A Combined Read-Aloud Think-Aloud Strategy Improves Student Learning Experiences in College-Level Biology Courses

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Reading aloud (RA) is a learning strategy commonly used to help younger students develop language comprehension skills and in adult literacy and language courses to help students master the pronunciation of words, grammar, and intonation. However, we know of no studies to date that investigate the possible benefits of RA at the college or university level. We propose that "reading aloud" (RA) immediately followed by "thinking aloud" (TA) during class can help college students enhance their reading abilities and cultivate their analytical thinking skills. This study explores the impact of a "read aloud–think aloud" (RA-TA) strategy in college-level biology courses. Students in 3 sections of 2 courses were asked about their experiences with RA via an end-of-semester survey. When pooled (N = 34 students), responses to all 5 survey questions significantly supported RA-TA. The responses to 4 survey questions very significantly supported the use of RA-TA: Students read the text more, understood it better, found the instructor's help useful, and in general learned to read difficult texts with greater comprehension. Results suggest that a RA-TA approach has the potential to greatly enhance student learning at the college level and provides a promising area for future research.

Community college students typically have diverse educational backgrounds and life circumstances (Cohen, Brawer, & Kisker, 2014). Many students are returning to the classroom after being away for many years, or are switching careers or disciplines. Others have just completed high school and are not experienced with studying independently. In a diverse classroom, helping every student meet learning goals can be a challenge, particularly in content-heavy subjects such as biology. An added obstacle for students learning about a science such as biology is the vast number of new vocabulary words that they must integrate in a short period (Snow, 2010). Students often face the same challenges in a biology course as they would in a foreign language course. At the same time, learning new words is easier when students are familiar with their context. These aspects of learning can be daunting. To serve these needs, a teaching approach that helps them to learn both vocabulary and course concepts is needed. To identify such an approach, we return to the foundations of educational pedagogy.

Of the many theories in the field of education, Lev Vygotsky's work seems applicable. Vygotsky emphasizes the roles of social interaction and cultural context in learning. The learner best acquires knowledge and skills through social connection and interaction with others (Gredler, 2009). Many educational concepts and practices are in turn based on this premise, including the zone of proximal development (ZPD) and scaffolding.

The ZPD is defined as what the learner cannot do alone, but can do with support and assistance from a more experienced and knowledgeable individual (Rogoff, 1990). Scaffolding is the temporary support that the more knowledgeable individual provides to help the learner move through the ZPD to higher levels of skill and knowledge. As the learner progresses, so does the nature of the support provided. Ideally, descaffolding will eventually occur and the learner will have acquired knowledge and skills that can be demonstrated independently (Collins, Brown, & Newman, 1989).

Lin et al. (2012) conducted a content analysis of 43 science education scaffolding articles, yielding three conclusions. First, the aims of scaffolding in science education are the development of conceptual un-

derstanding, procedural and strategic skills, and metacognition. Second, many representations of scaffolding are present in the science education literature. These can be categorized as visual representation, social interactions, and written prompts. Third, Lin et al. found consensus that descaffolding is necessary, but found little documentation of its occurrence.

Interactive reading aloud (RA) is a teaching tool that uses scaffolding. RA consists of several steps (previewing a storybook, scaffolding on prior knowledge, emphasizing story elements, answering purposeful questions, and summarizing what was learned). Two forms of RA have been used in educational practices: reading to students and round-robin reading (Brabham & Lynch-Brown, 2002; Trelease, 2013). In the former, the teacher reads the book aloud to the students, modeling appropriate fluency and intonation, while students experience the storybook by answering and asking questions as the book is read to them (Trelease, 2013). Round-robin reading is similar, but instead the students take turns reading passages. RA in various forms was observed to increase student mastery of new vocabulary words at both the preschool (Leung, 2008) and elementary school (Brabham & Lynch Brown, 2002) levels. The authors thus felt it worth exploring the potential of RA as a learning tool for students at advanced educational levels.

The teacher may also demonstrate "thinking aloud" (TA) at the same time, by describing his or her thought processes while reading. This models for the students how to search for meaning in what they read. RA to younger students has been demonstrated to broaden vocabularies, develop concept of story structure, strengthen understanding of the connection between spoken and printed elements, sharpen critical thinking skills, increase confidence with the reading process, model fluency, and encourage students to read on their own (Rog, 2001).

RA is less commonly used in the upper elementary, middle, and high school levels, and there are relatively few studies of its effectiveness in helping older students learn (Trelease, 2013). We know of no prior studies of RA at the postsecondary level. The decrease in the use of RA in higher grade levels may occur for many reasons. Some argue that RA is unengaging for the listener. Some studies suggest that it is anxiety producing for the reader and encumbers working memory for decoding, recoding, and articulation, thus preventing the student from fully comprehending what she or he is reading. Furthermore, RA may arguably be a linear process that does not facilitate comprehension (Klapper, 1992). Some feel that the slowed reading rate during RA results in the dissection of the language and an overall loss of message of the writing (Eskey & Grabe, 1988; Grabe & Stoller, 2011). Kelly (1995) noted that many teachers persist in using RA despite these arguments and the lack of research to support the effectiveness of RA.

However, more recent research provides support for RA in the classroom, especially when it is used in an active, rather than passive, manner. Dreher (2003) reported that RA helps engage students in lessons, increases their confidence, and improves their ability to read difficult texts. Specifically, these benefits occur when all students are involved in the reading process and subsequent discussion. Hale et al. (2007) found that RA enhances reading comprehension in elementary and high school students. Furthermore, Duncan (2015) reported that adults continue to engage in RA, apply it to a variety of reading materials, and value it for many reasons. These findings are particularly salient as they support the use of RA with older students and support the use of RA in other than storybooks.

The use of TA in conjunction with RA (RA-TA) might serve as a powerful learning tool even at more advanced levels of study. From the authors' experience, this approach seems to work best in smaller classes, preferably with fewer than 15 students. RA-TA provides a framework for strengthening students' reading skills in an interactive way. The concern of students becoming bored is offset by a TA session after the reading of a paragraph. During the TA session, the instructor would pose questions and provide explanation as needed. All students would be encouraged to contribute to the discussion by paraphrasing, summarizing, and asking and answering questions. RA alone may be a more passive activity, but in concert with TA it can engage all students in the classroom, while providing the scaffolding necessary to develop abilities central to both reading scientific literature and performing hands-on science. These abilities include critical thinking, data analysis, and integration of prior knowledge, all of which help students succeed in their courses and beyond. The authors thus felt justified in using class time to help students develop their reading skills.

In this study, the strategy of RA in class was implemented in three sections of two courses offered at an urban community college, Olive-Harvey College (OHC), one of the City Colleges of Chicago (CCC). CCC is one of the nation's largest community colleges and the largest in Illinois, with 6,000 faculty and staff and 120,000 students. The PI (corresponding au-

thor Pergams) is a tenured associate professor at OHC, the poorest of the seven colleges (95% minority, 84% below poverty level (CCC unpublished data, 2016). One course was Biology 119, Environmental Biology, a general education course that may be taken by biology nonmajors, although it is often also taken by majors. A second course in which this technique was applied was Biology 122 (Organismal Biology: Ecology, and Evolution), which is a majors' biology course usually taken by students who will transfer to a 4-year bachelor of science program. Sample course materials are included in Appendices I–VI (available at http://www.nsta.org/college/connections.aspx).

The PI had previously taught these courses in a traditional lecture-based style, using PowerPoint slides to convey much of the information. He felt that this "sage on the stage" approach was not engaging students enough and not motivating them to take ownership of their learning. The instructor asked the first group of students where they were facing challenges. Most responded that they had not read the textbook on their own, or that they had attempted to read the textbook but did not understand it. When asked to elaborate, most students cited one or both of two reasons: (1) a lack of adequate time, or (2) they did not enjoy reading the textbook or article, often because they felt overwhelmed by it.

To counter these challenges, the PI sought a different approach. Based on success of RA and TA in other educational settings discussed previously, RA-TA in class seemed to be a potentially effective approach to address all three concerns (encouraging students to read the material, helping students to understand the course concepts, and motivating students to become stakeholders in their own learning).

Methods

The PI decided to directly address the students' apprehension of reading (especially difficult textbooks) by having them take turns reading the textbook aloud during class. He also wanted to encourage them to think critically and to identify their own areas of challenge by asking questions as they read. A combined "reading aloud–thinking aloud" (RA-TA) approach was used.

Active student participation and buy-in were gained by first explaining RA-TA and its hoped-for benefits to them. Students then were asked to vote on a 2-week RA-TA trial period. At the end of the trial period students voted again on whether to retain RA-TA for the rest of the semester. All students agreed to abide by the majority opinion. In each course the majority voted in favor of retaining RA-TA for the duration. No students objected, so there was no need to incentivize participation by awarding points.

Each student and the instructor took turns reading a paragraph out loud. Under the guidance of the instructor, this was followed by a think-aloud during which the class took part in the paraphrasing and analysis of the paragraph. Students were asked to summarize the main idea of the paragraph and to ask questions on anything they did not understand, including unfamiliar vocabulary. Accompanying figures were also discussed. During the lesson, the instructor incorporated videos, models, ancillary texts, internet resources, etc., and paused for discussion to be sure students thoroughly understood concepts before reading would continue. RA also provided the instructor with instant feedback on students' reading ability and allowed the instructor to model the reading process and to demonstrate correct pronunciation and intonation. The goal was to increase students' self-confidence in their reading ability, improve their reading comprehension, and help them develop their metacognitive abilities. This also modeled for the students how to search for other sources of information to help them better understand what they had read.

Analysis

Three sections of two courses were involved in this project:

1. Biology 122 (Organismal Biology II) taught fall 2015 (N = 8 students)
2. Biology 119 (Environmental Biology) taught spring 2016 (N = 14 students)
3. Biology 122 (Organismal Biology II) taught fall 2016 (N = 12 students)

There were a total of 34 students in these three sections. The instructor gave the students a semester-end survey to fill out (see Figure 1). The

FIGURE 1

End-of-semester survey.

Please rate the following on a 1–5 scale, with 1 = *strongly disagree*, 2 = *somewhat disagree*, 3 = *neither disagree nor agree*, 4 = *somewhat agree*, and 5 = *strongly agree*.

1. It made me read the text more than I would have otherwise.
2. It made me understand the text more than I would have otherwise.
3. [The instructor] elaborating on the text was useful to me.
4. In general, I learned how to read difficult texts with greater comprehension.
5. I prefer a class conducted this way over a class with lecture and PowerPoints.

survey sheets were proctored by a student while the instructor was out of the room. The total sample of 34 students is small, but *p*-values take sample size into account. We used one-sample *t*-tests with null hypotheses of 3 on a 5-point Likert scale (*neither agree nor disagree*). In other words, we tested whether students' responses were significantly different from neutral for each question.

Because previous sections of both courses used different textbooks, homework, and quizzes, student grades in past sections of these courses taught by traditional lecturing could not be compared with these three RA-TA classes.

Results

Students in Biology 122 (fall 2015, $N = 8$) responded significantly and positively to all but two questions (Table 1). One was "My own 'translating' of the text after someone else read it helped me understand the text better." Later discussion with students suggested this was because "translating" started late in the class (Week 11 out of 16), and the students did not have time to get used to it. In fact, it was unpopular, and the instructor discontinued it in later classes. Students also did not respond significantly to "I prefer a class conducted this way over a class with lecture and PowerPoints." Subsequent student discussion revealed that it was difficult for students to embrace this approach to learning because it was novel. Traditional PowerPoint-based lectures were the norm in the majority of their classes, so it is not surprising that students were still not completely at ease with the RA-TA approach by the end of the semester.

Students in Biology 119 (spring 2016, $N = 14$) responded significantly and positively to all but one question: "I prefer a class conducted this way over a class with lecture and PowerPoints." Student discussion suggested that the novelty of the RA-TA approach was less important to them.

Students in Biology 122 (fall 2016, $N = 12$) responded significantly and positively to all but one question: "In general, I learned how to read difficult texts with greater comprehension," The question missed significance by a very small margin (2-tailed $p = .0688$). When asked about their response, some students shared that they felt they still needed the instructor's guidance to help them fully understand the readings.

TABLE 1

Results (2-tailed *P* values) of 1-sample *t*-tests on survey questions, using 3 on a 5-point Likert scale as a null hypothesis.

Bio 122 Fall 2015	Read Text More	Understand Text More	Pergams Elaborating	My "Translating"	Helped Reading In General	Prefer Class This Way
mean	4.13	4.13	4.88	3.69	3.69	3.13
2-tailed P	0.0379	0.0066	<0.0001	0.1885	0.0280	0.7627
(1-sample t-test w/3 as null hypothesis, *N*=8)						
Bio 119 Spring 2016	**Read Text More**	**Understand Text More**	**Pergams Elaborating**	**My "Translating"**	**Helped Reading In General**	**Prefer Class This Way**
mean	4.07	4.29	4.79		4.21	3.29
2-tailed P	0.006	0.0003	<0.0001		<0.0001	0.3649
(1-sample t-test w/3 as null hypothesis, *N*=14)						
Bio 122 Fall 2016	**Read Text More**	**Understand Text More**	**Pergams Elaborating**	**My "Translating"**	**Helped Reading In General**	**Prefer Class This Way**
mean	4.25	3.83	4.75		3.75	3.58
2-tailed P	0.0004	0.0172	<0.0001		0.0688	0.0116
(1-sample t-test w/3 as null hypothesis, *N*=12)						
TOTAL	4.15	4.09	4.79		3.93	3.35
2-tailed P	<0.0001	<0.0001	<0.0001		<0.0001	0.0437
(1-sample t-test w/3 as null hypothesis, *N*=34)						

When pooled ($N = 34$), responses to all five questions were positively significant, and all but one highly so (2-tailed $p < .0001$). The question that was positively significant but not highly so was "I prefer a class conducted this way over a class with lecture and PowerPoints" ($p = .0437$).

The authors attempted to implement the RA-TA strategy in larger classes (17, 18, 19, 29, and 32 students), but opted not to pursue it, based on an observed lack of student engagement. In these larger classes, instructors subjectively felt it was difficult to get through the material without substantially losing student attention. Further research could verify and refine this observation. When class sizes were >15, students had to wait too long for their turn to read again and lost focus. It was concluded that this RA-TA approach is most effective in smaller classes with fewer than 15 students.

Conclusions

Studies published within other contexts provide compelling evidence for the value of RA as a learning tool. However, most of this research focuses on its use with younger students. By contrast, RA is used much less often in middle school, high school, and postsecondary education. Instructors in these settings are increasingly facing pressure to demonstrate their effectiveness as measured by student performance on tests (Serafini & Giorgis, 2003). RA may be viewed as too slow to produce immediate results on examinations. In conversations with colleagues, the authors heard a few instructors state that they did not have time for RA. This attitude may partly arise from the pressure felt by some college instructors to cover extensive curricula in a short time. Another comment that the authors encountered was that RA is too "juvenile" or "basic" and thus is not appropriate for college.

Despite these objections to RA, the use of an RA-TA approach for teaching science is supported by research on the value of scaffolding (Lin et al., 2012). Specifically, RA and TA include the three elements found in scaffolding: visual representations, social interactions, and written prompts. Although Lin's findings applied to grammar school students, the findings of the current study together with Duncan's (2015) study of the value of RA in adults suggest that RA-TA is useful for adult learners as well.

Significant, positive responses from students to the postclass survey indicate that the use of the RA-TA method enhanced their learning experiences. However, some classes did not show a significant positive response to the process of "translating" the text. This is consistent with previous research that suggests that scaffolding methods should be tailored to the needs of the students being taught (Lin et al., 2012). In accordance with this need for tailored scaffolding, the authors discontinued the process of "translating the text" when students expressed that the process was unappealing and unhelpful.

Another important goal of scaffolding is for students to develop independence in performing learned skills through the process of descaffolding (Collins et al., 1989). In the current study, this was assessed by student responses to the fourth question on the postcourse survey, "In general, I learned how to read difficult texts with greater comprehension." Although the responses to this question for one class missed significance by a very small margin, there was a significant, positive finding in the pooled data. This supports the idea that descaffolding is effective. Future research might focus on examining descaffolding more directly, perhaps by using an assessment tool to measure students' ability to comprehend a scientific passage on their own.

A practical drawback is that the RA method may be difficult to implement in a larger class setting (>15 students). One suggestion is to split larger classes into smaller groups. However, given that RA-TA is very dependent on having a single expert reader, splitting classes would probably not work unless there was an additional expert reader. Also, without an expert reader we do not recommend RA-TA for use outside the classroom, such as study halls or peer tutoring. Finally, future studies by the authors will involve comparison of same-course sections in which RA-TA is used in one and lecture-based instruction is used in the other. This will allow for a measure of the impact that RA-TA has on learning outcomes in addition to its impact on learning experiences. These future studies will also use more detailed surveys given at both the beginning and end of the semester. ■

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