FEATURE ARTICLE

Best Practices for the Think-Pair-Share Active-Learning Technique

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ABSTRACT

"Think-pair-share" is a widely known active-learning technique. I summarize some of the best practices to use and some pitfalls to avoid when designing a think-pair-share activity for the classroom. Describing a think-pair-activity that I used to teach about biotechnology, I discuss question writing, logistics, assessment, and useful applications of think-pair-share in the science classroom.

Key Words: *Think-pair-share; active learning; assessment; biotechnology.*

○ Introduction

Active-learning teaching methods increase student performance in science and health-care-related classes. For example, peer discussion in an undergraduate introductory genetics course improved student understanding of course material (Smith et al., 2009). When a combination of several active-learning techniques was used in a physiology class for medical students, student scores improved by about 3 points on a 50-point test (Thaman et al., 2013). In a baccalaureate nursing course titled "Health Assessment," an active-learning technique known as "think-pair-share" that was used throughout the course fostered critical thinking by the students, as measured with a standardized Health Education Systems, Inc., exam that was used as a pretest and posttest for students in experimental and control groups (Kaddoura, 2013). Also, in a mental-health nursing course, use of the think-pair-share technique corresponded with an almost 20% increase in the number of students reaching a proficiency benchmark on an end-of-course assessment (Fitzgerald, 2013).

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Think-pair-share can be used in the classroom in a variety of ways. For example, it has been used at the middle school level to teach reading in the science classroom by asking students to list and then share ideas they remember from a piece they have read (Fernsten & Loughran, 2007). The think-pair-share technique can be incorporated into a science lesson plan for bilingual elementary students, in order to support the students' language development (Arreguín-Anderson & Esquierdo, 2011).

The think-pair-share active-learning technique was first described by Professor Frank Lyman (1981). With this technique, students first work on an activity individually and then, after a short interval, in pairs. Finally, after partners have had some time to compare ideas, the entire class discusses the activity as a large group (McTighe & Lyman, 1988). This teaching technique increases student engagement and understanding. The think-pair-share technique also gives students opportunities to practice communication and problem-solving skills. Although it is seemingly simple to use think-pair-share in the classroom, there are many factors to consider when deciding how best to implement this well-known technique to accomplish specific instructional goals.

Here, I discuss ways in which the think-pair-share technique has been effectively used in the classroom. I also reflect on the methods I used in a study to see whether think-pair-share helps enhance learning of biotechnology concepts in undergraduate biology courses. My study was conducted in two undergraduate biology courses, BIO 101 (Concepts of Biology) and BIO 251 (General Survey of Microbiology), at the University of Wisconsin–Marathon County in Wausau, Wisconsin. In some semesters, the think-pair-share activity supplemented a traditional lecture-style format before the student assessment. In the other semesters (one semester per course), as a control, the topic of biotechnology was taught without the think-pair-share technique. During these control semesters, students were

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taught about biotechnology using only a traditional lecture-style format.

○ Writing Questions/Problems for a Think-Pair-Share Exercise

Think-pair-share questions must be aligned with the instructional goal of the activity, and a backward design approach can be used to facilitate this alignment (Wiggins & McTighe, 1998). In the backward design approach, the instructor first considers the instructional goal, then designs assessments, and finally develops teaching strategies that are based on the desired learning outcomes.

Because the pairing and sharing parts of think-pair-share involve discussion, factors that contribute to good discussion should be considered when writing the (formative assessment) questions. When using think-pair-share in the classroom, the questions or problems that students work on should have many possible responses (Barkley et al., 2005). Open-ended questions are best for classroom discussion. Students should not think that the instructor is looking for one specific answer (Ritchhart et al., 2011). In a paper about group discussion in a physics classroom, Li and Demaree (2010) suggest that good classroom discussion goes beyond concepts and focuses on deeper things, such as assumptions that need to be made to answer the question and how the answer might apply to other scenarios.

Li and Demaree (2010) also suggest that the instructor, when preparing questions for a classroom discussion, needs to be mindful of the learning identities and knowledge base of each student. There are many types of learning identities, such as received knowing and connected knowing (Belenky et al., 1986). A received knower gets information from authorities. Connected knowing includes learning by considering the perspectives of others, especially peers. Connected learning is desirable because it promotes a broader understanding of ideas. Therefore, the goal is to move received knowers into connected learning. Instructors can consider this in order to design questions and instructions that promote the most interaction between students with different learning styles, with the goal of promoting discussion and facilitating connected learning.

When designing questions for a think-pair-share discussion, the instructor also needs to consider what constraints to put on the scope of the discussion. One example of a constraint is to ask students to use certain discipline-specific terms in their answers. Constraints can guide students in their discussion (Li & Demaree, 2010), but constraints that are too tight for a particular question take away from the open-ended nature of the discussion. With constraints that are too restrictive, students have difficulty applying information to situations outside the classroom (Boaler, 2000).

One interesting adaptation of think-pair-share is to incorporate the technique as a part of an observation station (Rutherford, 2011). An observation station includes a science-related object that students observe and then write about. Students then share what they wrote for feedback from a partner. To promote large-group class sharing, students can state things their partner wrote down that they did not (Ritchhart et al., 2011). While this unique approach has been used at the elementary level to combine science and writing instruction (Rutherford, 2011), the technique could certainly be adapted for use beyond the elementary level. For example, students could look at pictures of cells in various stages of mitosis or observe bacteria growing on a solid growth medium to which various antibiotic disks have been added.

In a secondary school science classroom, metacognitive questions, which require students to explain their thought processes, and a think-pair-share activity both improved student scores on a posttest (Ibe, 2009). While a think-pair-share activity can be metacognitive in nature, the best approach is to intentionally combine the two strategies. For example, an instructor can ask students to describe their thought processes in all three phases of think-pair-share. Students can explain to their partner and then to the entire class why they answered the way they did. In this way, students are free to bounce ideas and thinking strategies back and forth with a partner and then with the entire class. The instructor can document what was said during the metacognitive discussions so that misconceptions can be uncovered and addressed (Ritchhart et al., 2011).

For younger children, the think-pair-share activity can be based on an investigative game rather than on a question. In one adaptation of think-pair-share used to teach mathematics to kindergartners, students played a mathematical game individually and then shared mathematical strategies and discoveries with the class. After playing the game again with a partner while being encouraged to share their ideas with their partner, students participated in a whole-group sharing discussion (Tyminski et al., 2010).

○ Guiding Students during a Think-Pair-Share Activity

The instructor needs to decide how to interact with students during the sharing part of the formative assessment. This decision is influenced by the level of difficulty of the discussion question. A more difficult discussion question requires more involvement by the instructor. However, connected learning happens when the instructor participates more as a discussion partner than as an authority figure (Li & Demaree, 2010).

The instructor must decide whether students can use notes and other resources as guides during all three phases of the formative assessment. Alternatively, the instructor can limit the use of such resources, depending on the learning goal. As mentioned above, Fitzgerald (2013) describes successfully using think-pair-share in a mental-health course for nursing students. In what seems much like a flipped-classroom approach, the students in that course watched a taped lecture prior to class, in preparation for think-pair-share activities. Then, during the think-pair-share activities, the students were allowed use of resources for only 1–2 minutes at the end of the "pair" time.

Instructors can use technology to guide and enhance think-pair-share activities. Slone and Mitchell (2014) used Google Drive in a graduate-level abnormal psychology course to facilitate the pair discussion and to allow for answers from multiple groups to be viewed simultaneously during large-class discussion. Using Google Drive, students and the instructor can also see postings from other groups during the small-group phase of the activity. Google Drive can be adapted for the undergraduate and K–12 levels as well. In another approach, think-pair-share was adapted to Collaborative Environment for Teaching and Learning systems (CETLs), which enable an instructor to interact in real time with student groups through messaging as the students work (Azlina, 2010). CETLs are an effective way for an instructor to supervise multiple student groups simultaneously at the secondary and higher education levels. CETLs also allow students to collaborate online and promote active participation by students.

○ Assessing the Think-Pair-Share Activity & Student Learning

Instructors need a way to assess the influence of think-pair-share activities on student learning and engagement. As mentioned previously, the summative assessment questions used after a think-pair-share activity should be similar to, but not repeat, the questions used in the think-pair-share activity. This means that a think-pair-share activity and the subsequent summative assessment should both be focused on the same learning goal and the same course topic. Observing students' participation is a way for an instructor to assess their level of engagement in the discussion that takes place during the formative assessment. Also, when think-pair-share activities have been used throughout a course, end-of-course summative assessments serve as an indicator of the effectiveness of these active-learning activities. It is also possible to assess student learning that occurred during a single think-pair-share activity by using summative assessments during the semester, rather than at the end of the course.

○ Think-Pair-Share Is Not as Easy as It Looks: A Case Study

I conducted a think-pair-share activity as a formative assessment, giving students the following three tasks to do individually, then in pairs, and finally as a large group: (1) put a list of gene cloning steps in the correct order; (2) put a list of DNA fingerprinting steps in the correct order; and (3) list some important purposes of DNA fingerprinting. My case study did not include a pretest, since I was comparing "think-pair-share semesters" to "control semesters" in which students were taught using only a traditional lecture-style format. However, a pretest is a good way to determine the baseline knowledge of students at the beginning of a course, and pretests are essential when a control class section is not used.

My analysis of this activity found that think-pair-share had almost no effect on student performance on a summative assessment. Two of the three formative assessment questions (1 and 2) ask students to put a given list of items in a correct order. Although there are several possible responses, only one response is correct in each case. A better approach for parts 1 and 2 would be to ask students to make the list themselves or to justify their answer. This is one explanation for why I did not see the expected benefit to students when they completed a summative assessment of three questions immediately after using think-pair-share (Table 1 and Figure 1).

The results in Figure 1 show no statistically significant improvement when think-pair-share was used, except in the case of BIO 101 students answering the second assessment question. The nature and level of difficulty of the summative assessment questions differed from the think-pair-share (formative assessment) questions, which seemed simpler. This is an explanation for why the think-pair-share activity did not affect student performance on the summative assessment. Also, unlike the summative assessment questions, the formative questions did not ask for explanations and were therefore not aligned well with the summative assessment questions. It is important that the summative assessment questions and the formative questions are aligned with each other and with the instructional goals. In the first and second questions of the formative assessment, students should be asked to justify why they ordered the steps the way they did, to demonstrate their understanding of what each step involves. Consider the third question from my think-pair-share activity, "What do you think are some of the important purposes of DNA fingerprinting?" While the question is open-ended, it would be better to ask the students to explain why the items in their list are important, so that they stay engaged and see the medical and legal applications of DNA fingerprinting. During the think-pair-share and assessment activities I conducted, students were allowed to use their notes, textbooks, and whatever other aids they had available. Some students asked and were given permission to use the Internet while completing the activities. Even though textbooks and other sources of information can be learning tools, could the students have been relying too much on their textbooks and other aids? Since it is easy to look up information in a textbook, were the students doing that rather than focusing on the thought processes that were needed to answer the questions? In other words, could the textbooks have detracted from metacognitive thinking and from interaction with peers?

Table 1. The summative assessment tool used in all semesters.

Answer each question below. Use a short paragraph for each answer. Your answers will be graded based on accuracy and on how well the answer specifically addresses the question.	
1	Why are restriction enzymes used in gene cloning?
2	Why would one person have a DNA fingerprint that is different from that of another person?
3	In your own words, why is electrophoresis used in DNA fingerprinting?

The purpose of my think-pair-share activity was to help students retain information, but the results suggest that think-pair-share is better used when the goal is more than just learning facts, unless the formative assessment is the same as the summative assessment. Think-pair-share is best used when the goal is higher-order thinking, and a backward design approach, as described by Wiggins and McTighe (1998), is best for this purpose. For example, the formative and summative assessment questions can include prompts that ask students to explain their reasoning and apply their knowledge to real-life scenarios.

In my study of think-pair-share, I analyzed each student's answers to the three summative assessment questions to determine whether the answers mentioned key concepts that I considered important, regardless of whether the answers also contained inaccuracies. I developed a specific grading rubric for the assessment (Table 2).

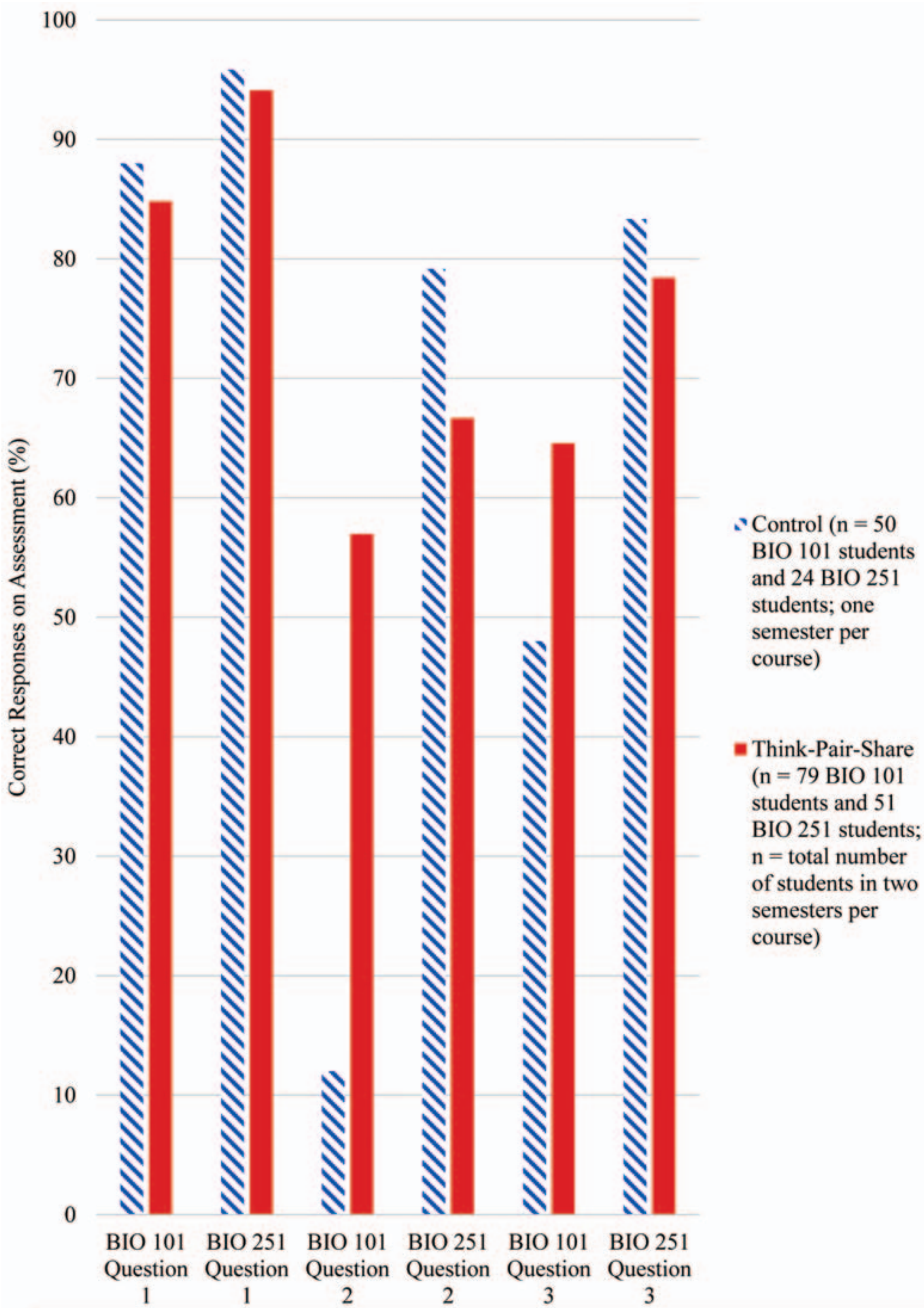

Figure 1. Student assessment results in semesters with and without the think-pair-share activity. If a student did the assessment in more than one semester, only the assessment in the first semester was included in the analyses. Students needed to be at least 18 years of age and, in the semesters in which the think-pair-share activity was used, be present during the think-pair-share activity in order for their assessment answers to be included in the research analyses. Students with unexcused absences on the day of the assessment activity were not included in the research analyses. Assessment answers of students who did part or all of the assessment outside of class time were not included in the research analyses unless I proctored them. The research analyses did not include answers from two students who were mistakenly not given consent forms due to their absence from class on the day on which the forms were distributed. To test for statistical significance of differences between control results and think-pair-share results, two-tailed P values were calculated using Fisher's exact test with the method of summing small P values using the calculator at http://www.graphpad.com/quickcalcs/contingency1/ (accessed July 28, 2014, through January 20, 2015). The P values were 0.7952 (BIO 101) and 1.0000 (BIO 251) for the first assessment question, <0.0001 (BIO 101) and 0.4151 (BIO 251) for the second assessment question, and 0.0699 (BIO 101) and 0.7618 (BIO 251) for the third assessment question.

Table 2. Grading rubrics for the biotechnology assessment.

Question	Response
1	**Why are restriction enzymes used in gene cloning?**
	Key concepts: cutting DNA, taking pieces out of DNA, creating gaps into which DNA can be inserted, isolation of a certain sequence. Answers were scored as unacceptable if they • simply mentioned restriction of DNA without also explaining what restriction means.
2	**Why would one person have a DNA fingerprint that is different from that of another person?**
	Key concepts: repetitive DNA, repetitive nucleotides, variation in base sequence or DNA sequence or chromosome sequence, mutations, nucleotide differences. Answers were scored as unacceptable if they • simply mentioned repeats of alleles, repeats of genes, shuffling of DNA or differences in DNA without further explanation. • simply mentioned different codes, different genotypes, or different restriction site locations. • simply mentioned that DNA fragments were of different lengths without also mentioning cutting of the DNA. • simply mentioned that DNA from different people was cut at different spots without mentioning why the different DNA samples were not cut at all of the same locations.
3	**In your own words, why is electrophoresis used in DNA fingerprinting?**
	Key concepts: separation of DNA fragments by size, determination of relative size of DNA fragments, shorter fragments traveling faster/farther, variation of migration rate based on the size of the DNA fragment, determining DNA sequence by size, determining repetitive patterns in DNA by size. "Banding" was not considered synonymous with "separating." Answers were scored as unacceptable if they • simply mentioned separation of DNA or spreading out different-sized DNA fragments without mentioning that separation was based on size.

Table 3. Best practices for think-pair-share.

• Have the learning objectives in mind when writing discussion questions.
• Closely align the summative assessment with the formative assessment, using the same prompts when necessary.
• Use open-ended questions with many possible answers.
• Ask students to explain their thinking processes as they are doing the activity. Focus not just on the answers but also on the how students arrived at the answers.
• Use questions that promote connected learning. Encourage students to focus on the perspectives of others.
• Encourage exploration and research. Consider having the students do this before the activity.

Upon reflection, I wonder whether students who did not meet the requirements of my grading rubric still learned what they were supposed to learn. The questions used in my summative assessment are not a sufficiently specific prompt for students to include information that I consider to be key concepts (see the second column of Table 2). Could I have written summative assessment questions that could be assessed with more general grading rubrics? Summative assessment questions that are more open-ended may have given students more of a chance to show their mastery of a broad biological concept. Summative assessment questions that focus on a larger number of the topics from the think-pair-share activity would be a more comprehensive assessment of what students learned during the activity. The summative assessment questions that I wrote were focused on facts, since that was the particular learning goal I had in mind for the think-pair-share activity. In retrospect, I see that my summative assessment prompts should match the prompts used in the formative assessment.

○ Conclusions

The think-pair-share activity requires thoughtful planning in order to be effective. The instructor should have the learning goal in mind before designing an activity. Therefore, a backward design is beneficial when writing questions for think-pair-share, so that the questions support the particular learning goal that is desired. Think-pair-share might not be the best approach if the learning goal is simply to have students acquire basic, factual information – unless the follow-up summative assessments use prompts from the think-pair-share activity. Questions with more than one possible answer best promote in-depth discussion. The discussion questions used in think-pair-share activities should be designed so that the topic is not too broad, but the focus should not be too narrow either. The instructor can decide how much access to information resources the students have during the discussion, but think-pair-share is best when students are asked to answer metacognitive questions or application questions rather than fact-based questions only. When writing questions for think-pair-share activities, the instructor can intentionally include prompts that promote connected learning. The instructor also needs to decide how much interaction to have with the student discussion groups while not stifling the discussion. Discussion constraints can be used to guide but not limit the discussion. A summary of best practices for think-pair-share activities is included in Table 3. Because they promote important knowledge and skill development in students, well-designed think-pair-share activities are valuable tools that instructors can use in science classrooms.

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