact about their partner to the class. (Goldberg, 1981, p. 212)
- To introduce the 5 algebraic groups of order 8, break the class into 5 teams and have each team study one of the groups. (Grassl & Mingus, 2007, p. 585)
- Have students prepare homework solutions in a group, to present in front of the class. Encourage the audience to help through difficulties that arise. (Berry & Sharp, 1999, p. 31)
- In tutorial, give groups of 4 students problems more difficult than what one student could solve alone. (Duncan & Dick 2000, p. 367; D'Souza & Wood, 2003, p. 1; Goldberg, 1981, p. 214)
- Use a team-oriented activity such as Jeopardy for review before the midterm or final exam. (Grassl & Mingus, 2007, p. 585; Goldberg, 1981, p. 216)

Student Quotes

Here are some representative student quotes that illustrate the effects of small group learning in undergraduate mathematics.

Applications to "CO 456: Intro. to Game Theory"

- Use a many-player game that is relevant to the course content in order to introduce students to each other in the first class.
- Give two-part assignments, consisting of an individual-only part that builds basic tools and skills, and a collaboration-optional part that requires more insight and creativity to solve.
- When introducing *impartial combinatorial games*, give the students first-hand experience. Explain the rules of several such games, pair up the students, and have them play these games against each other. Debrief them afterwards to see if winning strategies were developed.
- Design group-assessed projects with multiple components that can be worked on independently. As part of the final project, have students give group presentations about papers from game theory literature.
- Ask students to create a one-page review sheet to bring to the last class. Have them critique and improve each others' designs in small groups. Ask each group to give one tip to the rest of the class; discuss which were the most important ideas in the course.

Tips

+ Start small. Plan specific small group learning activities for your course. Tell your students what you plan to do and make sure the rationale and expectations are clear.
+ Give a specific collaboration policy to the students. E.g. can groups provide answers to other groups "so they have an example," or use on-line resources such as Facebook?
+ To form heterogeneous groups, give a pre-test and make each group have a mix of weak and strong students.
+ Plan activities appropriate to the class size.
+ If you encourage out-of-class group work, find out what on-campus resources exist for groups of students (e.g. group study areas) and advertise them to the class.
+ Make the fraction of the students' final grade allocated to small group learning activities match the fraction of their time spent in groups.
+ When groups have questions on the material, act as a catalyst for the group to answer it themselves, rather than a primary resource. Be willing to relinquish control of class discussions.
+ Track the effectiveness of your methods using formative assessment tools such as mid-term questionnaires and teaching observations.
+ Group homework yields fewer submissions, so give more feedback to each submission.
+ Encourage intra- and inter-team cooperation, and discourage competition.

Caveats

– Group learning can enhance delivery of course material, but is not a substitute for good course content. Using small group learning successfully requires careful planning and commitment on the part of the teacher.
– If using group assessment, give students a chance to evaluate their group peers for fairness.
– Some students (e.g. mature students) may prefer that you do not use group learning, due to past experience or personal preference.
– Avoid random selection of groups; student-selected groups and teacher-selected heterogeneous groups yield better results.
– Avoid gratuitous group tasks; if the benefits of being grouped are not evident to the students, they may work individually instead.
– Completely unsupervised groups may make uncorrected mistakes. Pay attention to each group to ensure steady progress.

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