

# Reconsidering the Share of a Think–Pair–Share: Emerging Limitations, Alternatives, and Opportunities for Research

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## INTRODUCTION

A key tenet of the nature of science is that “knowledge, although reliable and durable, is never absolute or certain” and is subject to change with the accrual of new bodies of evidence (Lederman *et al.*, 2002, p. 502). Similarly, pedagogical choices grounded in scientific teaching would also be expected to be modified, refined, and perhaps even shifted entirely as new evidence emerges about their impact. Prompted by our own experiences—as instructors, observers, and participants—as well as by multiple lines of emerging research evidence, we are reconsidering the necessity, impact, and assumptions behind the share of the think–pair–share (Lyman, 1981; Tanner, 2009). Consider three scenarios offered from the perspectives of a classroom observer, a student, and a seminar speaker.

### Scenario 1: Unnoticed Inequities

Janine invited me to her small class of ~20 students to observe, as she is very proud of how inclusive her classroom is now that she is using active-learning approaches. During the class session, Janine engaged students in several think–pair–share activities. While the pair discussions were always lively, I noticed as an observer that the same three students participated in every share portion of the activities. Not only did 85% of students not participate in the whole-group share discussions, the three participating students all appeared to be from a similar cultural background and gender as Janine. No men or students of color in the class shared their ideas aloud in that 90-minute class session.

### Scenario 2: Random Call Panic

Miguel is a student in a large-enrollment, ~300-student introductory course that includes active learning during every class session. While he always appreciates the time to think and then talk with a neighbor in a pair discussion, he is contemplating not going to class anymore. Every time the instructor does a random call question, Miguel panics and his heart races. While he appreciates the instructor’s intent to get different students sharing, he just cannot pay attention and learn when he is always worried he is about to get called on for his one share-out during the term.

### Scenario 3: Current Culture of Science Seminars

Sadet travels often to give research seminars and teaching workshops around the country. While they are eager to engage with the audience, especially graduate students, they have noticed that faculty almost always raise their hands first. To encourage more graduate student questions, Sadet has started using a 15-second think followed by a 2-minute pair discussion at the end of their talks to promote student questions. However, the question-and-answer time is still dominated by faculty, usually offering comments on their own work and not asking questions about the

CBE Life Sci Educ March 1, 2021 20:fe1

DOI:10.1187/cbe.20-08-0200

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**TABLE 1. Three steps of the think–pair–share adapted from Tanner (2009)**

Step	What students are doing during a think–pair–share
1	Give all students a chance to think by having them think quietly or jot down their ideas on a piece of paper.
2	Give all students a chance to talk by having them share their answers/responses and ideas with a neighbor in a pair or small-group discussion.
3	Give a few students a chance to share with the whole class by asking for some number of students to share what was discussed in their pairs/groups.

research that was just presented. Perhaps in the future, Sadet will just end the seminar early and take one-on-one questions at the front of the room to avoid the situation entirely.

### REINTRODUCING THE THINK-PAIR-SHARE PEDAGOGICAL STRATEGY

The think–pair–share is an active-learning strategy designed to give all students in a classroom the opportunity to think and talk about the ideas they are studying (Lyman, 1981). Originally proposed by professor Frank Lyman in 1981, the think–pair–share has been widely championed by the undergraduate biology education community as an effective active-learning strategy for more than 20 years (Sherman, 1991; Cavender and Rutter, 1997; Allen and Tanner, 2002; Tanner, 2009, 2013). When implementing a think–pair–share, an instructor first poses a question to students and gives them time to *think* individually about the question and often encourages them to write down their ideas. Then, students *pair* with another student or a small group and discuss the question. Finally, the instructor calls on several students to *share* their thoughts with the whole class (see Table 1). The think and pair steps of the think–pair–share appear to be particularly important for supporting student engagement and learning. Providing students with time to think independently about the question improves the complexity of students' responses and increases students' willingness to share their ideas with others (Rowe, 1972; reviewed in Allen and Tanner, 2002). And having students pair and discuss their thoughts with others provides students an opportunity to recall, process, practice, and communicate what they have learned in a low-stakes environment (reviewed in Tanner, 2009). However, the benefits of the share component of this active-learning strategy are somewhat less clear.

Think back to what you have noticed about the share portion of the think–pair–share approach as an observer, participant, instructor, or presenter in classrooms, workshops, meetings, and seminars.

*As an observer*, what have you noted about the number and types of students who participate in the share part of a think–pair–share? In what ways have you seen a share promote learning or lead students away from learning?

*As a student or as a participant*, were you likely to participate in a share or a whole-group discussion yourself? Why or why not? To what extent are your participation patterns as a professional similar to or different from your participation patterns as a student?

*As an instructor*, what role does the share part of a think–pair–share play in your teaching? What motivates you to engage your students in a whole-class share? What goals does it achieve? And to what extent have you seen the share discourage students or impede learning?

*And finally, as a presenter*, what have you noticed about who participates and how in the share question-and-answer session after a seminar or other presentation?

While the think and the pair pieces of a think–pair–share appear to be well grounded in accrued evidence from the fields of educational, cognitive, and social psychology, it is unclear to what extent the benefits from the overall approach are connected to the share piece. What are the goals of the share anyhow? To what extent does the share promote student learning, instructor insights about student thinking, or even student practice in voicing their ideas? Further, how might the share detract from teaching and learning? What might be the advantages of reconsidering the necessity of the share and refocusing classroom efforts instead on the practices of the think and the pair? We consider six common assumptions about the benefits of the share piece of the think–pair–share strategy and offer evidence and recent research that may challenge these assumptions (see Table 2).

### CHALLENGING COMMON ASSUMPTIONS ABOUT THE SHARE COMPONENT OF A THINK-PAIR-SHARE

#### Assumption 1: The Share Is an Effective Way for Me to Figure Out What Students Are Thinking so I Can Adjust to Their Needs

Imagine students have just finished a lively pair discussion centered around one of the core learning outcomes for today's class. As the noise from the discussion slowly fades, the instructor ponders, "What was the nature of all those different discussions? To what extent did the discussions align with our learning goals? Did any misconceptions arise? Where do I go from here?" This instructor admirably seeks insights into student thinking and desires to adapt to students' needs, two practices commonly observed among active-learning instructors (Auerbach and Andrews, 2018; Auerbach et al., 2018). Hearing from a subset of students in front of the entire class might seem like an effective strategy for accomplishing those goals.

However, some research casts doubt on the ability of the share to provide an instructor with useful and accurate information about student thinking. On the contrary, ideas shared during whole-group discussions might actively mislead instructors in this regard. For example, some researchers have used cameras to monitor all small-group talk as well as all public, whole-class talk for four groups of students over an entire semester of geometry at a large, PhD-granting institution (Ernest et al., 2019). They found that while high-quality discussion took place across small-group discussions, many of those important perspectives were absent from the whole-group sharing. Specifically, whole-group discussions failed to capture the many high-quality comments made by women in small-group discussions. Men and women contributed at relatively equal levels in small-group settings, with women contributing a large

**TABLE 2. Common assumptions about the share piece of the think–pair–share and challenges to those assumptions**

Assumptions about the share	Challenges to the assumption
Assumption 1: The share is an effective way for me to figure out what students are thinking so I can adjust to their needs.	Challenge: The ideas that emerge during a share may not reflect the richness or the diversity of student ideas exchanged in pair discussions.
Assumption 2: Randomly calling on students during the share decreases equity issues in whole-group discussion.	Challenge: Random call may perpetuate new inequities by causing student anxiety in both large- and small-enrollment courses.
Assumption 3: The more students talk in front of the whole class during the share, the more comfortable they will be.	Challenge: The amount of practice needed by each student to increase skill and comfort in sharing in front of the whole class may not occur in most contexts.
Assumption 4: The share motivates students to participate in the think and pair.	Challenge: There may be alternative or even better ways to internally motivate students to participate than the external motivation to avoid getting a question wrong in front of peers.
Assumption 5: Students benefit from hearing student language during the share, beyond what they have already heard in the pair.	Challenge: Students may embrace particular ideas offered in the share because of the status of the student sharing it.
Assumption 6: The share is particularly a problem in big classes, because small-class discussions involve everyone and likely do not cause student anxiety.	Challenge: A subset of students may still dominate discussions, and some students report experiencing anxiety in small classes.

number of high-quality perspectives, but men dominated the whole-group sharing (Ernest *et al.*, 2019). While this paper and others (e.g., Hsi and Hoadley, 1997; Eddy *et al.*, 2014; Ballen *et al.*, 2019; Aguilon *et al.*, 2020; Bailey *et al.*, 2020) specifically investigated gender, one wonders whether we would find similar trends suggesting systematic exclusion of high-quality ideas among other groups of students during the share portion of the think–pair–share.

Returning to the instructor just wrapping up a lively pair discussion and hoping to gain access to student thinking, we might now have concerns about the ability of a share to accomplish those goals. The share might filter out certain voices and perspectives. Further, the individuals excluded from the share might have contributed relatively equally in small-group discussions and contributed high-quality ideas there. Whole-group shares, therefore, may promote an inaccurate view of the nature of the pair discussions and an unrepresentative sampling of student thinking on the topic at hand. As such, the share might simultaneously promote classroom inequities while also misleading the instructor regarding the most appropriate next steps for the class session. Contrary to common assumptions, the share might not be an effective strategy for gaining accurate insights into student thinking across a class.

### **Assumption 2: Randomly Calling on Students during the Share Can Decrease Equity Issues in a Whole-Group Discussion**

When instructors ask students to share out during a think–pair–share, have you noticed that it is often the most confident or talkative students who volunteer to participate? How can we enhance the classroom dialogue to hear from a more diverse set of voices? Some instructors use a method of randomly calling on students to ensure that every student has the same chance of getting to participate in whole-class discussions (Eddy *et al.*, 2014; Waugh and Andrews, 2020). Even though random call can diversify who is speaking out, is it precipitating new forms of inequities in classrooms?

Some students fear negative evaluation or worry that others will judge their responses when they share in front of the class (Watson and Friend, 1969; Cooper *et al.*, 2018; Cooper and

Brownell, 2020; Downing *et al.*, 2020). Students in both large- and small-enrollment college science classes who experience fear of negative evaluation describe that they sometimes struggle to think through science problems during class (Heimberg *et al.*, 2010; Cooper *et al.*, 2018; Downing *et al.*, 2020). When students worry about whether they are going to be called on in front of the whole class, they often spend extra mental energy on their fear of needing to share their responses instead of focusing on the science learning at hand. Therefore, it is not surprising that these students often perceive that they learn less when being called on randomly (Downing *et al.*, 2020). Students have reported that even if they can think clearly through the science problem, fear may negatively affect how they communicate in front of both small and large classes (Cooper *et al.*, 2018; Downing *et al.*, 2020). You may have witnessed this when a student can eloquently explain an answer one-on-one, yet when that student is called on a few minutes later to share the answer in front of the class, it comes out jumbled and confusing. This may not reflect the student's lack of understanding, but rather the fear about speaking out. However, just relying on the answer in front of the class, one may incorrectly infer that the student did not understand the material. This would be in direct contrast with a student without this fear who can articulately explain an answer to the class and who receives affirmations for that answer.

There are modifications that can be made to random call to reduce student anxiety, such as calling on groups or posing questions so that students report collective ideas (Waugh and Andrews, 2020). While instructors can certainly be thoughtful about the way they implement random call to reduce student anxiety, some students may still experience high stress and anxiety during random call. It is important to note that student anxiety has been associated with increased discomfort with active learning (Buzinski *et al.*, 2020) and has been shown to negatively predict students' performance (Seipp, 1991; England *et al.*, 2017; Buzinski *et al.*, 2020) in class and intent to persist in biology (England *et al.*, 2017, 2019). So, even if two students both have the opportunity to share their thoughts during random call, their individual experiences, their own learning, and others' responses to their speaking can

be dramatically different. While random call can eliminate inequities in whose voices are heard, it may propagate inequities in the underlying experiences of students during the share portion of the think–pair–share.

### **Assumption 3: The More That Students Talk in Front of the Whole Class during the Share, the More Comfortable They Will Be**

While requiring students to participate may cause students fear and stress, some instructors view the share as an opportunity to help students become more comfortable with speaking in front of large groups. They may suspect that exposure will alleviate the anxiety associated with the share and that any speaking-related inequities will dissipate over time. This may resonate with you if you think about the fear that you experienced the first time you spoke in front of a class compared with how you feel now. However, there are some important distinctions that make requiring students to share in front of the class different from our own experiences in teaching.

For students to become less anxious about sharing their responses in front of the whole class, they likely need to have multiple opportunities to practice successfully sharing their thoughts with the class (Gray and McNaughton, 2000; Dallimore *et al.*, 2013). Can science courses offer students enough opportunities to truly reduce their apprehensions about public speaking? Let us imagine that, in a class of 300 students, the instructor calls on five students per class period. In a 15-week semester with three classes per week, there would only be 225 opportunities for a student to be called to share. So it would not be possible for every student in that large course to be called to share even once, much less multiple times that could give them substantial practice and confidence in their abilities to share. Even in a small class of 30 students where an instructor randomly calls five students to share per class, a student would on average be asked to share only seven times over the semester. Research has demonstrated that requiring students to participate can increase student comfort speaking out but that calling on students likely has to happen often (Dallimore *et al.*, 2013). The notion that most college science classes may not be able to provide students with enough practice to make them more comfortable speaking out is further supported by research in cognitive behavioral and exposure therapy (Gould *et al.*, 1997; Gray and McNaughton, 2000).

In classes where students do have sufficient opportunities to speak in front of the whole class, the next question is whether these opportunities are positive. Repeated exposure to a stimulus can reduce anxiety, particularly if the experiences are positive (Gray and McNaughton, 2000; Heimberg *et al.*, 2010). If students have negative experiences when they are required to share in front of the whole class, it might have the opposite effect and increase their fear of speaking out. For example, imagine an instructor accidentally embarrasses a student whose answer was incorrect. This negative reaction could increase student worry about sharing in the future (Heimberg *et al.*, 2010; Cooper *et al.*, 2018). So, while there may be courses in which some students have enough opportunities to practice speaking out, concerns about negative experiences could undermine such practice. If instructors want students to get practice and feel more comfortable sharing their ideas in groups, other avenues besides the randomly called share of the think–pair–share may

be more amenable to accomplishing this specific goal. Additionally, it is important to consider why we want students to be more comfortable speaking out in front of the whole class. Few careers, particularly science careers, require individuals to speak out in front of a group about a topic that they have only thought about for a few minutes. More commonly, professionals are asked to address a group about a topic that they have considered for years.

### **Assumption 4: The Share Motivates Students to Participate in the Think and Pair**

Does the share motivate students to participate in the think and pair of the think–pair–share? Asking for volunteers to share their ideas with the class will likely not affect the motivation of most students. However, studies suggest that randomly choosing students to share their thoughts with the class may motivate students to participate in the think and pair and enhance the quality of the pair discussion (Dallimore *et al.*, 2013; Broeckelman-Post *et al.*, 2016; Knight *et al.*, 2016; Leupen *et al.*, 2020). Some students have reported that random call motivates them to prepare for the share, because if they do not perform well, they may be judged by other students (Downing *et al.*, 2020). While randomly calling on students to participate in the share may be motivating for students, is increasing their fear the only way to encourage them to engage in the think and pair?

There are other ways to encourage students to engage with in-class activities. Instructor Talk, defined as any language used by the instructor that is not directly related to the concepts under study but instead focuses on creating the learning environment, might help internally motivate students (Seidel *et al.*, 2015; Harrison *et al.*, 2019). For example, instructors can be explicit about why they have students think and then pair and how they might benefit from participating, which could enhance student engagement (Seidel and Tanner, 2013; Cavanagh *et al.*, 2016). Additionally, instructors can cultivate instructor immediacy or decrease the social distance between students and the instructor by using student names, demonstrating respect for students, or revealing tips about how to be successful in class, which can increase students' willingness to engage in active-learning activities (O'Sullivan *et al.*, 2004; Seidel and Tanner, 2013; Harrison *et al.*, 2019). So, while randomly selecting students to participate in the share may be one way to encourage students to engage in the think and pair, there are many other ways to motivate student engagement and participation.

### **Assumption 5: Students Benefit from Hearing Student Language during the Share, beyond What They Have Already Heard in the Pair**

“Students might find the way I explain a concept less relatable than the way their colleagues explain that concept. I want to make sure my students have access to all those helpful alternate explanations!” This sentiment comes from a place of humility and demonstrates an intention to honor student voice in classrooms. There is evidence that students may benefit from watching their peers, as opposed to their instructor, solve complex problems (Schunk *et al.*, 1987; Monaghan and Stenning, 1998; Smith *et al.*, 2009; Chi *et al.*, 2017), and students have the opportunity to hear other students discuss problems during the

pair. However, do we have evidence that the share benefits students by re-examining a concept through student language?

Many studies raise questions about the utility of the share in providing the most useful information to students to help them grasp new concepts. The most rich, equitable, and high-quality discussions seem to happen in small-group discussions, not whole-group share-outs (Ernest *et al.*, 2019). The share might therefore be, at best, unnecessary or, at worst, unhelpful to the cognitive arc of the class if the share muddles ideas gained during small-group discussion. Further, students often conceptualize and explain course topics using intuitive reasoning that correlates with common misconceptions about course content (Coley *et al.*, 2017). Granting power to a limited number of students to explain concepts, likely through their intuitive reasoning, might promote and perpetuate misconceptions. Compounding this issue, students may unconsciously rate the knowledge and expertise of other students based on identity characteristics (e.g., gender; Grunspan *et al.*, 2016). As such, students might make decisions about which other students are most knowledgeable during the shares based on stereotypes about who is “good” at the subject and not based on actual knowledge or expertise. Further, instructors might inadvertently perpetuate those stereotypes based on disparities in who they hear from during the share in front of the whole class (Aguillon *et al.*, 2020; Eddy *et al.*, 2014). Taken together, this research evidence brings into question whether students really benefit from hearing concepts explained by other students during the share portion of the think–pair–share.

**Assumption 6: The Share Is Particularly a Problem in Big Classes, because Small-Class Discussions Involve Everyone and Likely Do Not Cause Student Anxiety**

In smaller-sized classes, it may be common to perceive that all students have the opportunity to share simply because there are fewer people in the room. Additionally, instructors may assume that there is little to no anxiety involved in sharing in front of the group in a small-class situation. As in the first scenario at the beginning of the article, small class sizes may give rise to an illusion of fairness in group sharing that may result in instructors not noticing inequities in sharing and not employing teaching strategies that would seem key in a larger class size.

Certainly, the dynamics of the share could be very different in a small class of less than 25 students as opposed to large courses with 100, 300, 600, or even 1000 students. However, think back to your own experiences in small classes. In particular, seminar courses are often less than 20 students, sometimes even less than 10. How equitable was group sharing in those experiences? To what extent was sharing done by all students or dominated by just a few? And to what extent did your instructor use equitable teaching strategies in these small classes—time to write, time to think, prepare for pair discussions? Even well-intentioned instructors can inadvertently facilitate sharing in a small class that engages only a few voices in sharing, as may be common in most graduate school seminar courses.

The dynamics of the share in a small class may result in challenges similar to those observed in large class sizes. While there is some evidence that class size affects voluntary student participation, there is additional evidence that the challenges of using a group share strategy likely persist in all class sizes. In one

study, Ballen and colleagues found that increasing class size had the largest negative effect on voluntary participation by women. Yet they also found that women were more likely to participate after small-group discussions across all class sizes, suggesting that equitable teaching strategies were influential regardless of class size (Ballen *et al.*, 2019). While feelings of anxiety may be different in smaller settings, do those feelings just disappear in a small setting? Recent evidence suggests that students in college courses of less than 50 students still expressed anxiety about being called on to speak in front of the whole class when they did not volunteer (Downing *et al.*, 2020). As such, the dynamics of sharing in a small class may be similarly susceptible to inequities of participation and heightening of anxiety that is seen in large class sizes. Alternatives to the share portion of a think–pair–share may be just as necessary in small classes as in big ones.

**ALTERNATIVES TO THE SHARE PORTION OF THE THINK-PAIR-SHARE**

Given the research challenging assumptions about the benefits of the share, what alternatives might exist that could allow us to still accomplish instructional goals that currently drive the use of the share? How might instructors understand student thinking, honor student voices, and gain feedback on where to go next in class without a traditional whole-group share? We discuss four alternatives to the traditional think–pair–share, which include: 1) modifications to the share, 2) real-time instructor synthesis of student ideas, 3) asynchronous synthesis of student ideas, and 4) the possibility of eliminating the share entirely (see Table 3). Each of these alternatives would seem to be adaptable to a wide range of class sizes and group arrangements, as well as amenable to both in-person and online formats.

**Modifying the Share**

Could we create more equitable experiences for students by simply changing the way they share information in front of the class? Instructors have engineered a variety of creative modifications to having students share out in front of the whole class to ensure equity in who is talking and to help students feel more comfortable speaking out. Below we discuss three ways to modify the share portion of the think–pair–share: *optional consent to share*, *local sharing*, and a *go-around* (a.k.a. whip-around).

The optional consent to share is one modification to the share that instructors may use when implementing random call and aspiring to help students practice and increase confidence in speaking out. When students are discussing their ideas together, instructors can first randomly select a student who they will ask to share. Alternatively, they can listen to students’ conversations and identify a student’s answer they would like to have shared with the class. In either case, the instructor can then use an optional consent to share, whereby the instructor approaches individual students and asks if they would be willing to share their ideas with the class. This approach can be used in small- or large-enrollment courses where the instructor is able to talk to individual students during class. Explicitly getting student consent may make students more willing and comfortable participating in the share for a few reasons. Eliciting consent acknowledges learner agency; instead of being required to participate, the student has a choice about whether to share. Not only does

**TABLE 3. Descriptions and benefits of alternatives to the share.**

Alternatives to the share	Description of the alternative	Benefit of the alternative
<b>Modifying the share</b>		
Optional consent to share	During the pair, the instructor privately asks individual students if they would be willing to share their ideas with the whole class before calling on them.	It provides students more time to prepare to speak in front of the whole class. It gives students a chance to opt out if they do not feel comfortable sharing.
Local share	Students exchange ideas beyond their pairs (e.g., with another pair of students or with their table mates), but the discussion is not opened up to the whole class.	It provides students with practice articulating their thoughts in front of a larger group without being intimidated by the possibility of being asked to share in front of the whole class.
Go-around	The instructor poses a question with many possible ways to answer and then goes around the class so that each student can contribute an idea to the discussion.	Every student's voice is heard. It may reduce students' fear of negative evaluation.
<b>Real-time synthesis of student ideas</b>		
Classroom polling	Instructors collect and respond to evidence gathered from polling systems (e.g., clickers) immediately following a pair discussion.	Every student can contribute to the poll. Anonymous polling can reduce students' anxiety associated with sharing their ideas.
Listening in	During a pair discussion, an instructor can walk around and listen to students' conversations to gain insight into students' ideas.	It likely offers the instructor richer insight into students' thinking, compared with hearing from only a few students.
Assigning competence	Instructors summarize pair discussions and strategically bring attention to the contributions of certain students.	It increases the students' expectations for themselves as well as the class's expectations for those students.
<b>Asynchronous synthesis of student ideas</b>		
Index cards	Instructors ask students to record their ideas on a note card following pair discussions. Instructors can review all cards or a subsample of the cards after class.	Instructor has access to all student ideas. Instructor has more time to review students' responses for common themes or misconceptions.
Electronic posts	Students contribute their ideas via an electronic platform (e.g., discussion board, online survey) following a pair discussion.	Students may be more comfortable sharing their thoughts via an electronic platform. It gives the instructor more time to review and synthesize all student responses.
<b>Eliminate the share</b>		
Eliminate the share	Students' thoughts and ideas are not shared with the instructor or the class after a pair discussion.	Instructors may be able to meet all their learning goals using only the think and pair. It allows for more time for other in-class activities while reducing student anxiety about speaking out in front of the whole class.

this choice allow students to opt out on days when they might struggle to contribute to the class in this way, but it also indicates that the instructor respects students' autonomy. Although any situation in which students volunteer to share acknowledges student agency, this approach of optional consent to share may be more equitable than hearing from volunteers, because it does not require the student to take initiative to share. The act of asking students for their consent to share can also imply that the instructor respects the students' ideas, reassuring them that they will likely not be judged for their responses. Additionally, giving the students a heads-up about sharing their responses may give the students time to prepare to share, maximizing the chance that they will successfully articulate their ideas. In large class sizes, a strategy for implementing optional consent to share is for students to have name tents: one side has just the student's name, while the other has the student's name and a filled-in box (Brame, 2019). On days when students do not want to contribute to the whole-class share, they can simply point the box side of their name tents toward the instructor (Brame, 2019).

Additionally, a local share is a modification of the share that gives students opportunities to exchange ideas with more than

one or two other students. In a local share approach, students exchange ideas beyond their pairs, but the discussion is not opened up to the whole class. In courses in which students work at tables, they can share their thoughts with their table mates. Alternatively, in large auditorium-style lecture halls, one pair of students can join up with another pair of students in a different row ahead or behind them to exchange ideas. This gives students the opportunity to practice articulating their thoughts in front of a slightly larger audience without the intimidation that may come in sharing in front of the entire class. This approach would also increase the overall number of opportunities for practicing sharing to more students.

Finally, a go-around approach is a third modification to the traditional share in which every student in a class or a group contributes an idea to the class discussion (Tanner, 2013). A go-around is most amenable to smaller class sizes or large class sizes for which students are organized into subgroups or table groups. A go-around strategy is best structured so that there is not one right answer, but rather a variety of possible responses to an open-ended question. Not only is every student's voice heard in a go-around, but if there are many possible ways to

answer, this may reduce students' fears of being negatively evaluated based on their contributions.

All these modifications—optional consent to share, local share, and go-around—are intended to create a more equitable and purposeful share portion of a traditional think–pair–share. As such, it is important to note that all of them should continue to be preceded by a think period and a pair discussion period to ensure that all students first get the opportunity to contemplate and compose a response, as well as rehearse their ideas with a buddy before communicating to a larger audience (Tanner, 2009).

### Real-Time Synthesis of Student Ideas

In addition to modifications of the share, there are alternatives to the traditional share of the think–pair–share in which the instructor does real-time synthesis of student ideas, becoming the voice of the share. Research evidence suggests that many of the challenges surrounding the traditional share portion of the think–pair–share relate to unintended inequities in how power is assigned in a class. Further, traditional shares may give instructors inaccurate assessment of overall student thinking when only a few volunteers report for an entire class. Another alternative to the share might focus on gathering more systematic evidence of student thinking in a class and avoiding the need to assign power and status to only a limited number of sharers. We discuss three alternatives to the share grounded in real-time synthesis of student thinking by the instructor: *classroom polling*, *listening in*, and *assigning competence*.

Classroom polling associated with a think period and then a pair discussion allows instructors to systematically collect and then respond to evidence from all students without the need for a share. This creates opportunities for every student to have a voice in the share by submitting their ideas in the poll. Classroom polling may be accomplished by using commercially available polling systems or by using low-tech options such as having students hold up colored sticky notes corresponding to different answer choices. Some polling technologies additionally allow students to contribute a complete, written response and not just vote for a multiple-choice option. Students enter text contributions into their devices, which the instructor then reviews privately or displays anonymously in real-time on the screen. Collecting student ideas in real time is often particularly adaptable in online learning, as polling features and chat windows are built into videoconference programs. Alternatively, in online settings, instructors can send students to complete an external survey or to contribute to a collaborative online document in place of a share. These classroom polling strategies all allow for a more systematic collection and equitable review of student ideas that can then be synthesized by instructors to drive teaching choices in real time, in contrast to a traditional share, in which a handful of student ideas are influential.

Additionally, listening in is another approach that can allow instructors to conduct real-time synthesis of student ideas without need for a share. Thinking back to a pair discussion you experienced as a participant or a pair discussion you facilitated, what do you remember the facilitator or you doing during the pair? While many instructors might understandably be alone at the front of the room focused on the next class segment, this time represents a prime opportunity to gather evidence on student thinking. During the pair, the instructor can walk around

the room and listen in on the conversations to gain insights into students' ideas. In an online environment, this can be accomplished through the instructor visiting various small-group discussion rooms. Though the appearance of the instructor in a small-group online room might change the nature of the discussion there, the instructor will likely still get some insights into the nature of the discussion. Instructors can also ensure their video and audio are muted before joining a small-group room, which can make their entrance less obvious to students. Whether in person or online, instructors cannot listen in on every part of every pair conversation. However, they can likely hear from many more students than would be possible during a traditional share. Following the pair discussion, the instructor can bring the class together and summarize the themes of the conversations, addressing any misconceptions and tailoring the summary to meet their goals for the class. This signals to the class that the instructor values and is responsive to students' ideas, while avoiding the need to assign status to a small number of volunteers who might explain things in ways that promote misconceptions.

Finally, instructors can further create a more equitable classroom sharing by assigning competence when summarizing pair discussions by strategically bringing attention to the contributions of specific students (Tanner, 2013). Elizabeth Cohen and colleagues (1999) described instructors assigning competence to students by making a public statement that specifically recognizes the intellectual contribution a student has made to a group task (Cohen *et al.*, 1999). For example, an instructor can say, “Kiante just shared with me a really interesting idea” and proceed to share the student's idea with the whole class. Cohen noted that assigning competence can be especially impactful for low-status students who could be students who struggle academically, who are not proficient in the language of instruction, or who tend to socially isolate. By verbally acknowledging a student's ability, the instructor can change the individual student's expectations for competence as well as raise the class's expectations for that student. As such, the opportunity to assign competence is an advantage of synthesizing student ideas in real time in place of a traditional share portion of a think–pair–share.

### Asynchronous Synthesis of Student Ideas

Instructors may not always require immediate, real-time feedback regarding students' ideas following a pair discussion, and students may not always need a synthesis of ideas from their colleagues' pair discussions before moving on. In many cases, the instructor might feel comfortable waiting until after class to review evidence of the ideas generated by students during pair discussions. We discuss two strategies for reviewing asynchronous feedback as an alternative to a share: *index cards* and *electronic posts*.

One approach to synthesizing students' ideas asynchronously and then bringing back that synthesis to the whole class is the regular use of index cards. Some instructors include as one of the required course materials a pack of index cards and ask students to take out a card to record their ideas following pair discussions (Tanner, 2013). After class, the instructor can review the index cards to assess students' progress toward learning goals following pair discussion. In large classes, the instructor might subsample the cards and only review a subset

of cards in detail. Alternatively, the cards could be used as more formal assessments and evaluated by sorting, perhaps with opportunities for students to revise their responses (Schinske and Tanner, 2014). The instructor can note common themes among the cards to share back with students during the next class meeting, in place of the more immediate share portion of a think–pair–share. As with some of the examples in the preceding section, index cards honor the voices of all students by allowing all participants to share their thoughts. An additional advantage is that the instructor has more time between class sessions to be thoughtful about what ideas to bring back to the whole group.

Additionally, many options exist for asynchronous synthesis of students' ideas following pair discussions using electronic posts. Instructors might invite students to post their ideas to an online discussion board, in an online survey form, or in a shared document located in the cloud for later review. Instructors could then review and evaluate those responses after class, as described for index cards above. Evidence suggests online approaches to sharing exhibit greater gender equity and provide students with a greater sense of comfort than traditional shares (e.g., Hsi and Hoadley, 1997).

### Eliminating the Share

Given recent research on the challenges that sharing in front of the whole class might present for students, one may question whether it is necessary to have a subset of students share out in front of the whole class. To create more equitable learning spaces, some instructors have chosen to eliminate the share portion of the think–pair–share. You may be wondering: Are those classes silent? Do students get to hear what other students are thinking? Does the instructor dominate the class time? If instructors choose to teach in an active-learning way, in which students engage in activities and small-group discussions, then minimal lecturing and the exchanging of student ideas are still conserved. In fact, these classrooms might be even louder than classrooms that continue to include the share if there are more frequent pair or small-group discussions (Owens *et al.*, 2017). If instructors practice local sharing, in which students exchange ideas with five or six other students instead of having one or two students share with the class, then students may get to hear hundreds more ideas over the course of a term. While excluding the share might at first seem like an instructor-centered shift in teaching, it may actually be the more student-centered choice. By eliminating the share portion of a think–pair–share, the instructor no longer dictates who gets to share their ideas and who does not, leaving more time for more students to get to talk with one another. Just because we are used to hearing students' voices in front of the whole class does not mean it is an integral part of effective teaching, especially in light of the research presented earlier.

So, when might it be useful to include the share, as compared with modifying it, replacing it with an alternate strategy, or actively eliminating it all together? As with all decisions in teaching, there are no simple answers, and all these options may be useful in different situations and course contexts, depending on the instructors' goals. Giving students the opportunity to think quietly to themselves and then participate in a pair discussion may be sufficient if the goals are to allow students to engage with an idea, explore their knowledge, and

practice their ideas with a buddy. For these particular goals, a share is not necessary, and students can simply return their attention to the instructor after the pair discussion as the class session moves forward. Given the emerging research on the inequities of the share portion of the think–pair–share, instructors are encouraged to reconsider the reasons why they are implementing a whole-class share and to be purposeful in choosing this strategy.

### CONCLUSIONS AND OPPORTUNITIES FOR FUTURE RESEARCH

For decades, the think–pair–share pedagogical strategy has no doubt been a key tool for many instructors in shifting their undergraduate science teaching toward more active-learning and student-centered approaches. As with all aspects of science and education, new evidence will and should prompt us to revisit our assumptions, question our practices, and make new instructional choices that continuously improve teaching and learning. Here, we have attempted to articulate and question several common assumptions about the benefits of the share component of the think–pair–share approach. We were prompted to do this after experiencing the inequities of the share ourselves in teaching, as well as encountering recent research that demonstrates the challenges that may arise from having individual students share in front of the whole class. Additionally, we have proposed several modifications to the share, some alternatives to the share, and even rationales for eliminating the share entirely in some situations. As with all pedagogical choices, there are no right or wrong ways to teach, and reconsidering the nature and necessity of the share phase of the think–pair–share approach will most certainly be dependent on the context, the instructor, and the goals for students.

As we collectively reconsider the goals and benefits of the share, there will be many opportunities for future research. For example, are the challenges of using the share actually different in the contexts of large and small class sizes? To what extent do modifications of the share address and resolve inequities related to who participates, student anxiety, and whose ideas get heard? To what extent do in-the-moment teaching decisions based on sharing from a few individuals serve or not serve learning for the entire population of students in the classroom? And how might other classroom variables such as Instructor Talk—the noncontent language that introduces the share— influence student participation, student anxiety, and the quality of classroom interactions during whole-class sharing (Harrison *et al.*, 2019; Seidel *et al.*, 2015)? Such future research will no doubt yield even more insights about the seemingly timeless approach of the think–pair–share and continue to productively challenge our assumptions about how to foster equitable and effective learning environments for all students.

### POSTSCRIPT: GROUP SHARING IS JUST HOW WE DO SCIENCE. THAT'S JUST THE CULTURE OF SCIENCE...

In this article, we have explored reconsidering the share in the context of teaching, but the share—often without either the think or the pair—is a hallmark of many professional contexts in science that would seem to be far removed from discussions of teaching. As such, some science colleagues may resist a reconsideration of the share approach in their teaching, as this approach to interacting seems so inextricably linked to the

culture of science. After the presentation of a weekly seminar or a conference talk, there is a widespread cultural assumption that an open question-and-answer session will promptly follow. How have you experienced these postpresentation share sessions? Who do you notice participating and not participating? Has your heart raced at the thought of asking a question or making a comment in front of your scientific colleagues? How might scholarly exchanges and communication of ideas be different if that “share” portion was transformed to be more equitable and inclusive of more scientists’ voices?

Generally, and unfortunately, there are no equitable teaching strategies used in our public scientific conversations in large groups after talks and presentations. Unless actively employed by an equity-minded facilitator, there is generally no time to think, no time to write, and no time to try out your idea with a neighbor before launching it publicly for the speaker and the audience. Without such strategies, one would predict that—much like research has shown in classrooms (Grunspan *et al.*, 2016)—primarily those individuals with the highest comfort level and/or the highest professional status in the room would choose to speak. In fact, one study has demonstrated that women ask proportionally fewer questions during academic seminars than men (Carter *et al.*, 2018). While this is an area ripe for further systematic research, most of us have experienced share sessions in the scientific community that are deeply inequitable, that are dominated by a few voices, and that perpetuate stereotypes about who does great science. In some cases, these postpresentation share sessions can appear more of a status-building game than an earnest exchange of ideas. And the anxiety and fear of negative evaluation in sharing may be too high for many talented scientists in the room to risk participation, just as has been described for science students (Cooper *et al.*, 2018; Downing *et al.*, 2020). Further, one wonders whether this cultural tradition of the share session in science additionally contributes to implicit bias and lower evaluations of those individuals who choose not to talk during a share, similar to the underestimation of women by men in unregulated classroom settings (Grunspan *et al.*, 2016). Yet this cultural norm persists in most scientific spaces, largely unquestioned even in contexts whose explicit purpose is to promote diversity, equity, and inclusion in science.

While postpresentation share sessions may seem inextricably linked to the culture of science, the research cited earlier increasingly suggests that this aspect of the culture of science is deeply exclusionary, an impediment to diversifying science, and is likely undercutting our attempts to solve complex problems in the natural world. In particular, the current culture of science has emerged as a reflection of the culture of a subset of individuals, usually those of financial means, most often men, and most often of European descent. The scholarly field of intercultural communication has documented so many ways in which communication is culturally bounded—in tone, gesture, turn-taking (or not), emotion, eye contact (or not), and directness (or not; e.g., Gomez, 1995). A shift away from traditional share sessions in science may be essential for improving science, realizing authentic inclusion, and increasing the success of women, scientists of color, and anyone who is unaccustomed or unwilling to participate in this very culturally specific form of communication. This would demand a shift in the culture of science, rather than continuing with the current assumption that students just

need to learn to fit into this fundamentally inequitable and exclusionary aspect of our professional culture. As such a reconsideration of the postpresentation share beyond classrooms—in seminars, conferences, lab meetings, and other professional spaces in science—not only seems warranted, given emerging research, but also essential if we are to realize aspirations for the discoveries and insights that emerge from great science.

## ACKNOWLEDGMENTS

We thank the instructors and students who have shared their experiences with us over the years, which helped shape our thinking and encouraged us to reconsider our own teaching practices. We also thank Sarah Cooper, Alison Crowe, Jennifer Kurushima, Dax Ovid, Sarah Pickett, Mallory Rice, Brie Tripp, and Gloriana Trujillo for their thoughtful review of an earlier draft of this work. Finally, we are very grateful to Sara Brownell for her supporting and encouraging us to write this essay, for sharing her ideas with us, and for her helpful feedback.

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