SPEAK AGENT IN THE CLASSROOM

A quasi-experimental study on the impact of an academic learning tool on second and third grade students' science language development

Summary Report

June 2018

Rockman et al
Research & Evaluation

Rockman et al

Rockman et al (REA) is an innovative research, evaluation, and consulting company that specializes in examining critical issues in formal and informal education. We provide relevant and timely information to help our clients make decisions and inform funders. REA works with corporations, state and federal agencies, local school districts, foundations, universities, and community-based organizations. We plan and conduct formative and summative evaluations, design and implement rigorous research models, undertake strategic planning and policy research, conduct market research, and provide technical assistance for using data for decision-making and planning. Our areas of interest and experience include: technology use in formal and informal settings; telecommunications and media; whole-school reform initiatives; professional development programs; informal educational programs; special education; English language learners; arts education; math and science initiatives; curriculum and assessment; NCLB mandates and accountability; and community-based youth programs.

As independent researchers, we often serve as an external evaluator for grant-funded projects supported by foundations, state and federal agencies, and private industry. REA has a national reputation for providing such services in the area of informal science (NSF-funded projects), and the role of technology in school reform initiatives (U.S. and state departments of education). The staff of REA includes evaluators with advanced degrees in education, cognitive science, child development, and psychology. Rockman designs and conducts evaluations and research for all types of education-related organizations. We identify trends, determine strengths and weaknesses and offer feedback and recommendations to help our clients succeed.

Evaluation & Report Credit:

Julia Li, Ph.D., Associate Researcher
Rockman et al
201 Mission Street, Suite 1320
San Francisco, CA 94105

Project Credit:

Executive Summary

For the 2017-2018 academic year, Rockman et al, an independent evaluation and research consulting group, implemented a quasi-experimental study design to explore the effects of using the Speak Agent academic language learning tool on science language development for ESOL students. REA worked with two elementary schools from a central Texas school district, and partnered with second and third grade science teachers and their students. In the first term, half the student sample was given access to Speak Agent, while the other half did not have any interactions. By the second term, all students were given access to the language tool. Students' science vocabulary knowledge was measured at the start and end of each term by an original assessment created by REA.

The following highlights the main findings from the study:

- Second graders who had access to Speak Agent showed greater science content knowledge growth than those who did not have access to the Speak Agent tool.

- Second graders' science language development was not affected by the type of access given to teachers (control over Speak Agent science content).

- Second graders reported high confidence and interest in learning about science and new vocabulary.

- Third graders showed overall improvement in science content knowledge over the academic year, but there were no statistically significant differences between students who did or did not use Speak Agent.

- Third graders' reported interests and confidences in learning about science/new vocabulary increased by the end of each term.

- Although use of the Speak Agent activities was limited and inconsistent within the second and third grade student samples, teachers reported that the experience engaged and motivated students to learn more about science.

Introduction

The objective of the Speak Agent tool is to accelerate acquisition of key academic concepts and related vocabulary for students with learner variability, particularly for those who are non-native English speakers. To understand the impact of the Speak Agent language learning tool on student language development, Rockman et al (REA) collaborated with Speak Agent to design a quasi-experimental study that assessed differences in student vocabulary growth as a result of engagement with the Speak Agent tool. REA partnered with second and third grade classes from a central Texas public school district. Teachers and their students were given access to the Speak Agent tool at different points of the year (i.e., beginning of the year versus mid-year), and student vocabulary knowledge was measured by assessments developed by REA based on the district curriculum.

Before the start of the study, the school district requested that the study focus on improving second and third grade science vocabulary, a subject area that does not receive as much intervention and support as other school subjects. Thus, REA and Speak Agent worked with district administrators to build the Speak Agent lessons and assessments around the second and third grade science curricula. A total of nine classes (five 2nd grade, four 3rd grade) participated in the study. Half of the classes received access to Speak Agent at the beginning of the school year, while the other half proceeded with their regular course agenda without use of the Speak Agent tool. By the second term (January 2018), all but one class were given access to the Speak Agent tool. This design ensured that the majority of participating classes would have access to the language tool during the academic year, but also allowed REA to compare differences in students' vocabulary growth between those with and without use of the tool.

Study Participants

Figure 1. Distribution of Students by Gender
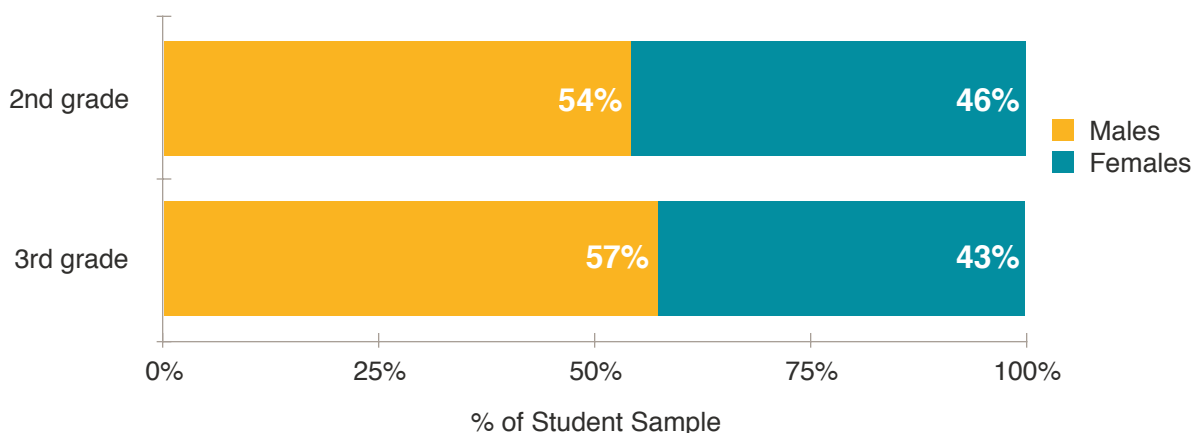
The nine participating classes all came from two elementary schools in a single public school district in central Texas. Classes were selected by the district based on their class sizes and teachers' willingness to participate in the study for the entire academic year. However, one second grade class dropped out of the study after the first term (August - September 2017), and they were replaced with another second grade class from the same school. For each academic term (Fall 2017, Spring 2018), there were a total of four second grade and four third grade classes participating in the study. The student sample was also fairly evenly represented by male and female students (Figure 1).

Across the nine classes, there were a total of 74 second graders and 77 third graders in the study. The majority of second grade (n = 59, 80%) and third grade (n = 67, 87%) students were identified as English as a Second Language (ESOL) students by the district (Figure 2), with the home language identified as Spanish.

Figure 2. Distribution of Students by ESOL Status
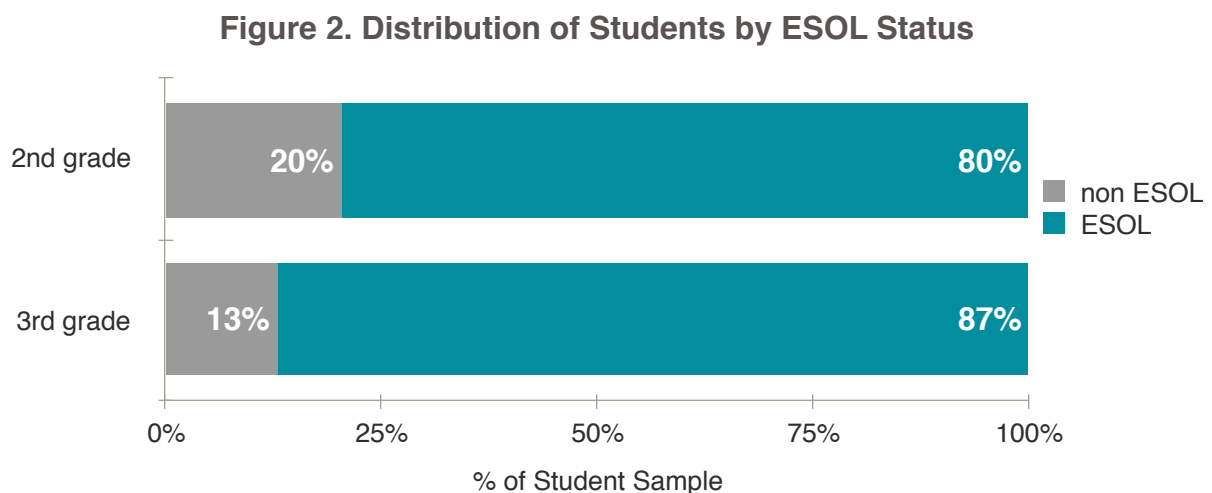

Study Design & Procedure

The study was divided into two terms: Fall 2017 and Spring 2018. Each term covered different science curriculum and vocabulary. REA and Speak Agent followed the district curriculum and pacing guides to develop the Speak Agent activities and assessments. Before the start of each academic unit, Speak Agent released the activities that focused on the targeted vocabulary (aligned with the district guides & learning objectives) for second and third grade. However, not all classes received access to the Speak Agent tool.

Classes were assigned to one of two possible conditions. In the Fall 2017 term, the conditions started as: *Usage* (access to Speak Agent tool) and *No Usage* (no access to Speak Agent tool). In the *Usage* condition, teachers were given guided instructions and suggestions for how the activities related to the science curriculum units and suggestions for amount of usage time students should have with each activity. The classes were not restricted to using the Speak Agent activities only as suggested by the guides; teachers had

freedom to decide when and how the Speak Agent tool would be incorporated into their class lessons. However, all *Usage* classes were asked to try to give students about one hour of access to the Speak Agent tool each week. In the *No Usage* condition, teachers and classes did not have access to the Speak Agent tool. They were instructed to carry on with their regularly scheduled lesson plans.

By Spring 2018, the classes in the *No Usage* condition transitioned to the *Guided Usage* condition, where students had access to the Speak Agent tool and teachers were given suggested guides for how to incorporate the activities into the curriculum and how much time students should spend on each activity. However, for the third grade sample, only one class transitioned to the *Guided Usage* condition. The remaining class stayed as a *No Usage* sample as they continued to have no interaction with the Speak Agent activities. For the classes that were in the *Usage* condition in the Fall 2017 term, they transitioned to an *Open Usage* condition in the Spring. Here, teachers were given opportunities to change and tailor the Speak Agent activities to fit the needs of their classes. For example, teachers could change the targeted vocabulary or reading passages to focus on lessons they wanted to work on with their students. Creative access was only granted to teachers in the *Open Usage* condition; teachers in the original *Usage* condition could not alter the Speak Agent materials, but all classes with access to Speak Agent were again asked to utilize the tool for an average of one hour per week. Figure 3 illustrates the study design and progression of conditions across the academic year. Students from all conditions completed a pre assessment at the beginning of each term and a post assessment at the end of each term. This allowed researchers to monitor changes in vocabulary knowledge, both within and between conditions.

Figure 3. Schedule and progression of Speak Agent conditions from Fall to Spring term.
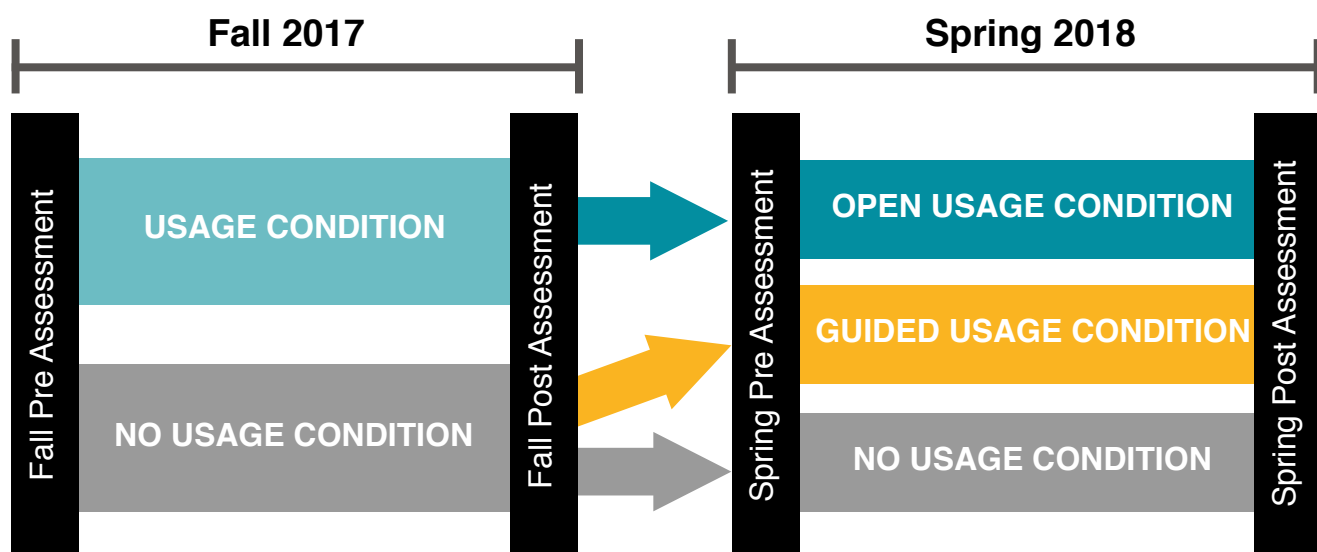
Study Assessments

The curriculum for each academic term covered different units and targeted vocabulary. Because of this, REA created separate assessments for the Fall and Spring term. Table 1 details the academic units covered in each assessment.

Table 1. Academic Units Covered in Speak Agent Assessments by Grade & Term

Second Grade		Third Grade	
Fall Assessment	**Spring Assessment**	**Fall Assessment**	**Spring Assessment**
• Investigating Matter • Investigating Force & Motion • Earth Materials & Natural Resources	• Exploring the Water Cycle • Observing the Sky • Characteristics of Living Organisms • Organisms and Environment	• Investigating Properties of Matter • Investigating Energy • Investigating Force & Motion • Investigating the Natural World	• Investigating the Solar System • Investigating Weather • Investigating Ecosystems • Investigating Structures and Functions of Organisms

Each assessment consisted of between 16-20 questions, covering between 40 to 52 key science concepts and related vocabulary that were provided by the district curriculum guides. The question formats included a mixture of multiple-choice, true/false selection, picture identification, connecting terms, and fill-in-the blank responses. To control for order effects, two versions were created for each assessment, with the order of questions randomized between versions. Each assessment version was randomly and equally distributed to half the classes in each grade. At the end of each assessment, there were also six attitudinal questions that were included to measure students' non-cognitive skills. These questions used a 4-point scale to measure students' self-rated interests and abilities in learning science and new vocabulary. Table 2 displays the six attitudinal questions posed at the end of each assessment. Appendices A-D display samples of the full second and third grade assessments.

Teachers were asked to administer the assessments to their classes as a group. They were allowed to read the instructions, as well as the questions & answer choices, out-loud to help any students who were not capable of reading on their own. Teachers were instructed not to provide any assistance with answering the questions, but they were allowed to clarify instructions (e.g., "select the right answer" versus "circle the correct word"). For the participating school district, second grade curriculum is taught completely in Spanish for the first term (Fall 2017), and then the curriculum is taught completely in English for the second

Table 2. Questions Used to Assess Student Attitudinal Changes

Attitudinal Measures	
Questions	**Answer Scales**
• How much do you like learning science? • How much do you like learning new words? • How good are you at learning science? • How good are you at learning new words? • How easy is it for you to learn science? • How easy is it for you to learn new words?	Hate it/ Very bad/ Very hard Don't like it/ Bad/ A little hard Like it/ Good/ A little easy Love it/ Very good/ Very easy

term (Spring 2017). Therefore, the Fall assessments and Speak Agent activities were translated into Spanish for the second graders.

The Speak Agent tool also recorded students' usage across the terms. Total usage (in minutes) was captured for each student who had access to the Speak Agent tool during the study, and the results were used to explore relationships between usage and performance on the assessments.

Second Grade Results

Fall 2017

Assessment Scores

The second grade Fall 2017 assessment consisted of 20 questions, with a total value of 60 points. All but one student was able to complete both the pre and post assessments. For every item on the assessment, at least one participant was able to achieve the maximum point value, indicating that all questions were answerable for the student sample. A total of 31 second graders were in the *Usage* condition, while 28 second graders were in the *No Usage* condition.
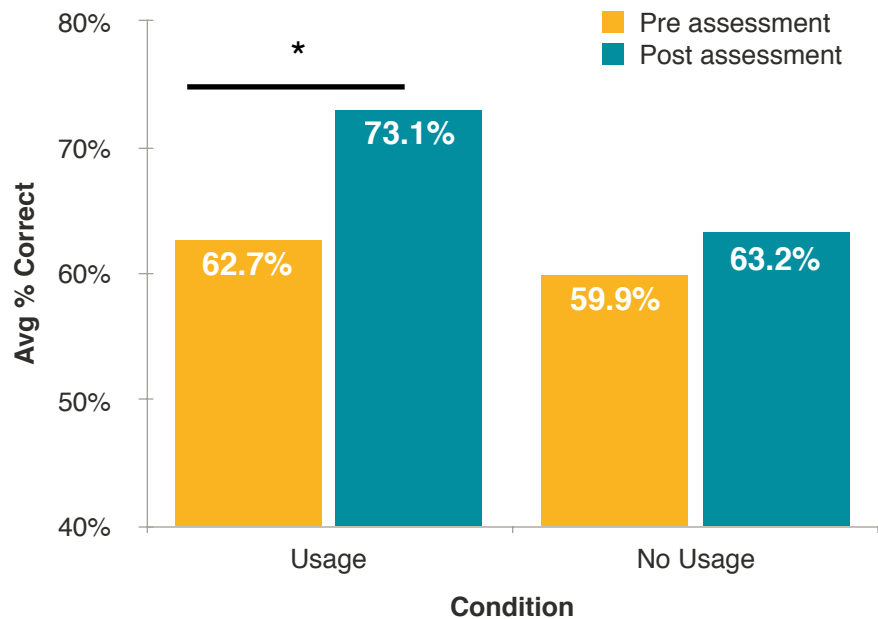
On the pre assessment, average assessment score was 61.6% (*SD* = 11.9%, *Range:* 33.0% - 85.0% points). An independent t-test was used to compare pre assessment scores between conditions (*Usage* vs. *No Usage*). No significant differences were found, *p* > .05, suggesting that students in the *Usage* condition (*M* = 62.7%, *SD* = 12.2%, *95% CI*: 58.2% - 67.2%) had a comparable understanding of the targeted vocabulary at the start of the Fall term as the students from the *No Usage* condition (*M* = 60.4%, *SD* = 11.6%, *95% CI*: 55.9% - 64.9%). On the post assessment, average assessment score was 68.5% (*SD* = 14.3%, *Range:* 28.0% - 93.0%). A two-way ANOVA was used to examine the effects of condition (*Usage* vs. *No Usage*) and assessment period (pre vs. post) on vocabulary performance. All

effects were reported as significant at the $p < .05$ level. There was a significant main effect of condition, $F(1,56) = 4.16$, $\eta_p2 = .069$), with students in the *Usage* condition ($M = 67.9\%$, $SE = .02$, *95% CI:* 63.7% - 72.1%) scoring higher on the assessments than students in the *No Usage* condition ($M = 61.6\%$, $SE = .02$, *95% CI:* 57.0% - 66.1%). There was a significant main effect for assessment period, $F(1,56) = 27.83$, $\eta_p2 = .33$, with students scoring higher on the post assessment ($M = 68.1\%$, $SE = .02$, *95% CI:* 64.6% - 71.7%)

Figure 4. Average 2nd Grade Pre & Post Assessment Scores by Condition for Fall Term

* significance at the p < .01 level

compared to the pre assessment ($M = 61.3\%$, $SE = .02$, *95% CI:* 58.2% - 64.5%), indicating that as a whole, students showed progress from the beginning to the end of the term. Finally, there was also a significant interaction of Condition x Assessment Period, $F(1,56) = 7.49$, $\eta_p2 = .12$. This indicates that the change in scores from pre to post assessment was different between conditions. There was a greater change in performance from pre to post for the *Usage* condition ($M = 10.4\%$) than for the *No Usage* condition ($M = 3.3\%$) (Figure 4). In fact, a follow-up independent t-test comparing differences in change scores (difference between pre and post assessment scores) between conditions revealed a significant effect, $t(56) = 2.74$, $p < .01$. Students in the *Usage* condition, on average, demonstrated greater positive gains ($M = 10.3\%$, $SD = 10.5\%$) than students in the *No Usage* condition ($M = 3.3\%$, $SD = 8.9\%$) (Figure 5).

Figure 5. Average 2nd Grade Change Scores by Condition for Fall Term

* significance at the p < .01 level

Speak Agent Usage

Speak Agent was able to track activity usage for those who had access to the tool. However, data was only available for 20 of the 31 *Usage Condition* students, indicating that about a third of the sample did not interact with the Speak Agent tool. Students in the *Usage* condition spent an average of 234.0 minutes (*SD* = 146.7 minutes) interacting with the Speak Agent activities over the course of the Fall term. A Pearson correlation was used to explore any relationships between students' performance on the post assessment or pre-post change scores against the amount of usage time, but no significant effects were observed (*p* > .05).

Attitudinal Scores

At the end of each assessment, students answered six attitudinal questions to assess their self-reported enjoyment and ability to learn science and new vocabulary. Mann-Whitney U tests and Wilcoxon Signed Ranks tests were used to compare differences in attitudinal responses between conditions and changes between pre and post assessment, but no significant effects were found. Figures 6 - 8 illustrate the distribution of responses for all six attitudinal items for both pre and post assessment. For both pre and post, the majority of students reported to "like" or "love" learning about science and new vocabulary (Figure 6), being "good" or "very good" at learning science and new words (Figure 7), and finding it "easy" or "very easy" to learn science and new words (Figure 8). Because students reported high interests and ability to learn science and new vocabulary at the beginning of the study, there was not a lot of room for improvement and their perceived abilities remained stable across the Fall term.
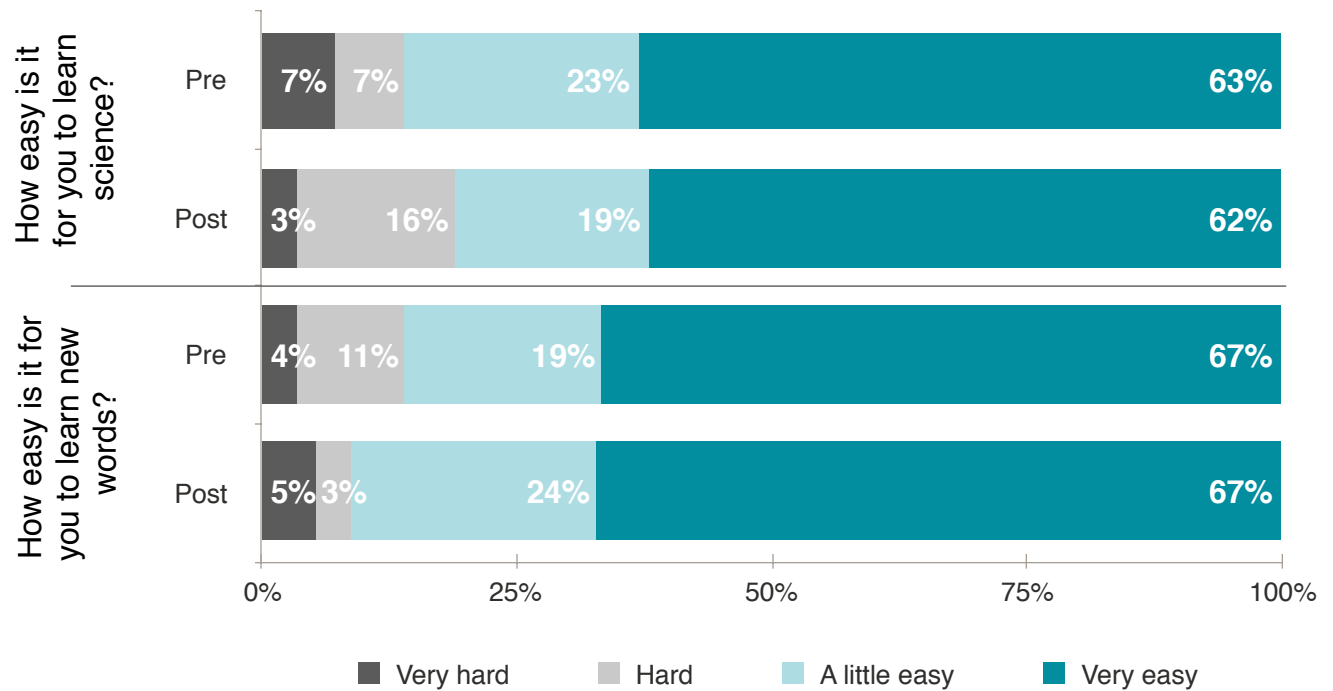
Figure 6. 2nd Grade Student Ratings for "How Much You Like Learning Science & New Words?" for Fall Term
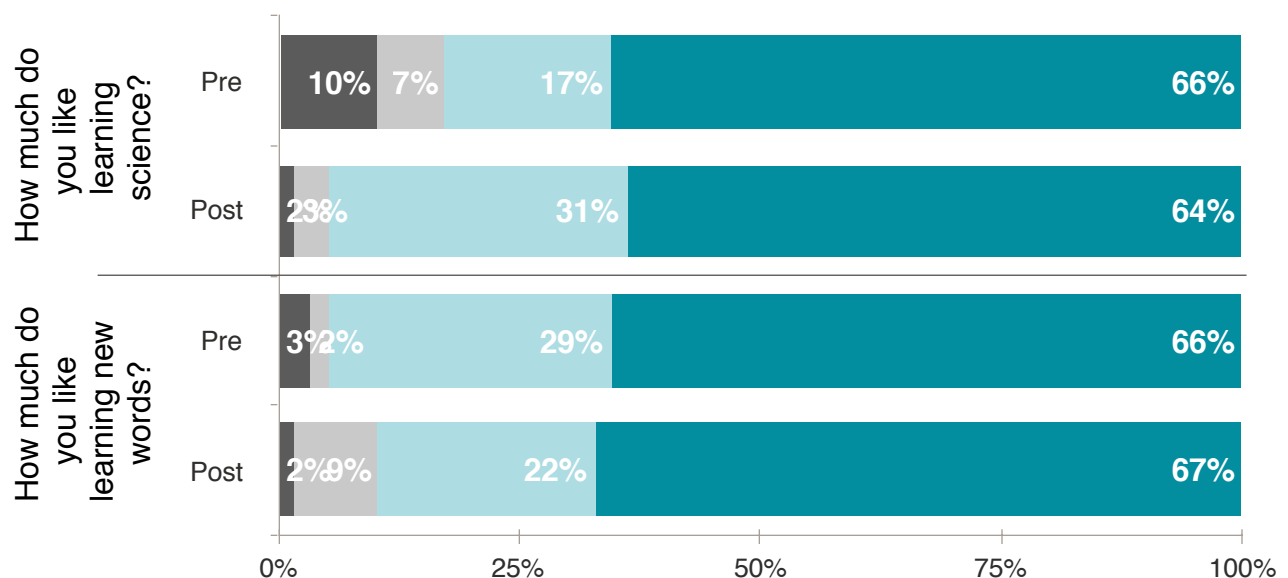
## Figure 7. 2nd Grade Student Ratings for "How Good You Are at Learning Science & New Words?" for Fall Term

How good are you at learning science?

Pre: Very bad 2%, Bad 7%, Good 21%, Very good 71%

Post: Very bad 2%, Bad 9%, Good 28%, Very good 62%

How good are you at learning new words?

Pre: Very bad 5%, Bad 5%, Good 31%, Very good 59%

Post: Very bad 2%, Bad 7%, Good 19%, Very good 72%

Legend: ■ Very bad ■ Bad ■ Good ■ Very good
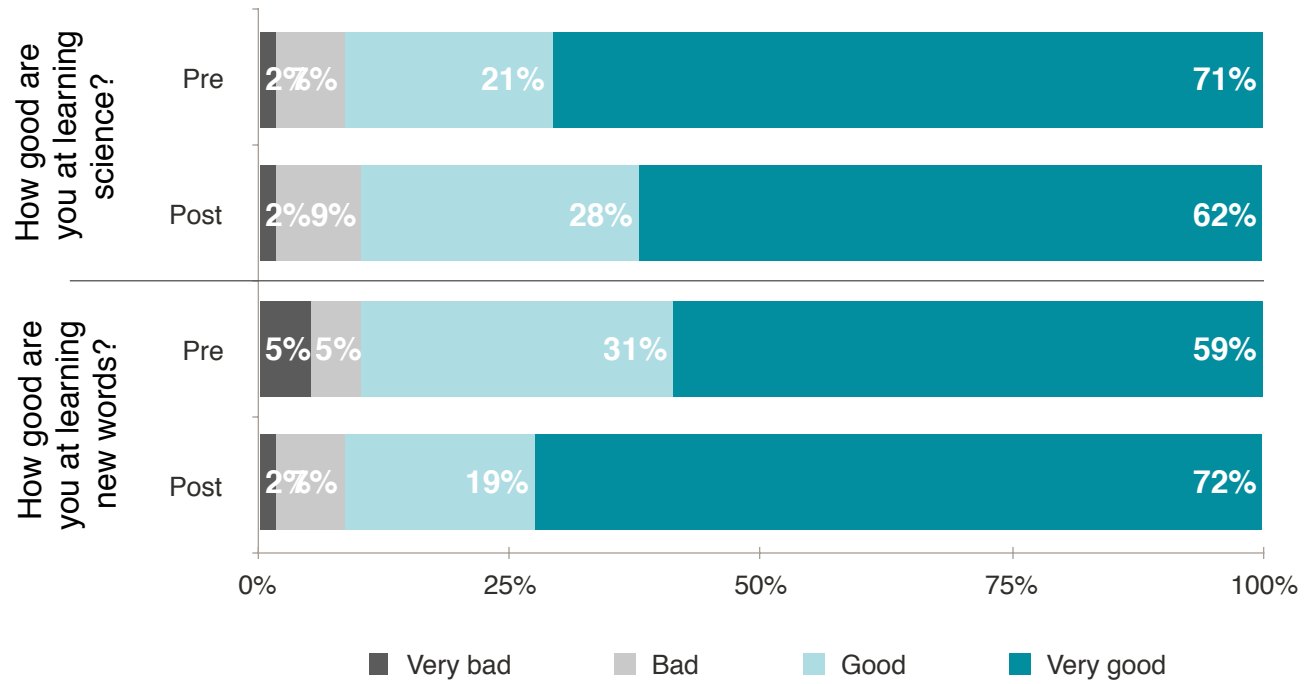
Figure 8. 2nd Grade Student Ratings for "How Easy Is It For You to Learn Science & New Words?" for Fall Term

How easy is it for you to learn science?

Pre: Very hard 7%, Hard 7%, A little easy 23%, Very easy 63%

Post: Very hard 3%, Hard 16%, A little easy 19%, Very easy 62%

How easy is it for you to learn new words?

Pre: Very hard 4%, Hard 11%, A little easy 19%, Very easy 67%

Post: Very hard 5%, Hard 3%, A little easy 24%, Very easy 67%

Legend: ■ Very hard ■ Hard ■ A little easy ■ Very easy

Assessment Scores

The 2nd grade Spring 2018 assessment consisted of 19 questions, with a total value of 51 points. A total of eight students were unable to complete both the pre and post assessments. For every item on the assessment, at least one participant was able to achieve the maximum point value, indicating that all questions were answerable for the targeted audience. A total of 29 second graders were in the *Open Usage* condition, while 28 second graders were in the *Guided Usage* condition.

On the pre assessment, average assessment score was 58.5% (*SD* = 14.4%, *Range:* 27.0% - 88.0% points). An independent t-test was used to compare pre assessment scores between conditions (*Open Usage* vs. *Guided Usage*). No significant differences were found, *p* > .05, suggesting that students in the *Open Usage* condition (*M* = 59.8%, *SD* = 14.4%, *95% CI*: 54.3% - 65.3%) had a comparable understanding of the targeted vocabulary at the start of the Spring term as the students from the *Guided Usage* condition (*M* = 59.3%, *SD* = 13.7%, *95% CI*: 52.9% - 65.8%). On the post assessment, average assessment score was 73.8% (*SD* = 13.2%, *Range:* 37.0% - 94.0%). A two-way ANOVA was used to examine the effects of condition (*Usage* vs. *No Usage*) and assessment period (pre vs. post) on vocabulary performance. A significant main effect for assessment period was found, $F(1, 47) = 75.4$, $p < .01$, $\eta_p2 = .62$, with students (across conditions) scoring significantly higher on the post assessment (*M* = 74.8%, *SE* = .02, *95% CI:* 70.9% - 78.6%) than on the pre assessment (*M* = 59.5%, *SE* = .02, *95% CI:* 55.4% - 63.7%) (Figure 9). However, there were no significant differences between *Open Usage* and *Guided Usage* conditions, or interactions between Condition x Assessment period. This would suggest, that overall improvement from pre to post assessment was similar between conditions. This was further demonstrated in the follow-up independent t-test comparing differences in change scores (difference between pre and post assessment scores) between conditions. No significant effects were found, as average change scores was comparable between the two groups. Therefore,

Figure 9. Average 2nd Grade Spring Assessment Scores
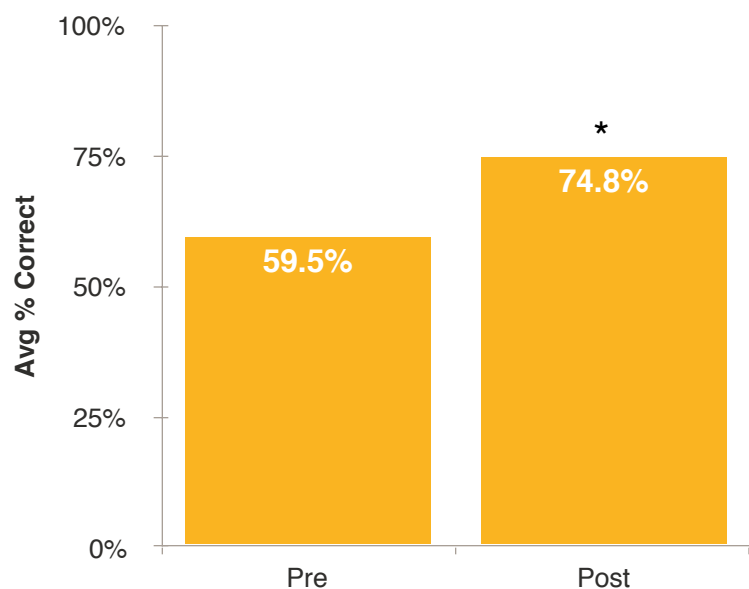
* significance at the p < .01 level

students in both the *Open Usage* and *Guided Usage* conditions experienced significant improvements on the Speak Agent assessment, but this was not influenced by the type of interaction they had with the learning tool.

Speak Agent Usage

In the Spring term, students in the *Open Usage* condition spent an average of 116.6 minutes (*SD* = 55.8 minutes), while students in the *Guided Usage* condition spent an average of 179.6 minutes (*SD* = 60.4 minutes) interacting with the Speak Agent tool. An independent t-test was used to compare usage times between the *Open Usage* and *Guided Usage* participants, and a significant difference was observed, $t(55) = 4.09$, $p < .01$. Students in the *Guided Usage condition* spent significantly more time using Speak Agent compared to their peers in the *Open Usage* condition. However, follow-up Pearson correlations between performances on the post assessment scores or change scores with usage time did not reveal any significant relationships. This indicates that students' performance on the post assessment or overall improvement was not directly related to how much time they spent using Speak Agent.

Attitudinal Scores

Once again, attitudinal measures were assessed on the pre and post assessments to gauge students' self-reported competency and interest in learning science and new vocabulary. Wilcoxon Signed Ranks tests were used to compare differences in attitudinal responses between pre and post assessment, but no significant effects were found. Mann-Whitney U tests were used to explore differences in change scores on the attitudinal questions between conditions, and significant effects were found for the questions "How much do you like learning science," $U = 286.5$, $p < .05$, and "How good are you at learning science," $U = 228.5$, $p < .05$. For both items, students in the *Open Usage* condition reported greater positive changes from pre to post assessment than students from the *Guided Usage* condition (Figure 10). Although students in the *Open Usage* condition may have reported greater positive changes on these two items, students in the *Guided Condition* were still fairly confident in their interest and ability to learn science as their average responses never fell below a 3 (i.e., "like" or "good").

Figures 11 - 13 illustrate the distribution of responses for all six attitudinal items for both pre and post assessment in the Spring term. For both pre and post assessments, the majority of students reported to "like" or "love" learning about science and new vocabulary (Figure 11), being "good" or "very good" at learning science and new words (Figure 12), and finding it "easy" or "very easy" to learn science and new words (Figure 13). Overall, students' interests and perceived abilities for learning science and new vocabulary remained fairly stable across the study.
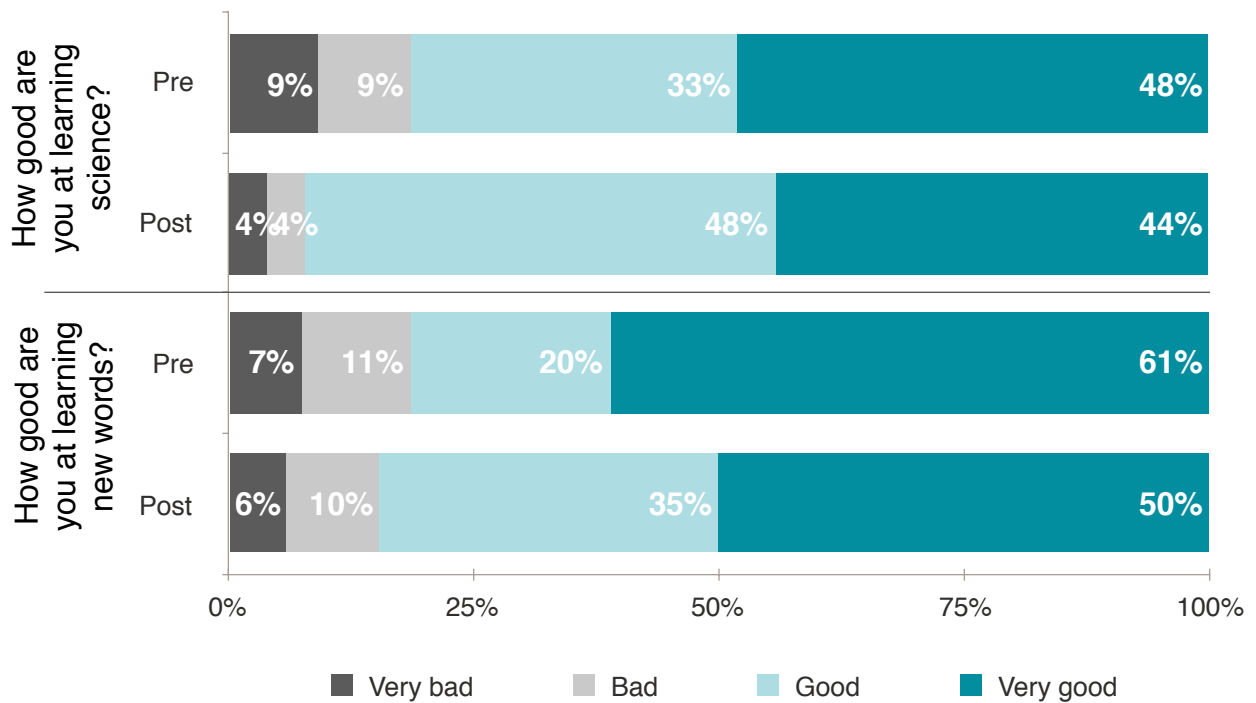
Figure 10. Average 2nd Grade Student Ratings for "How Much Do You Like Learning Science" & "How Good Are You at Learning Science" on Pre & Post Spring Assessment
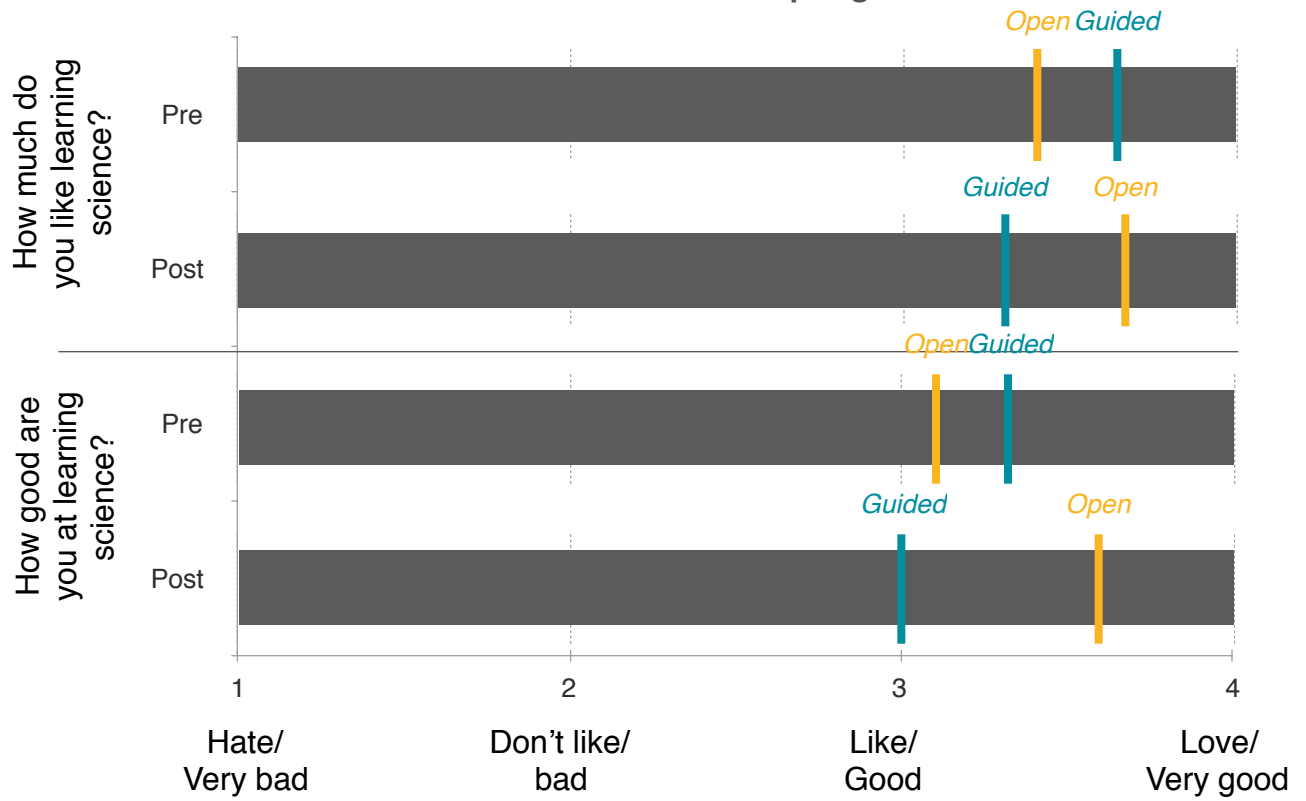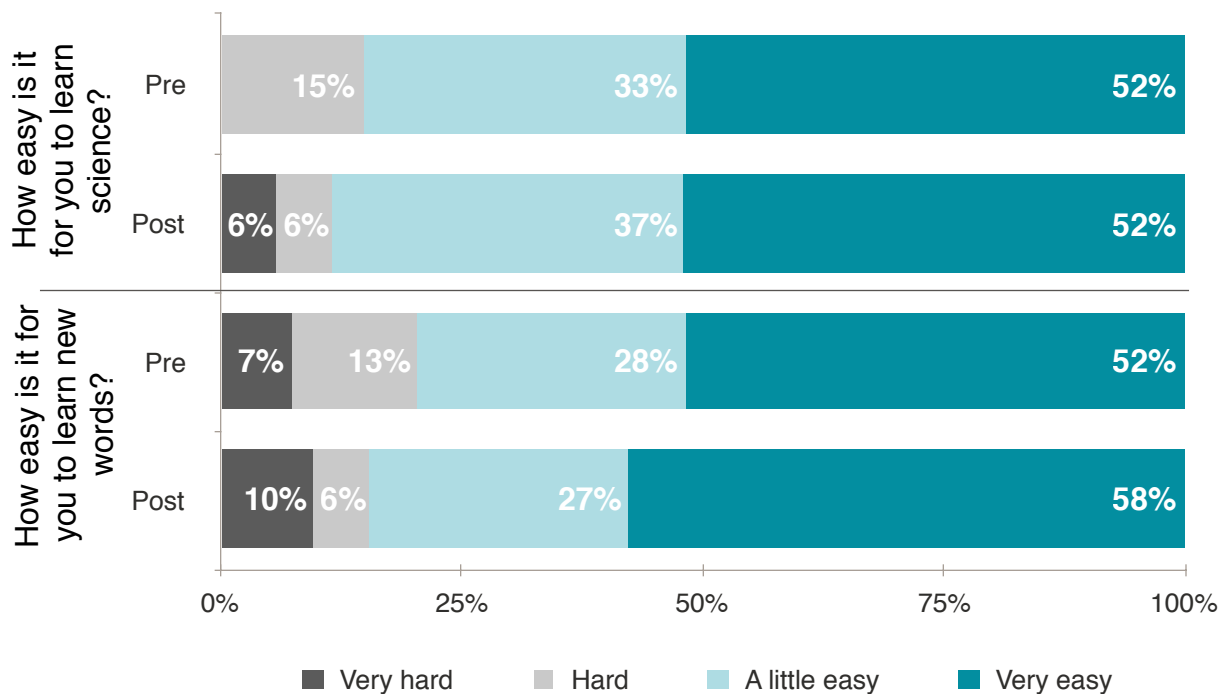

Figure 11. 2nd Grade Student Ratings for "How Much You Like Learning Science & New Words?" for Spring Term
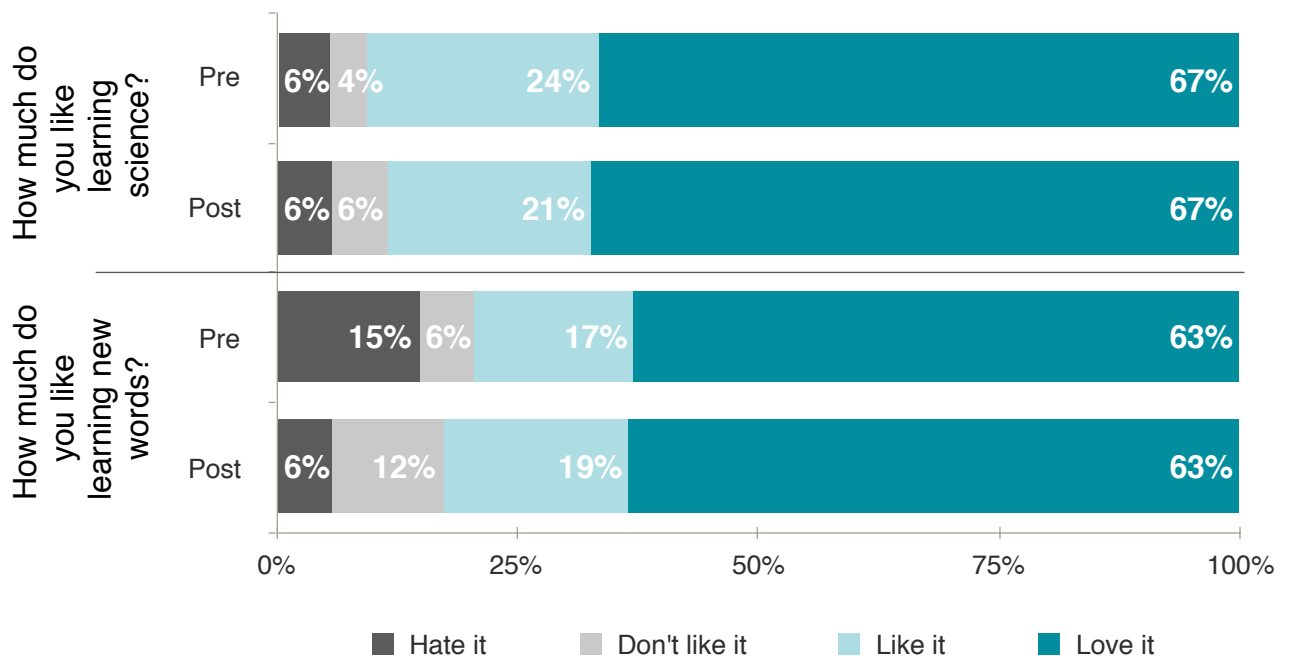
Figure 12. 2nd Grade Student Ratings for "How Good You Are at Learning Science & New Words?" for Spring Term

How good are you at learning science?

	Very bad	Bad	Good	Very good
Pre	9%	9%	33%	48%
Post	4%	4%	48%	44%

How good are you at learning new words?

	Very bad	Bad	Good	Very good
Pre	7%	11%	20%	61%
Post	6%	10%	35%	50%

Legend: Very bad ■ Bad ■ Good ■ Very good ■

Figure 13. 2nd Grade Student Ratings for "How Easy Is It For You to Learn Science & New Words?" for Spring Term

How easy is it for you to learn science?

	Very hard	Hard	A little easy	Very easy
Pre		15%	33%	52%
Post	6%	6%	37%	52%

How easy is it for you to learn new words?

	Very hard	Hard	A little easy	Very easy
Pre	7%	13%	28%	52%
Post	10%	6%	27%	58%

Legend: Very hard ■ Hard ■ A little easy ■ Very easy ■

Second Grade Findings

The results of the Speak Agent study demonstrated that, across both Fall and Spring terms, the Speak Agent tool supported second grade students' science vocabulary development. In the first term, only half of the second grade students received access to Speak Agent, and those with experience interacting with the language-learning activities showed significantly greater gains on the vocabulary assessment compared to their peers who did not use Speak Agent. By the Spring term, all students were given access to Speak Agent and they all showed significant improvement from pre to post assessment. Furthermore, all students reflected positively on their interests and abilities to learn about science or new vocabulary terms. Students were confident in their self-assessment from the beginning of the year and did not change much over the course of the study. However, students who had access to Speak Agent for the entire academic year did report greater interest in learning about science by the end of the Spring term.

There were no significant differences between groups in regards to the type of access they had (*Open* vs. *Guided*), but this could have been due to the limited usage exhibited by both groups. On average, students from both conditions only used the tool for a total of 2-3 hours over the Spring term. This is much less time than the recommended one hour per week protocol. Furthermore, teachers liked that the Speak Agent tool allowed for more user control whereby teachers could incorporate different texts and vocabulary into the lessons, but there was very limited use of the customization feature. Therefore, there was little difference between conditions in terms of the amount and type of usage, and this seems to be reflected in the lack of significant differences between conditions in the Spring term. Although, students from the *Guided Usage* condition did engage with the Speak Agent tool significantly more than those from the *Open Usage* condition, this could have been due to novelty. In the Spring term, the *Guided Usage* group was getting access to Speak Agent for the first time, and they may have been more engaged in the activities than those who already had one previous term of experience. However, performance on the assessments was not linked to amount of usage. Even though the two conditions did not have the same amount of Speak Agent engagement, it seems that just having time with the activities helped to foster vocabulary development for second graders.

Third Grade Results

Assessment Scores

The 3rd grade Fall 2017 assessment consisted of 19 questions, with a total value of 57 points. A total of seven students were not able to complete both the pre and post assessments. For every item on the assessment, at least one participant was able to achieve the maximum point value, indicating that all questions were answerable for the student sample. A total of 39 third graders were in the *Usage* condition, while 38 third graders were in the *No Usage* condition.

On the pre assessment, average assessment score was 58.8% (*SD* = 12.2%, *Range:* 25.0% - 89.0% points). An independent t-test was used to compare pre assessment scores between conditions (*Usage* vs. *No Usage*). No significant differences were found, *p* > .05, suggesting that students in the *Usage* condition (*M* = 57.6%, *SD* = 11.6%, *95% CI*: 53.8% - 61.4%) had a comparable understanding of the targeted vocabulary at the start of the Fall term as the students from the *No Usage* condition (*M* = 61.5%, *SD* = 12.8%, *95% CI*: 56.8% - 66.1%). On the post assessment, average assessment score was 64.4% (*SD* = 13.2%, *Range:* 28.0% - 86.0%). A two-way ANOVA was used to examine the effects of condition (*Usage* vs. *No Usage*) and assessment period (pre vs. post) on vocabulary performance. There was a significant main effect for assessment period, $F(1, 68) = 13.2$, $p < .01$, $\eta_p2 = .16$, with students (across conditions) scoring higher on the post assessment than the pre assessment (Figure 14). However, there was no significant main difference between conditions or an interaction between Condition x Assessment period. Therefore, student improvement on the Speak Agent assessment was not influenced by their use of the Speak Agent tool. A follow-up independent t-test comparing differences in changes scores (difference between pre and post assessment scores) between conditions confirmed that there were no significant differences in change scores between the *Usage* and *No Usage* conditions (*p* > .05).

Figure 14. Average 3rd Grade Assessment Scores for Fall Term
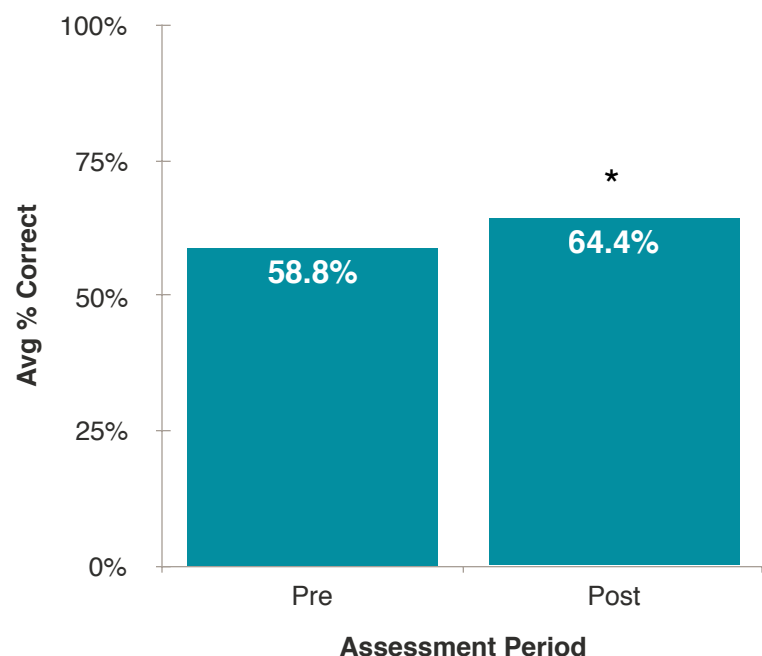
* significance at the p < .01 level

Students in the *Usage* condition spent an average of 133.7 minutes (*SD* = 62.7 minutes) interacting with the Speak Agent activities over the course of the Fall term. However, data was only collected from 27 out of the 39 *Usage Condition* participants. Therefore, about a third of the sample did not interact with the Speak Agent tool. Pearson correlations were used to examine any relationships between students' performance on the post assessment or pre-post change scores against the amount of usage time, but no significant effects were observed (*p* > .05).

Attitudinal Scores

Paired-sample t-tests and Wilcoxon Signed Ranks tests were used to compare differences in attitudinal responses between conditions and changes between pre and post assessment. A significant difference was found between pre and post assessment scores for the item, "How much do you like learning science," *Z* = - 2.60, *p* < .01, indicating that the median rating on the pre assessment was significantly different from the median rating on the post assessment. Specifically, there were more students who reported lower ratings on the post assessment compared to their ratings on the pre assessment. Figure 15 displays the distribution of responses for the items "How much do you like learning science" and "How much do you like learning new words." More students reported to "like" or "love" learning science on the pre assessment than on the post assessment. There were no other significant

Figure 15. 3rd Grade Student Ratings for "How Much Do You Like Learning Science & New Words?" for Fall Term
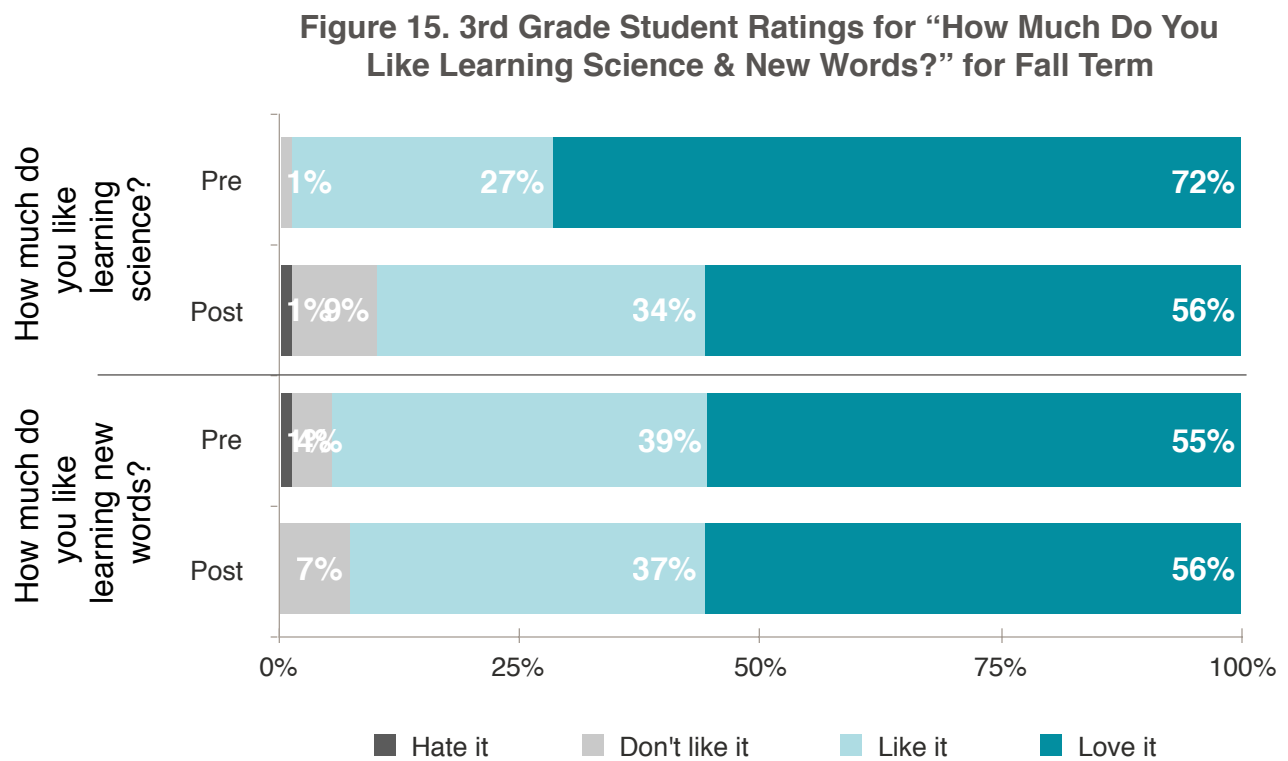
Figure 16. 3rd Grade Student Ratings for "How Good Are You at Learning Science & New Words?" for Fall Term

How good are you at learning science?
- Pre: Bad 8%, Good 54%, Very good 38%
- Post: Bad 3%, Good 66%, Very good 31%

How good are you at learning new words?
- Pre: Bad 4%, Good 49%, Very good 47%
- Post: Bad 9%, Good 40%, Very good 51%

Legend: Very bad | Bad | Good | Very good
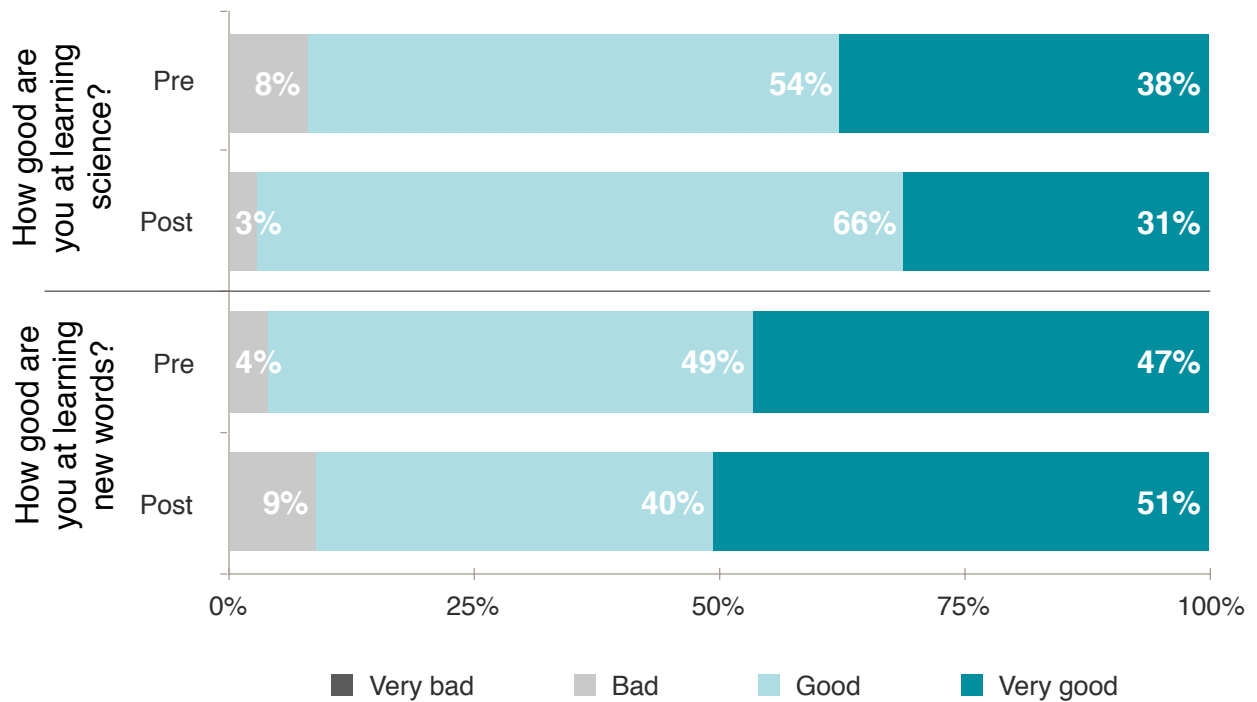
Figure 17. 3rd Grade Student Ratings for "How Easy Is It For You to Learn Science & New Words?" for Fall Term

How easy is it for you to learn science?
- Pre: Hard 7%, A little easy 45%, Very easy 49%
- Post: Very hard 1%, Hard 13%, A little easy 44%, Very easy 41%

How easy is it for you to learn new words?
- Pre: Hard 5%, A little easy 47%, Very easy 46%
- Post: Very hard 3%, Hard 7%, A little easy 34%, Very easy 56%

Legend: Very hard | Hard | A little easy | Very easy
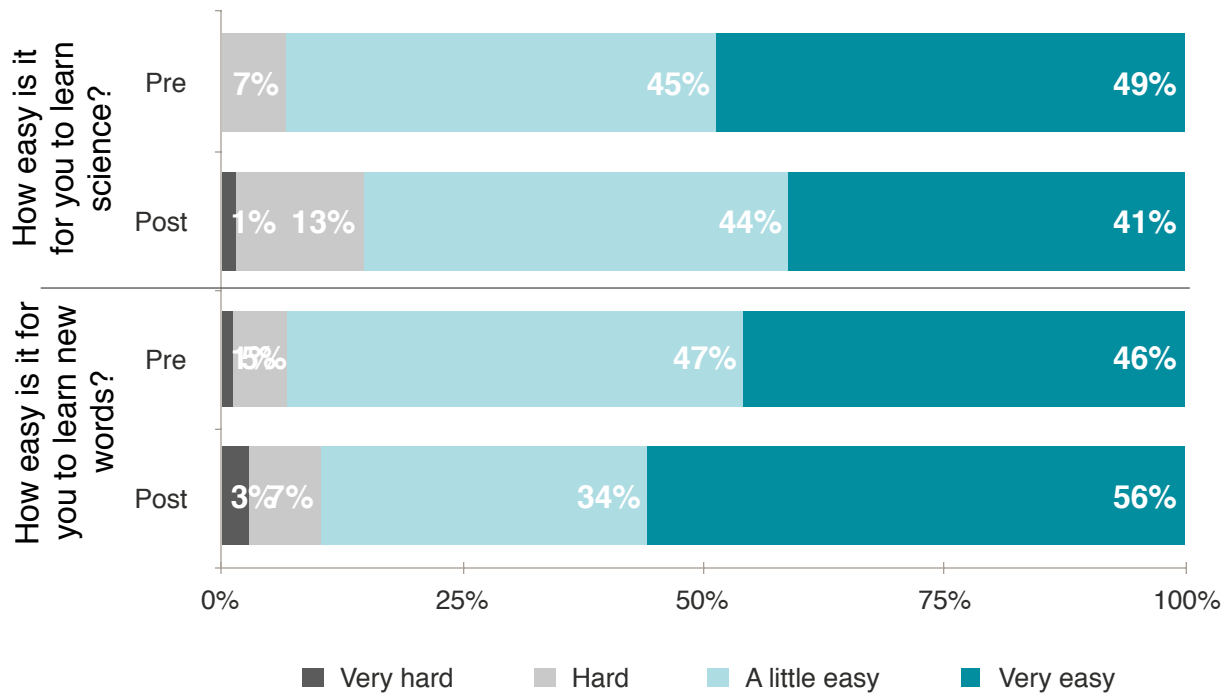
differences in ratings between pre and post assessments, and there were no significant differences in rating changes between conditions. Figures 16 & 17 illustrate the distribution of responses for all other attitudinal items for both pre and post assessment. In general, there was high agreement across the samples that students believed they were "good" or "very good" at learning science and new words (Figure 16), and they it was "easy" or "very easy" for them to learn science and new words (Figure 17).

Spring 2018

Assessment Scores

The 3rd grade Spring 2018 assessment consisted of 16 questions, with a total value of 52 points. Only two students were unable to complete both the pre and post assessments. For every item on the assessment, at least one participant was able to achieve the maximum point value, indicating that all questions were answerable for the student sample. For the Spring term, 3rd grade students were divided into three conditions: *Guided Usage* (*n* = 24), *Open Usage* (*n* = 36), and *No Usage* (*n* = 14).

On the pre assessment, average assessment score was 48.8% (*SD* = 13.1%, *Range:* 21.0% - 79.0% points). A one-way ANOVA was used to compare pre assessment scores between conditions (*Open Usage, Guided Usage,* & *No Usage*). No significant differences were found, *p* > .05, suggesting that students in all three conditions had comparable understanding of the targeted vocabulary at the start of the Spring term. On the post assessment, average assessment score was 61.6% (*SD* = 13.8%, *Range:* 33.0% - 94.0%). A two-way ANOVA was used to examine the effects of condition (*Open Usage, Guided Usage,* & *No Usage*) and assessment period (pre vs. post) on vocabulary performance. A significant main effect for assessment period was found, $F(1, 69) = 74.3$, $p < .01$, $\eta_p2 = .52$, with students (across conditions) scoring significantly higher on the post assessment (*M* = 60.6%, *SE* = .02, *95% CI:* 57.2% - 64.1%) than on the pre assessment (*M* = 48.7%, *SE* = .02, *95% CI:* 45.5% - 52.0%) (Figure 18). However, there

Figure 18. Average 3rd Grade Spring Assessment Scores
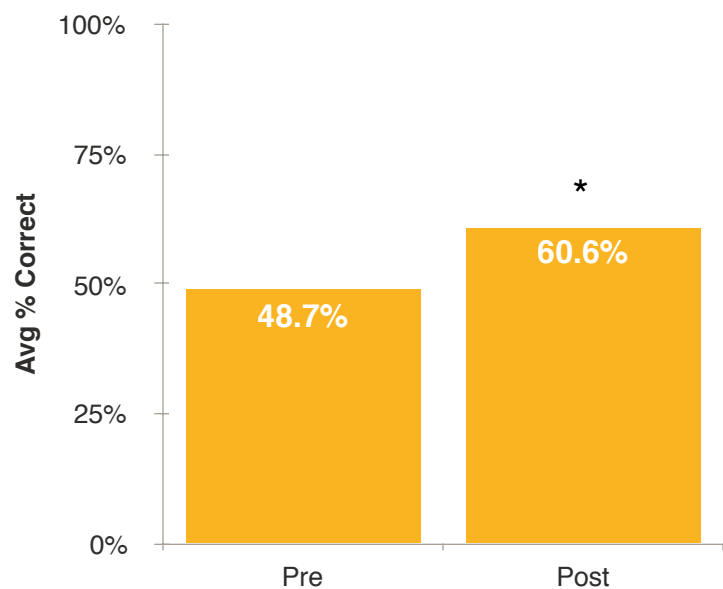
* significance at the p < .01 level

were no significant differences across conditions, or interactions between Condition x Assessment period. This would suggest, that overall improvement from pre to post assessment was similar between conditions. This was further supported by the follow-up one-way ANOVA for differences in average change score (pre to post assessment) across the three conditions, where no significant effects were observed ($p > .05$). Students from all conditions exhibited comparable improvement regardless of their experience with or without Speak Agent (Figure 19).

Figure 19. Average 3rd Grade Spring Assessment Scores by Condition
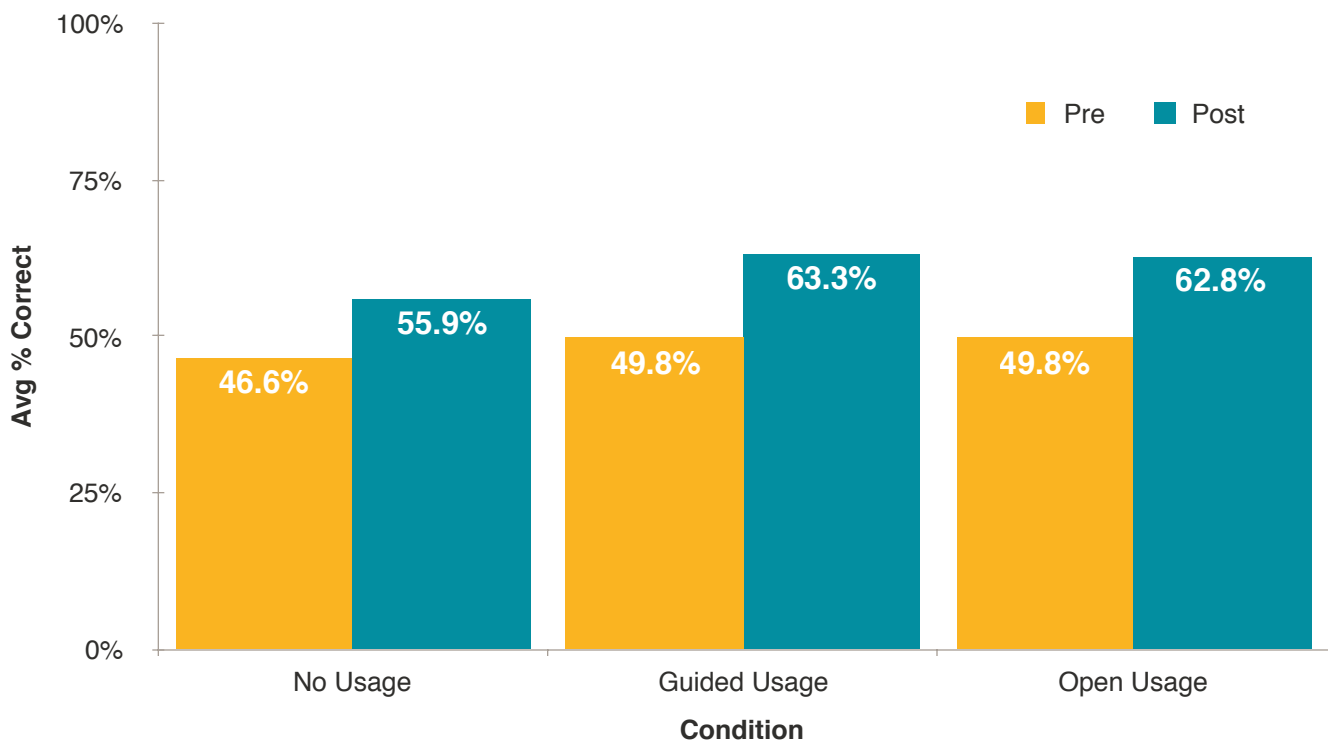
Speak Agent Usage

Students in the *Guided Usage* condition spent an average of 241.6 minutes ($SD = 97.8$ minutes) interacting with the Speak Agent activities, while students in the *Open Usage* condition spent an average of 203.3 minutes ($SD = 133.8$ minutes) using the Speak Agent tool over the course of the Spring term. Usage data was only missing from two students who were suppose to be in the *Guided Usage* condition. Pearson correlations were used to examine any relationships between students' performance on the post assessment or pre-post change scores against the amount of usage time, but no significant effects were observed ($p > .05$).

<u>Attitudinal Scores</u>

   Paired-sample t-tests and Wilcoxon Signed Ranks tests were used to compare differences in attitudinal responses between conditions and changes between pre and post assessment. A significant difference was found between pre and post assessment scores for the items, "How much do you like learning new words," $Z = -2.04$, $p < .05$, and "How good are you at learning new words," $Z = -2.13$, $p < .05$, indicating that the median rating on the pre assessment was significant different from the median rating on the post assessment for both these items. For both ratings questions, there were significantly more students who reported more positive changes: higher self-reported interest and ability to learn new words on the post assessment. Figure 20 displays the distribution of responses for these two items on the pre and post assessments. For both items, more students reported "loving" to learn new worlds and being "very good" at learning new words on the post assessment compared to the pre assessment.

Figure 20. 3rd Grade Student Ratings for "How Much Do You Like/How Good Are You at Learning New Words?" for Spring Term
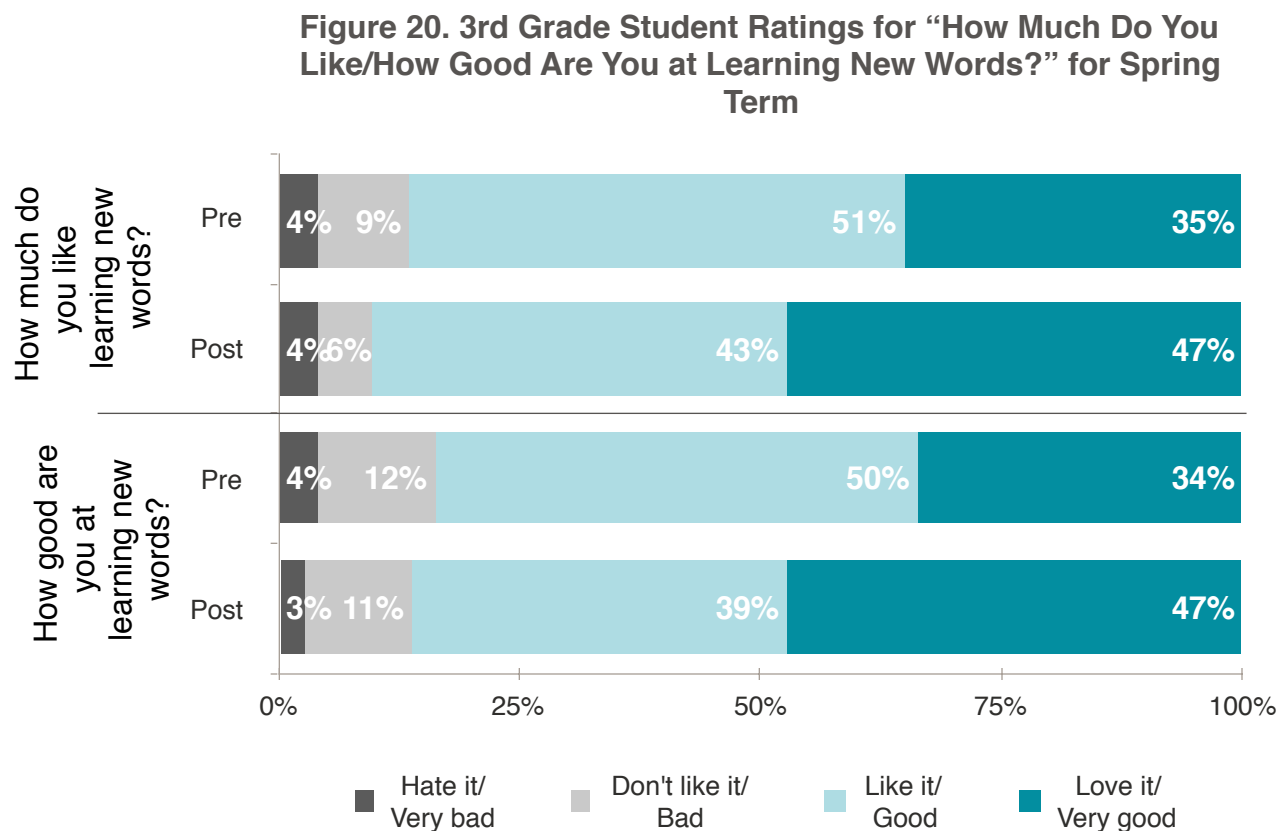
   There were no significant differences across conditions in terms of changes in ratings from pre to post assessment for any of the attitudinal measures. Figures 21 and 22 illustrate the distribution of responses for the remaining four attitudinal items for both pre and post assessment in the Spring term. For both pre and post assessments, the majority of students reported to "love" or be "very good" at learning science (Figure 21), and finding it "easy" or

"very easy" to learn science and new words (Figure 22). Overall, students' interests and perceived abilities for learning science remained fairly stable, while their assessment of their ability to learn new vocabulary improved by the end of the term.

Figure 21. 3rd Grade Student Ratings for "How Much Do You Like/How Good Are You at Learning Science?" for Spring Term

How much do you like learning science?
- Pre: 8% | 46% | 46%
- Post: 1% 8% | 35% | 56%

How good are you at learning science?
- Pre: 3% 8% | 64% | 26%
- Post: 1% 11% | 53% | 35%

Legend:
- Hate it/Very bad
- Don't like it/Bad
- Like it/Good
- Love it/Very good
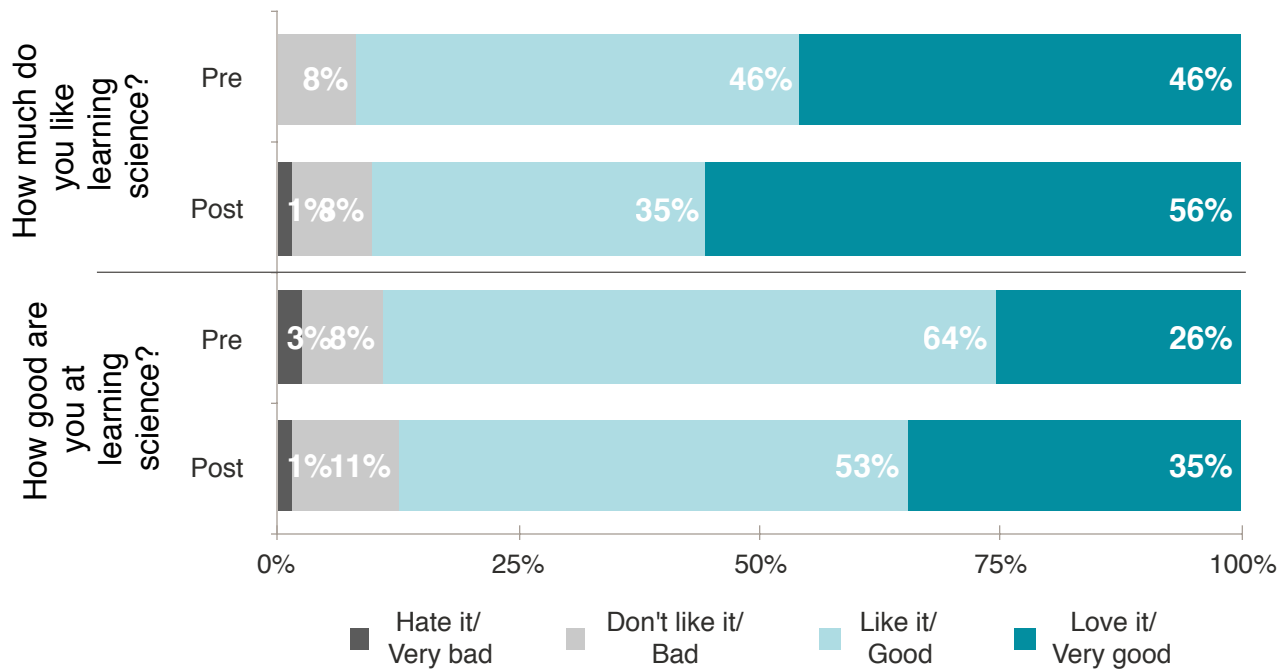
Figure 22. 3rd Grade Student Ratings for "How Easy Is It For You to Learn Science & New Words?" for Spring Term

How easy is it for you to learn science?
- Pre: 3% | 14% | 53% | 31%
- Post: 17% | 35% | 49%

How easy is it for you to learn new words?
- Pre: 4% | 15% | 45% | 36%
- Post: 4% 7% | 46% | 43%

Legend:
- Very hard
- Hard
- A little easy
- Very easy
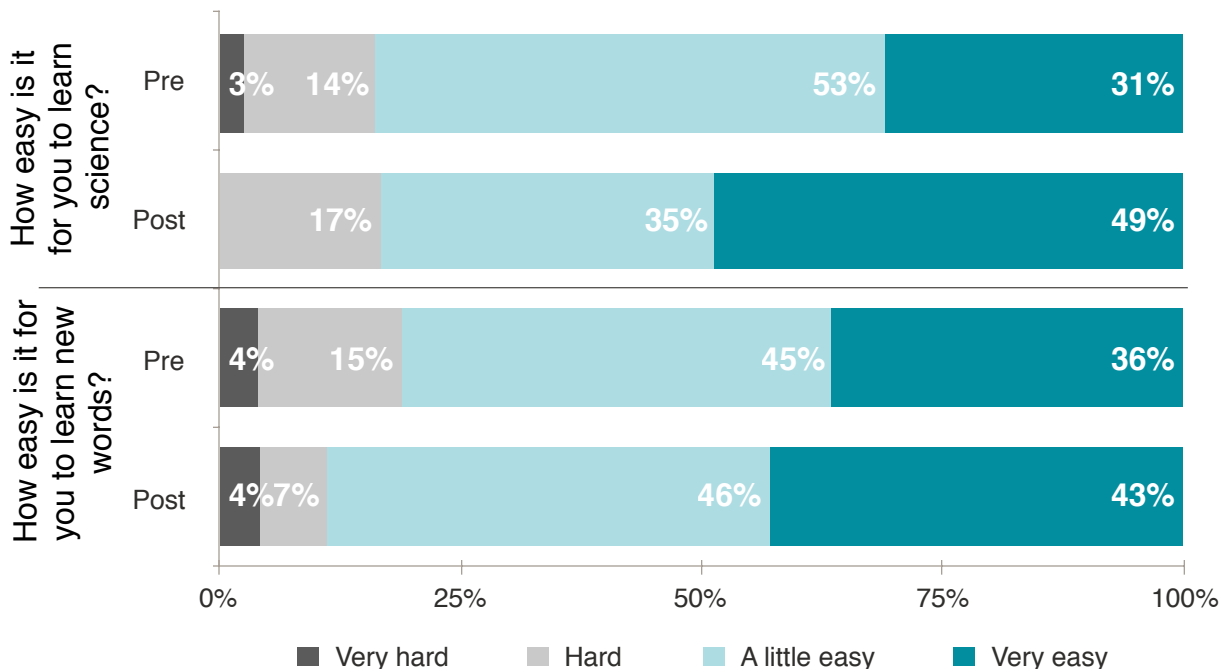
Third Grade Findings

The results from the participating third grade classes suggested that there was vocabulary growth over the academic terms, but change in science vocabulary knowledge may not be directly related to their use of the Speak Agent tool. For both Fall and Spring terms, there were overall improvements on the science assessments from pre to post, but there were no significant differences between usage conditions. Also in the Fall, students seemed to report lower interests in learning about science by the end of the term. However, by Spring, students were more interested and believed they were better capable of learning new vocabulary.

The lack of significant differences between usage conditions could have been due to the limited and inconsistent use of Speak Agent activities within and between third grade classes. Originally, the Spring term was only suppose to consist of two conditions: *Open Usage* and *Guided Usage*, but one teacher opted out of using the Speak Agent tool with her class. This created the *No Usage* condition that was carried over from the Fall term. Although it is acceptable to have three comparison groups, the division of the classes resulted in fewer participants for two of the conditions, and this would have resulted in lower effect size and power. Additionally, like the second grade classes, there was inconsistent use of Speak Agent throughout the terms. On average, third grade classes only spent 2 - 3 hours interacting with the activities over the course of each term, and usage data was only available for about 2/3 of the student sample. Therefore, limited interactions with Speak Agent across conditions may have resulted in very similar learning experiences that would not have generated significant differences between groups.

Summative Findings

Learning Impact

The goal of this quasi-experiment was to study the impact of the Speak Agent language learning tool on vocabulary growth for second and third grade ESOL students. Speak Agent utilizes digital games and activities to teach targeted vocabulary. This study worked with second and third grade science classes from one school district in central Texas. Speak Agent tailored the digital activities to incorporate the targeted science vocabulary outlined by the district, which is part of its standard practice. REA developed original assessments to measure changes in vocabulary comprehension across the academic terms.

At the start of the Fall term, half of the second and third grade classes were given access to Speak Agent, with the hopes that teachers would incorporate the activities that complemented each science unit. Teachers were asked to give students at least one hour of Speak Agent interaction per week. However, usage data revealed that students often fell short of this expectation. Speak Agent usage was limited and inconsistent within and between classes. Despite these shortcomings, there were significant effects observed between those who did and did not have access to Speak Agent. Specifically, second graders who used the language tool showed a significant improvement on the vocabulary assessment over those who did not use the tool. However, this effect was limited to just the second grade sample. There were no statistically significant differences in vocabulary achievement between conditions within the third grade student population.

In the Spring term, the goal was to give all students access to Speak Agent, but vary the type of control teachers had over the content. All teachers were given broad guidelines with suggestions for how to use each activity in conjunction with their unit curriculum, but teachers in the *Open Usage* condition were given more opportunities to change or add to the vocabulary content presented in Speak Agent. However, teachers did not take advantage of the customization feature, resulting in students from both the *Open* and *Guided Usage* conditions following the same protocol. Teachers reported that while they appreciated having the option to be in control of the content in Speak Agent, they either did not prefer to make changes or did not have the time to customize Speak Agent activities. Therefore, the lack of customization resulted in limited implementation differences between usage conditions. While there was not a statistically significant difference in third grade assessment change scores across the three conditions in the Spring term, further research (i.e. greater and more balanced samples sizes) is needed to either confirm the lack of statistically significant findings or observe any moderate differences that may emerge between conditions.

Challenges to Fidelity

Time and access to adequate technology were the greatest obstacles to successful implementation of this study. Throughout the study, there were unexpected time and technology restraints that limited teachers' and students' access to the Speak Agent tool, which changed the intended study design. Before the start of the study, REA worked with the school district to select schools and classes that would have regular access to technology (i.e., computers, laptops, or tablets) so that students would be able to consistently use the Speak Agent tool throughout the academic terms. However, in follow-up interviews with teachers, it was revealed that not all classes had consistent access. For instance, some classes only had a few computers that had to be shared by all students in a single class. This limited each student's time with Speak Agent, as well as burdened the teachers with keeping track of who did or did not had a turn with the devices. Other classes had devices available, but they would constantly fail or prevent students from logging in to the tool. It is possible that some of the Speak Agent usage time for individual students was not accounted for throughout the study because when devices failed, students would share with their peers or do group activities with their teachers, and these usage periods would not be recorded for the individual users.

Additionally, teachers noted that providing time for science activities is a great challenge district-wide. For second and third grade, teachers and students are focused on preparing for reading and math standardized assessments. Science then becomes a lesser priority as there is just not enough time to integrate science activities into their schedules. Thus, it seemed to be a challenge for most classes to provide at least one hour of usage per week, which resulted in overall limited usage of the Speak Agent tool across the academic terms. Future in-school implementations should consider more controls to ensure consistent technology availability to support usage and to better understand the impact of the tool on student academic development.

Another potential issue was that the participating teachers all had different curriculum goals or leaning objectives that may or may not have matched up with the content in Speak Agent. REA and Speak Agent used the district curriculum pacing guides and instructional focus documents to develop the activities and assessments for the study. However, interviews with teachers revealed that they were not obligated to follow those documents strictly; they had more freedom to create their own curriculum by utilizing resources they found elsewhere. Many teachers did utilize the district-approved curriculum resource (i.e., STEMScopes) that was suppose to align with the district instructional documents, but most teachers believed that the Speak Agent vocabulary and science content was much more advanced than the content in the district resources. This encouraged some teachers to explore more advanced science lessons, and even use the Speak Agent content as a guide for developing curriculum lessons for their classes. This may have resulted in greater

variabilities in science lessons across classes, which is a potential confound for measuring change and growth in the student sample. However, teachers acknowledged that the assessments aligned with the Speak Agent curriculum, and for classes that did try to utilize the tool consistently, it was a good measure for assessing learning and comprehension of the challenging science material presented through Speak Agent.

For this study, researchers also tried to obtain science assessment results for second and third graders from measures implemented by the district. The school district had scheduled recurrent curriculum-based assessments to capture students' science comprehension. However, implementation of these assessments was not uniform across schools or classes, and many teachers did not report results throughout the academic year. Thus, REA was unable to obtain enough data to track progress or correlate Speak Agent usage and performance on the vocabulary assessment with student performance on the district science assessments.

Teacher Feedback/Observations

At the end of each term, a sample of teachers (n = 2 - 6 teachers) provided feedback on their experiences in the study and their observed impacts of the Speak Agent tool.

<u>Implementation</u>

Teachers explained that it was a struggle at first to learn how to implement the tool and understand how the activities fit in with their science lessons. For teachers who had access to Speak Agent for two academic terms, they became more confident in their interactions with the activities and supporting student use. However, most teachers did not engage in customizing the activities because it was too difficult or they could not figure out how to tailor the activities. Teachers wished there was more support and exploration time during on-boarding so that they could better familiarize themselves with all the different functions and understand how to incorporate the activities with different lessons. Although teachers liked the idea of having more control over digital resources and customizing activities to fit the needs of their classes, very few individuals actually wanted to utilize this function. As one teacher explains,

> "Teachers are really busy, and there's not a lot of time for customization. Teachers want materials that are already organized and ready to use: they want to know exactly what each activity/lesson will cover. Don't give teachers too much freedom, we don't do well with too much freedom; we go rogue!"

Therefore, customization features should be offered only to those who have had more extensive experience working with Speak Agent, feel confident enough to play around with technology, and actually want to make changes to the activities.

Positive Student Impacts

Teachers reported observing many positive effects of using the Speak Agent tool with second and third graders. Teachers liked that the Speak Agent tool focused on individual students' needs and helped teachers assess where students struggled and thrived. Multiple teachers explained that their students represent a broad spectrum of abilities, and Speak Agent can be used by all.

> "For the 'higher learners,' [Speak Agent] allows them to get through lessons quicker and process it quicker. I was able to spend more time helping the 'slower learners'… There's not enough time to cover everything from STEMScopes, Speak Agent fits in well to give students more time to review the content."

> "For students who are behind academically or struggle with technology, they don't want to play when you mention Speak Agent because they find it too hard. But once they start playing, they get really engaged, and don't want to stop!"

Speak Agent is also an engaging way for students to review science content. As one teacher explains, students do not have a lot of opportunity to use technology with science curriculum. Most of their interactions/activities on devices involve reading or math lessons. Speak Agent presents new opportunities for students to engage with technology, and it helped them learn difficult concepts.

> "It's fun for kids. They don't see it as work; they see it as a game, but they are still learning…It helps with the long units: to break it up and use Speak Agent to review [content]. They would rather review on Speak Agent than listen to me review in class"

> "I find that anything with technology [is engaging]. This generation of children is so technology driven, it helps them [to learn]."

Most teachers believed that the Speak Agent content was very challenging for their second and third grade students. One teacher recommended using Speak Agent with higher grades (fourth & fifth graders) because they focused more on science content than the lower grades. However, teachers liked that the tool challenged students and introduced them to more complex concepts. They observed students engaging in more science content, asking questions about challenging topics, and wanting to look up additional information on their own time. Students would create their own experiments (e.g., model volcanos) based on content introduced in Speak Agent, or they would go to the library to find additional information about a concept discussed through the activities. Students also seemed to remember information from Speak Agent and apply it to class lessons and discussions. One teacher said she was pleasantly surprised by her students' performances on the district's curriculum-based assessments. She believed that the assessment would be too difficult, and her students

would not know a lot of the information. However, her students performed better than she had anticipated because they had seen a lot of the content through the Speak Agent tool.

> "They get excited [in class]….'This is from the game!' "

Thus, teachers liked using the Speak Agent tool because it encouraged students to think more critically, presented challenging yet engaging content, and inspired greater interests in science.

Another important learning outcome of using Speak Agent was that the tool supported English language development for ESOL students. Teachers reported that majority of their students were ESOL students, with a broad range of reading skills. There were many students who struggled to read passages in English, and they tended to find Speak Agent activities with long passages intimidating. However, teachers used the activities as reading exercises to encourage children to develop their reading comprehension skills. Teachers have noticed that students have become more confident in their use of the Speak Agent tool, and they had great senses of pride when they did complete activities.

> "They're not as scared as they were in the first semester…[scared of] getting kicked out, not progressing, not knowing the words…they are more confident [now]. I noticed a difference in them and their confidence."

> "They are learning and sharing, telling stories and facts. As a bilingual teacher, that is one of our [objectives], to have them practice the language with each other, especially regarding scientific content."

> "They liked the reading and had meaningful conversations on what they were reading."

Future In-Class Use

Teachers are interested in using the Speak Agent tool with future classes, but they felt they needed more support in order to make usage most impactful. Teachers felt that it was overwhelming and challenging to receive a new digital tool without a lot of guidance. They wanted more instructions or assistance to understand how the tool can be most effectively applied to the science curriculum. They can also see this as a tool better suited for older elementary grades. If they were to continue to use Speak Agent with second and third graders, the tool would have to be customized for younger students with reduced/easier content and reading passages.

Students really enjoyed doing the group activities and having a Speak Agent representative come and do a demonstration. Teachers would love to have more opportunities to engage the class as a group, but they wanted more guidance on how to initiate and oversee such activities. They did not feel confident in their abilities to run the group activities on their own or customize activities to fit their needs. They also did not know

how to use the teacher controls to monitor student progress, and they felt they needed more assistance.

Teachers also acknowledged that it was difficult to sustain consistent digital learning activities in second and third grade because of time and technology restraints. Classes have a lot of other priorities that take precedence, leading to limited usage of the Speak Agent tool. Teachers believed that the tool is a great resource that has challenged and supported language development, but there was not enough time or available technology to ensure consistent use and growth. They hope to have better technology support in future years.

Recommendations

Although there were limitations and challenges encountered throughout the study, the overall results were still positive. ESOL second and third grade students developed a significantly better understanding of science vocabulary terms over the academic year. They enjoyed using the Speak Agent tool and became more confident and interested in learning science and unfamiliar vocabulary. Teachers found the Speak Agent tool and guides to be useful for helping to shape science curriculum.

Future implementations of the Speak Agent tool should focus on establishing consistent usage by teachers and students to further support the positive learning and attitudinal gains observed in this study.

To support future in-school use, Speak Agent could provide more support for teachers at the onset of implementation in the form of guided demonstrations, suggested coordination between class lessons and Speak Agent activities, and more exploration time. Teachers want to develop a better understanding of how to use the tool to support student learning.

Future usage could also extend to students of different grades or for different subject areas. Teachers see a lot of potential for using the tool to help older students prepare for science standardized tests, but they did not consider the possibilities of syncing the tool with other subjects.Teachers may not have realized that this is a tool that can be customized to teach content and language in all subject matters. Perhaps usage would have improved if the tool was synced with reading or math curriculum that were a higher priority in second and third grade.

Appendix A

Sample of Second Grade Fall 2017 Assessment

Appendix B

Sample of Second Grade Spring 2018 Assessment

Name: _____ Grade: _____

1. Select the correct word to fill in each blank.

EROSION   EVAPORATION   MELTING   CONDENSATION

A. When LIQUID changes to GAS, it is called _____

B. When a GAS changes to LIQUID, it is called _____

2. A METEOROLOGIST is someone who studies:

Circle only ONE

METEORS   ROCKS   WEATHER   ANIMALS

3. Which of the following are Types of PRECIPITATION?

Circle ALL that apply

RAIN   SNOW   DUST   HAIL   WIND   HEAT

4. This chart is explaining the steps of:

Circle only ONE answer:

A. The Earth Cycle
B. The Wind Cycle
C. the Water Cycle
D. the Life Cycle

5. Which of the following are BASIC NEEDS that living things need to SURVIVE?

Circle ALL that apply

WATER   SHOES   ELECTRICITY   AIR

6. This picture shows the _____ of a caterpillar into a butterfly.

Circle only ONE

METABOLISM   METAMORPHOSIS   METEOR   MIGRATION

7. When an organism goes into a state of inactivity by lowering its body temperature, metabolism, and breathing, it is starting:

Circle only ONE

CONDENSATION   NESTING   HIBERNATION   COLORATION

8. A pattern of stars in the sky is a:

Circle only ONE

CONDENSATION   COLORATION   CYCLE   CONSTELLATION

9. This chart is explaining the chicken's:

Circle only ONE answer:

A. Earth Cycle
B. Life Cycle
C. Water Cycle
D. Wind Cycle

10. The _____ is the air that surrounds the Earth and is made up of a mixture of gases.

Circle only ONE

ATMOSPHERE   MARINE   POLAR   APPEARANCE

11. Select the correct word to fill in each blank:

DESERT   POLAR   MARINE   FOREST

A. Animals that live underwater, live in a _____ environment.
B. Animals that live in the Arctic, live in a _____ environment.

12. True or False?

For each sentence, circle TRUE or FALSE

The Earth is the only planet with a moon.   TRUE   FALSE
The Moon revolves around the Earth.   TRUE   FALSE
The Moon is the Earth's closest neighbor in space.   TRUE   FALSE

13. Humans have which types of BODY COVERINGS?

Circle ALL that apply

SCALES   HAIR   SKIN   FEATHERS   CLOTHES

14. Select the correct word to fill in the blank:

SATELLITE   METEOR   STAR   MOON

A _____ is an object in space that is made up of gas that gives off light and heat.

15. Which of these sentences describes GROWTH?

Circle YES if the sentence describes GROWTH

A. A tree gets taller.   YES   NO
B. A rock breaks into many pieces.   YES   NO
C. A cub becomes a bear.   YES   NO
D. More and more people move into a Town.   YES   NO

16. Coco is a monkey. Which of these sentences describes Coco's BEHAVIOR?

Circle only ONE sentence

A. He was born in January.
B. He swings from trees.
C. He is brown.
D. He has a tail.

17. Select the correct word to fill in each blank:

INACTIVITY   MIGRATION   BREEDING   SHELTER

A. When organisms move seasonally for breeding, it is called _____
B. An animal builds a _____, which is a structure for protection.
C. _____ is when organisms have offspring or babies.
D. _____ is when organisms do not move or do anything.

18. Which of these are EXTERNAL characteristics of this hedgehog?

Circle ALL that apply

Hairy   Gentle   Small   Spikey
Strong   Brown   Round   Hungry

19. True or False?

For each sentence, circle TRUE or FALSE

Only people and animals are ORGANISMS.   TRUE   FALSE
NESTING is building a nest for young/offspring.   TRUE   FALSE
DEVELOPMENT is how organisms grow and change.   TRUE   FALSE
DEW forms when WATER VAPOR CONDENSES.   TRUE   FALSE

A. How much do you like learning science?

B. How good are you at learning science?

C. How good are you at learning science?

D. How much do you like learning new words?

E. How easy is it for you to learn science?

F. How easy is it for you to learn new words?

Appendix C

Sample of Third Grade Fall 2017 Assessment

Name: _____ Grade: _____

1. Label each PLANET:

JUPITER   EARTH   MERCURY
URANUS   VENUS   SATURN
NEPTUNE   MARS

2. Select the correct word to fill in each blank:

REVOLUTION   ROTATION   ORBIT

1. A/an _____ is the path that an object in space takes around another object in space.
2. A/an _____ is to make a circle around another object.
3. A/an _____ is to spin on an axis.

3. True or False? For each sentence, circle TRUE or FALSE.

The SUN orbits the EARTH.   TRUE   FALSE
The SUN is a huge ball of gas.   TRUE   FALSE
The SUN is a star.   TRUE   FALSE

4. Select the correct word to fill in each blank:

WEATHER   POLAR   ATMOSPHERE   DESERT

The _____ is the air that surrounds the Earth and is made up of a mixture of gases.

_____ is the condition of the air that surrounds the Earth at a place for a short time. It includes humidity, cloud cover, temperature, wind, and precipitation.

5. Select the correct word to fill in each blank:

FUNCTION   STRUCTURE

A _____ is a body. Its _____ is to pick up food and stay _____.

This _____ of a form is to push and stay _____ and stay.

This _____ of a form is too pick up food and stay.

6. Which of the following are Types of PRECIPITATION? Circle ALL that apply.

RAIN   SNOW   DUST   HAIL   WIND   SLEET   HEAT

7. What are these instruments used to measure? Draw lines connecting the pictures of the instruments with what they measure.

Wind Vane
Compass
Thermometer
Rain Gauge

PRECIPITATION
WIND DIRECTION
DIRECTION of MAGNETIC NORTH
TEMPERATURE

8. Draw lines connecting the pictures with the correct description.

A COMMUNITY   AN ECOSYSTEM   A POPULATION

9. Select the correct word to fill in each blank:

FROGLET   EGGS   FROG   TADPOLE

10. Select the correct word that describes each picture:

FOOD CHAIN   BASIC NEEDS   LIFE CYCLE

Write the correct answer to fill in the blank:

This chart shows the _____ of a frog.

REVOLVED   PERISHED   PRECIPITATED   THRIVED

This plant → _____
← This plant _____

11. Circle the picture that is the correct answer. Which picture shows the sky with the most CLOUD COVER? Circle only ONE.

12. Select the correct word to fill in each blank:

SOLAR SYSTEM   ROTATION   PLANET

A. EARTH is the 3rd _____ from the SUN.
B. The _____ is the SUN and all the objects that move around it.

13. Select the correct word to fill in each blank:

SURVIVE   REPRODUCE   PERISH   ADAPT

A. When an animal has figured out how to survive in a new place, it has learned to _____.
B. To _____ is to have offspring.
C. To _____ is to continue to live or exist.

14. Which chart is an example of a FOOD CHAIN? Check the BOX it next to your answer. Only check ONE box.

15. Draw lines connecting the descriptions to the matching words.

A group of similar organisms that can have offspring together
Defend oneself from harm
Lots of differences among living organisms

PROTECTION
DIVERSITY
SPECIES

16. A METEOROLOGIST is someone who studies _____. Circle only ONE.

METEORS   ROCKS   WEATHER   ANIMALS