Divide and Conquer: A Simple, Modern Technique for Collaborative Small Group Learning with Reciprocal Peer Teaching[†]

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INTRODUCTION

The benefits of collaborative group learning and peer teaching have been well documented over the last several decades (1–7). These active learning techniques foster student learning and help build the oral communication, teamwork, research, and problem-solving skills that employers desire in STEM graduates and are aligned with the *Vision and Change* recommendations (3, 8–11). Increasingly, students and instructors interact with technology in their lives and in the classroom; internet resources are used in a constructivist approach to researching and solving problems (12). In the classroom, the internet and computer technologies facilitate collaborative group learning by enabling synchronous interaction with digital documents and immediate access to information. Though collaborative group learning and peer teaching are effective active learning techniques, challenges in the design, execution, and evaluation of group learning can be a barrier to implementing this pedagogy in the higher education classroom.

In this Tip and Tools article, we describe "Divide and Conquer," a simple, easy-to-use, modern technique for rapidly transforming traditional lecture content into collaborative small group learning experiences. In Divide and Conquer, students are divided into groups, complete instructor-prescribed activities on a shared Google Slide deck, and then teach the class what they learned. Although activity selection depends on course and learning objectives, Divide and Conquer is particularly amenable to self-contained, related mini-research topics (i.e., the lowest level of organization on the outline of a lecture). Courses with a large number of examples (e.g., Organismal or Plant

Biology) are especially well suited for Divide and Conquer group learning. This technique requires minimal instructional design time, student access to Google Slides, and a fast, reliable internet connection in the classroom. It can be used to explore a range of topics, including discipline-based science content and other applications, such as discussion syllabus exploration (Table 1).

This innovative technique was inspired primarily by the Jigsaw strategy for active learning (13, 14). However, it is distinct in that it deliberately builds technology skills and includes a class-level presentation. We suggest that, as a structured, in-class experience, Divide and Conquer supports inclusiveness in the classroom (15, 16). All uses of Divide and Conquer described in Table 1 have been tested in the Biotechnology Program at North Carolina State University (NC State), a large, public, doctoral degree–granting institution. It is adaptable to any higher education classroom across disciplines.

PROCEDURE

Materials and prerequisite skills

Students must have in-class access to the internet, a computer or tablet, and a Google Slides–compatible web browser. The classroom internet must have an adequate

TABLE 1.
Examples of uses of the Divide and Conquer technique.

Use	Field-tested activity examples

Microbiology and biology topics	• Complex, detailed topics
	  ▪ Cas9 variants
	  ▪ CRISPR diversity
	• Broad topics
	  ▪ Protein visualization assays
	  ▪ Model organisms

Document analysis	• Syllabus exploration • Analyze selected literature or news articles
Discussion preparation	• Examples of biotechnology • CRISPR-Cas9 patent battle timeline

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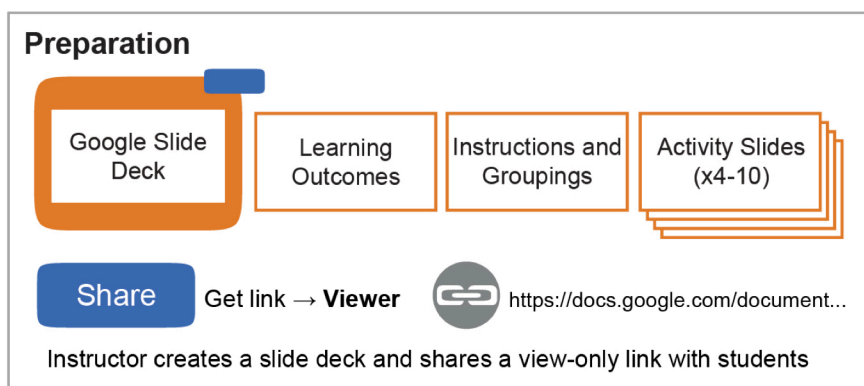
FIGURE 1. Schematic of instructor preparation for Divide and Conquer. (Top) The instructor creates a new Google Slide deck with two instructional slides to state learning outcomes, instructions and groups and a set of 4 to 10 activity slides. Each activity slide will be completed by one group of students. (Bottom) The instructor generates a link to the slides that gives viewer permissions to those who follow the link and shares the link with students.

bandwidth for all students to be using the internet with up to 100 users editing a single slide deck at the same time. If this is not possible, see modification tips in Table 2. Students should be proficient at using presentation software like Microsoft Powerpoint or Google Slides and using browser-based tools. Google accounts for each student are recommended but not required for this technique.

Safety issues

There are no physical safety issues related to this technique, but there may be some information security risks associated with students sharing links to the editable slides and having in-class access to each other's work. These issues are mitigated by controlling the timing of edit privilege release and including expectations for netiquette in the syllabus.

Method

To prepare a Divide and Conquer experience, the instructor generates an editable Google Slide deck and then adds two instructional slides and one slide per activity with ~4 to 10 activities (Fig. 1, top). The instructional slides delineate the learning objectives, assign students to groups, and provide specific instructions for the Divide and Conquer experience. Next, the instructor generates one slide for each group's activity and adds activity-specific instructions to those slides. Activity instructions students to research a topic and edit the slide(s) to summarize and communicate information about that topic. For example, if using Divide and Conquer to cover the six classes of enzymes, the instructor makes six content slides and titles each one with a group number and the name of an enzyme class. Slide activity instructions could direct students to search
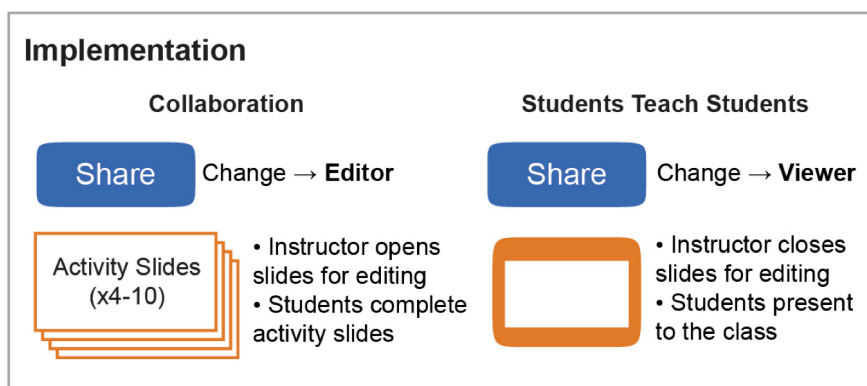

FIGURE 2. Schematic illustrating implementation of Divide and Conquer in the classroom. (Left) The instructor opens the slides for editing by changing the link-sharing settings (no need to distribute a new link). During class, student groups complete their assigned activity and edit their slide to generate a resource on their activity. (Right) When time is up, the instructor closes the slides for editing and student groups present their findings to the class.

TABLE 2.
Tips for use and modification of Divide and Conquer .

Problem	Tip
Group assignments	Unlike most collaborative learning approaches, we recommend that groups are randomly assigned for Divide and Conquer activities. This helps reinforce the temporary nature of the groupings, which itself gives an "end in sight" for incompatible groupings and maximizes student opportunities to build skills in working with new teammates. Students can be divided into groups ahead of time or during class as part of the live presentation. A random team generator (e.g., https://www.randomlists.com/team-generator) is recommended to rapidly group students. Simply snip and paste the readout from the team generator into one of the instructional slides.
Students express concern about the need to "perform" on the spot to complete the activities	Reassure students that there is no expectation for perfection, that class time was designated for the activity to help level the playing field for students who do not have as much out of class time for school work, and that learning to work with a team and within time constraints is a useful skill.
Students accidentally delete a slide	Access the Google Slide's version history. Then, locate and copy the deleted slide. Return to the current version and paste the delete slide into the appropriate portion of the slide deck.
The quality of student-generated slides is below expectations	Try setting the stage with an example slide, but be cognizant that students tend to copy the format of the example slide, so this can influence their creative process.
Groups complete the assignment at different rates	Circulate throughout the class and differentiate instruction by adding challenge questions to groups who finish early and provide extra support to groups who are struggling. A simple, easy-to-remember differentiation is for students to add notes for their classmates in the speaker notes section of their slide.
Insufficient bandwidth in the classroom	Ask students to use one computer per group to limit the number of devices that are using the internet in the classroom. Or, ask students to supplement their slide research using their phone's network connection.
Over 100 individuals would need to access the slides at the same time	Scale up with multiple documents and select one document for presentation to the class. Additionally, assign groups based on seating. For example, a lecture hall with 150 students may have two sections of seats. The instructor prepares two copies of the Divide and Conquer activity Google Slide deck and instructs students to access one or the other based on their seating. Students are asked to form groups with their neighbors and "claim" an activity slide by opening, editing, and adding their names to the slide.
Making appropriate accommodations for student accessibility	As a nongraded, in-class activity, this can be treated as a formative assessment and can be easily adapted to most individuals' needs. The Google Slide deck is compatible with screen readers. Students who may need extra time can be notified of the assignment before class and provided opportunity to prepare.
Course is in online-only format	As part of the assignment instructions, assign students to breakout rooms if the course is in a synchronous online format; if the course is asynchronous, ask students to arrange to meet synchronously as a group and set a timer for the designated activity duration. Students can present their findings to the class in a synchronous virtual meeting or asynchronously through a video-recording and -sharing resource (e.g., FlipGrid). Alternatively, the presentation portion can be replaced with an assessment that requires students to examine other groups' slide content.

the internet (or specific provided sources) to locate specific information about their assigned class of enzymes and then edit the slides to prepare a communication about their findings. See the supplemental materials for examples of Divide and Conquer activities designed to explore CRISPR-Cas9 variants (Appendix 1) and a syllabus exploration activity (Appendix 2).

When the slides are set up, the instructor shares a view-only link to the slides with students through e-mail, posting to their online course management system, adding

a link in lecture slides, or other preferred communication method (Fig. 1, bottom).

To implement a Divide and Conquer experience, the instructor presents the two instructional slides in class and asks students to break into groups. While they are assembling groups, the instructor changes the slide link permissions from "viewer" to "editor," to "open" the slides for editing. Students complete the knowledge-generating task prompted on the slide during an alloted period of class time. As students are working on the task, the instructor circulates throughout the room to correct misconceptions, guide student inquiry, and differentiate instruction as necessary (Fig. 2, left). When time is up, the instructor removes editing privileges to "lock" the slides and students may duplicate the slides to create a copy for their notes. Then, each group presents their findings to the class using the slide(s) that they created (Fig. 2, right).

CONCLUSION

We have field-tested the Divide and Conquer technique to create active learning experiences in five different courses in the Biotechnology Program at NC State. These courses include face-to-face lecture and lab or lecture-only courses, as well as a COVID-19-induced transitioned asynchronous online-only lecture and lab course.

In general, we used Divide and Conquer to cover content that was too difficult or tedious for individual students to do; this fostered positive interdependence and collaborative constructivism in the class. Instructor just-in-time teaching adjustments allowed the instructor to adjust difficulty for groups during class, which helped tailor the assignment to reach a level of desirable difficulty. Overall, students enjoyed the Divide and Conquer experiences and embraced the challenges of their individual activities. It encouraged them to work with and get to know new classmates, got everyone involved, improved instructor-student interactions, and helped build a classroom culture that values inquiry and exploration.

From the field tests and extrapolation, we have collected several tips to use and modify the Divide and Conquer technique (Table 2). Use these tips to expand its use to a variety of courses and settings and foster student collaboration and learning.

SUPPLEMENTAL MATERIALS

Appendix 1 Divide and conquer example activity #1: CRISPR-Cas9 variants
Appendix 2 Divide and Conquer example activity #2: Syllabus exploration

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