The development and evaluation of Readorium programs by Mtelegence Corporation was funded by Small Business Innovative Research (SBIR) Grants from the Institute of Education Sciences (U.S. Department of Education). The report that follows was required by the Department of Education.

Readorium is a web-based program with automatically adaptive science books aligned to the NGSS and state standards. It was created to address the unique reading challenges associated with the comprehension of non-fiction text. During Phase 1 of the development of both Readorium Rising Reader (grades 3-5) and Readorium Scholar (grades 6-8), research was conducted on the usability and feasibility of the programs and iterative changes were made based on this research. Phase 2 evaluation research was conducted by Christopher Rhoads, PhD, University of Connecticut, and his graduate assistant, John Madura. All research and findings are detailed below.

Research and Development:

a. Key technical objectives of the Phase I and Phase II R/R&D effort, including the specific research questions that were addressed in the project

The following research questions were addressed in the three field tests conducted during Phase I and Phase II of this project as indicated below:

Usability and Feasibility (FT1, FT2, FT3)

- Does *Readorium* work in classroom settings?
- Can students use it independently?
- Can the program be integrated into the regular curriculum?

Motivation

- Which program features motivate students? (FT1, FT2, FT3)
- What motivational features should be added to the program? (FT1, FT2)
- Which program features should be eliminated or modified to increase motivation? (FT1, FT2)

Engagement

- Which program features engage students? (FT1, FT2, FT3)
- Which additional features might enhance student engagement? (FT1, FT2)
- Which program features should be eliminated or modified to increase engagement? (FT1, FT2)

Promise of *Readorium* to Achieve Intended Outcomes (FT1, FT2, FT3)

- Does *Readorium* improve nonfiction reading comprehension, in general?
- Does *Readorium* improve nonfiction reading comprehension for specific subgroups, such as struggling students?
- Which program features are effective in helping students comprehend text?
- Does the number of topic series read and/or time using *Readorium* increase reading comprehension?
- Do students transfer reading skills learned in *Readorium* to comprehend outside text?

b. The technological R/R&D that occurred in Phase I and Phase II, including what was done, where it was be done, and how it was carried out. This will demonstrate how the key components of Readorium were developed and refined through iterative research.

Following is the history of the iterative development of *Readorium* based on the R/R&D that was completed during Phase I and Phase II.

Readorium's development is based on the results of continual Phase I and Phase II R/R&D. When *Readorium*'s prototype was completed it contained 19 books (each with 7 chapters written at 12 different readability levels) and eight strategy lessons. Eighty students and four teachers from diverse NJ districts used the program for 6 weeks from October 15th through November 30, 2010. Six types of data were collected and analyzed as follows.

A. ***Pre and Post External Online Reading Comprehension Test****:* Students took the Diagnostic Online Reading Assessment by Let's Go Learn before and after program use to measure comprehension growth. The differences in these scores were analyzed.

B. ***Interviews****:* Teachers were interviewed *before* the study to identify problems that students had with comprehending nonfiction text and to set up an implementation schedule for each school.

C. ***Student Progress****:* The *Readorium* Assessment Engine collected quantitative student data and tracked student progress. This included the number of strands and strategy lessons completed, frequency of avatar assistance needed for each topic strand, initial reading placement level, current readability level of articles presented to each student, and average reading level of all articles presented to each student.

D. ***Questionnaire and Survey Data****:* Field test students and teachers filled out surveys with Likert-Scaled and open-ended questions to determine the program's ease of use, clarity of instruction, ability to engage students, ease of navigation, value of the Teacher Management System, and whether *Readorium* functioned as intended (i.e., students transferred learned strategies to reading comprehension in other content areas).

E. ***Ongoing Comments****: Readorium* users and teachers were encouraged to use the optional feedback form on the system, or to email the *Readorium* staff directly, so that any glitches in the program could be fixed immediately.

F. ***Focus Groups of Students***: Students in three of the four schools were videoed using the program, and students were asked questions about what they learned from the program, liked about it, and how they thought it could be improved.

Based on the analysis of the results of the prototype field test, the Mtelegence team determined that the following program changes would be developed in Phase II for the second iterative round of field testing:

- Additional interactive strategy lessons
- Changes to the demo lesson to allow students who were capable of working independently to do so
- Additional preview and instructional information added to Topic Screen
- Development of word learning games
- Creation of the *Readorium* Village and all venues within it
- Teacher management system to collect additional data on student program use
- Wider range of score reports for teachers
- Additional content vocabulary learning and practice features

- Technology improvements to make the addition of new content and strategy lessons more effective and efficient, including coding articles, using *Readorium* Markup System and the development of the content management system (CMS)

The second field test was conducted from April 16 - June 1, 2012.
Approximately 171 students, in 15 classes, in seven school districts in New Jersey and Connecticut, participated in Field Test 2. They encompassed a range of socio-economic levels, racial/ethnic diversity and academic achievement

The purpose of the field test was to examine the feasibility and usability of the *Readorium* program, as well as to provide both quantitative and qualitative information to the Mtelegence staff for further development. Data from the field test was collected to help Mtelegence researchers do the following:

Troubleshooting Identify which *Readorium* components, features, and technology features perform as int+ended, and what needed to be added or modified to ensure ease of use.

- Informal interviews with students and teachers at test sites conducted during the third week of the field test in seven classrooms

Analysis of Field Test 2 Data
Improvement in Reading Comprehension: (Over a six-week period)
While the expected increase in reading comprehension is .17 school years for the 6-week testing period, the average reading level improvement for all *Readorium* users (N=171) was .83 school years. Grade 6 regular education students (N=98) increased an average of .75 and Grade 6 intervention students' (N=42) increase was .95. There was also a correlation between number of strands completed and average increase so that students who completed 5 or more strands (N=71) increased by 1.03. About two-thirds of students reported that they understood science text better and that their comprehension of all text improved.

C. Research Conducted to Demonstrate the Usability and Feasibility of *Readorium* and its Promise for Achieving the Intended Outcome of Increasing Student Comprehension of Non-Fiction Text
(Field Test 3: March 4, 2013-May 1, 2013)
Mtelegence conducted an 8 week field test of the *Readorium* software in nine NJ School districts. In the next two sections we will address the research questions, research design, district and sample characteristics, measures and procedures, qualitative and quantitative results, analysis and conclusions.

Research Questions:

Usability and Feasibility

- Does *Readorium* work in classroom settings?
- Can students use it independently?
- Can the program be integrated into the regular curriculum?

Motivation

- Which program features motivate students?
- How did teachers motivate students to use the program?

Engagement

- Which program features engage students?

Promise of *Readorium* to Achieve Intended Outcomes

- Does *Readorium* improve nonfiction reading comprehension in general?
- Does *Readorium* improve nonfiction reading comprehension for specific subgroups of students?
- Which program features are most effective in helping students comprehend text?
- Does the number of topic series read and/or time using *Readorium* increase reading comprehension?
- Do students transfer reading skills learned in *Readorium* to comprehend outside text?

Research Design:

The main research design utilized was a randomized, controlled experiment, and the majority of classrooms participating in the study were randomized to one of two conditions. The treatment condition incorporated 8 weeks of using the Readorium software into regular class activities. The business-as-usual, or control, condition made no change to regular class activities. The field test was conducted mainly in 6th grade science classrooms within schools in New Jersey. However, in one school a 7th grade classroom was included to ensure that two classes were available within the school to randomize. Although students in grades 5-8 participated, our research focuses on sixth grade.

Certain schools would only agree to participate in the field test if school administrators could decide which classrooms would receive access to Readorium. Thus, while the main research design was a randomized experiment, there is a subset of students for whom only a causal-comparative research study was possible. This report focuses attention on results from the randomized experiment portion of the study, and additional information on the randomization procedures will be detailed later in this section.

Participating treatment groups agreed to have students use Readorium for a minimum of 6 weeks during the 8 week trial period. Students were asked to use the program for a minimum of two class periods per week, (80 minutes), and to complete a minimum of 6 topic series. In addition, students could use the program for all eight weeks at school. Teachers could assign Readorium as homework. Students also could use the software at their own discretion outside of class. Teachers were required to view score reports.

Sample:

The sample included: eight public school districts in New Jersey: Bridgewater-Raritan, Hackensack, Hasbrouck Heights, Leonia, Orange, Ridgefield, Teaneck, Wood-Ridge, and one private school, the Noble Leadership Academy.

Below is the district demographic data taken from the NJDOE website. Data for the Noble Leadership Academy was not available.

Percent of School Enrollment by Race, Subsidized Lunch and Limited English Proficiency 2012-2013									
District	**White**	**Black**	**Hispanic**	**Asian**	**Hawaiian Native American**	**2+ Races**	**Free/Reduced Lunch**	**ELL***	**Total Enrollment**
Bridgewater-Raritan	64.0	3.0	9.2	22.7	0.8	0.3	7.8	1.7	8,747.5
Hackensack	12.5	27.5	52.8	6.4	0.6	0.1	55.7	0.0	5,164.5
Hasbrouck Hts.	60.4	3.3	20.5	15.3	0.0	0.6	15.9	0.0	1,758.0
Leonia	32.6	4.2	21.6	40.0	0.2	1.4	14.0	0.0	1,822.0
Noble Academy	NA	NA	NA	NA	NA	NA	NA	NA	NA
Orange	0.2	75.1	24.3	0.2	0.1	0.0	86.0	0.0	4,618.0
Ridgefield	38.3	3.2	28.4	29.9	0.1	0.2	24.3	0.0	1,673.5
Teaneck	13.4	42.4	28.3	12.8	0.7	2.4	37.8	0.0	3,838.5
Wood-Ridge	77.0	2.2	14.2	6.5	0.9	0.1	9.7	0.0	1,157.5

*The data for English Language Learners does not seem accurate. For example, the 2011-12 Hackensack data showed 385 students out 5,164 students were classified as ELL and the 2012-13 reported no ELL students in Hackensack.

Treatment and Control Groups

The following chart is a comparison of the characteristics of the treatment and control group students,

Characteristics of Treatment and Control Groups 2013		
	Treatment	**Control**
Gender (Sample Size)	330	224
Male (%)	48.8	51.3
Female (%)	51.2	48.7
Race (Sample Size)	314	175
Asian (%)	15.9	15.4
Black (%)	28	26.3
Hispanic (%)	24.5	17.7
White (%)	30.9	40
Other (%)	0.6	0.6
F/R lunch (Sample Size)	240	145

Yes (%)	36.3	36.6
No (%)	63.8	63.4
ELL (Sample Size)	271	157
Yes (%)	3.7	3.2
No (%)	96.3	96.8
Spec Ed (Sample Size)	276	145
Yes (%)	8.7	5.5
No (%)	91.3	94.5
Basic Skills (Sample Size)*	278	167
Yes (%)	21.9	22.2
No (%)	78.1	77.8

Measures and Procedures

Several types of measures were used to collect data for analysis of feasibility, usability, and promise of *Readorium* to achieve the intended outcome of increasing student nonfiction comprehension. Independent and Dependent Variables were determined for analytic purposes. (See three charts below).

Teacher Feedback: Measures and Procedures

Before field test	During field test	After field test
Data: School meetings with administrators and teachers were conducted at every test site **Collection method**: Meeting notes **Analysis procedure**: Information was categorized and analyzed for setting up appropriate field test procedures	**Data:** Interviews to ascertain information about feasibility, usability, and perceived impact of *Readorium* on comprehension were conducted in Hackensack, Teaneck, Orange, and the Noble Academy **Collection method**: On-site interviews were videotaped in Hackensack, Teaneck, Orange and the Noble Academy **Analysis procedure**: Feedback was indexed and summarized based on independent and dependent variables, e.g., perception of student engagement, based on specific features of *Readorium* **Data:** Thirty to sixty minute phone conferences were conducted with every treatment teacher to discuss questions concerning the program and its integration into the curriculum, address any problems they were experiencing, instruct them in the use of the student score reports and *Readorium* resources for differentiating instruction, and to listen to suggestions for improved program use. **Collection method**: Summative notes were taken based on teacher responses and feedback. **Analysis procedure**: Information was categorized and used iteratively to add features suggested by teachers to increase feasibility and usability. **Data:** Emails, phone correspondences and school meeting **Collection method**: Notes were taken about technology issues such as streaming delays, score reports, and explanations and suggestions for improving the program **Analysis procedure**: Feedback was categorized and used to improve the program	**Data:** Online surveys with Likert scale and open-ended questions were completed by 11 teachers of treatment classes **Collection method**: Online responses were categorized by the objectives of the program in terms of the **independent variables** (features); the **dependent variables** (improving nonfiction comprehension and related variables, e.g., reading enjoyment) and the **intervening variables**, e.g., motivation and engagement. **Analysis procedure**: Feedback was indexed and summarized based on independent and dependent variables

Student Feedback Measures and Procedures

Before field test	During field test	After field test
Data: Program launch with students at a few school sites **Collection method**: Notes summarized on student responses **Analysis procedure**:	**Data:** Interviews to ascertain information about feasibility, usability and impact of *Readorium* were conducted **Collection method**: On-site interviews were videotaped in Hackensack, Teaneck, Orange and the Noble Academy **Analysis procedure**: Feedback was indexed and summarized based on specific features of *Readorium* such as whether the reward system **(independent variable)** increased student motivation (**dependent variable).** **Data:** Classroom observations **Collection method**: Mtelegence staff observed and took notes	**Data:** Online surveys with Likert scale and open-ended questions were completed by 370 treatment group students **Collection method**: Responses were categorized by the objectives of the program in terms of the

Information categorized and analyzed for setting up clear directions for student testing **Data:** DORA test was administered to treatment and control groups just prior to the field test. **Collection method**: Test data was collected from Let's Go Learn **Analysis procedure**: Initial test data was entered into the *Readorium* system for treatment group students as a baseline for their first article reading level. For both treatment and control groups initial test data was entered into a spreadsheet.	on student behaviors while using *Readorium.* **Analysis procedure**: Notes were indexed and summarized based on **dependent variables**, such as usability, where the **independent variable** is uninterrupted use of the program. **Data:** Online "Bug report" feature continuously available to students so that Mtelegence tech staff could immediately address technical problems. **Collection method**: The *Readorium* system was designed to immediately note specifically the location of the problem, the browser being used, etc. so the tech team did not have to rely on vague reports. This system (**independent variable**) was critical in enhancing the ease of use of the program (**dependent variable**). **Analysis procedure**: The tech team collected ongoing bug report information during the field test, fixed problems, and emailed the results to teachers and/or students **Data:** Reflection sheets, with Likert scale and open-ended questions were completed by students after each topic strand. **Collection method**: The *Readorium* system automatically sorted the information into a spreadsheet **Analysis procedure**: Student responses were sorted by category and analyzed. **Data:** The *Readorium* system collected individual student data on the number of topics read, number of strategy lessons completed, average readability level of articles read, total time on task, average number of hints needed per article **Collection method**: The *Readorium* system automatically sorted the information into a spreadsheet **Analysis procedure**: Student responses were sorted by category and analyzed. This data was correlated with DORA scores.	**independent variables** (features); the **dependent variables** (improving nonfiction comprehension and related variables, e.g., reading enjoyment) and the **intervening variables**, e.g., motivation and engagement. **Analysis procedure**: Feedback was indexed and summarized based on independent and dependent variables **Data:** DORA test was administered to treatment and control groups just after the field test. **Collection method**: Test data was collected from Let's Go Learn **Analysis procedure**: Final test data was entered was entered into a spreadsheet for comparative analysis.

The survey questions that students and teachers answered on Survey Monkey are attached to an email. The Diagnostic Online Reading Assessment cannot be attached because it is an adaptive online test by Let's Go Learn but you can get details about this assessment on the Let's Go Learn website.

External Reading Assessment

Participating students in both the treatment and control groups were administered the Diagnostic Online Reading Assessment (DORA) by Let's Go Learn, both immediately prior to the 8 week field test period and immediately after completing the 8 week field test. Details about this assessment and its administration can be found in the section entitled, Data on the Promise of *Readorium* for Improving Nonfiction Comprehension.

Dependent and Independent Variables

Dependent Variables	Independent Variables
Usability and Feasibility	
• Does the technology work smoothly for students?	• Bug report features and tech team responses minimize interruptions in program use
• Can students use *Readorium* independently?	• Getting Started videos for program components give students the information they need to work independently
• Does *Readorium* work in classroom settings?	• Do teachers have access to *Readorium* system requirements, such as adequate numbers of computers, Internet access, adequate network system, and availability of compatible browser?
• Are teachers able to integrate the intervention within their existing curriculum?	• Can topics and lessons be easily integrated with regular classroom curriculum? • Are topics and lessons aligned with national standards?
Motivation and Engagement	
• Are students motivated to use the program?	• Do features, such as the money and medal reward systems, the Hall of Fame competition, and the *Readorium* Village "earning by learning" features keep students motivated to use the program?
• Are students engaged while using the program?	• Do features, such as word fill-ins, lightning round questions and interactive vocabulary cards keep students engaged with text as they use the program?
• Are text and instruction tailored to individual needs?	• Do differentiation features, such as guides reading and explaining strategic thinking, automatically leveled text, and instructional supports such as increasingly pinpointed hints enhance the usability for students?
Promise of *Readorium* for Improving Nonfiction Comprehension	
• What is the impact of the use of *Readorium* on nonfiction comprehension for middle school students?	• Are strategy lessons effective?
	• Are the use of strategies transferred to other texts and content areas?
	• Do vocabulary lessons help students with word learning skills?
	• How does use of *Readorium* impact comprehension scores? o Control versus treatment groups o Impact of the amount of time using *Readorium* o Impact of the number of topic series completed o Impact of *Readorium* on various subgroups
	• Would teachers recommend the use of *Readorium* to their colleagues based on its impact on improving comprehension?

Readorium Feasibility and Usability Data

Data to determine usability and feasibility was the feedback from student and teacher interviews and online surveys (370 students and 11 teachers), as well as from the student reflection sheets. First teacher feedback and then student feedback will be addressed in each category.

Feasibility and Technology: Teachers

Computer availability Although we were assured beforehand that field test students would have access to computers, limited access was a problem for some of the field test classes. Computers were available to students *most of the time* according to 36% of teachers and *some of the time* according to 55%. Some schools reported scheduling conflicts and/or network problems, which prevented their students from using the program for the requisite number of hours or completing the requisite number of topics.

Mtelegence's response to reported problems with *Readorium* All the teachers felt that their own concerns, e.g., tech problems, questions and concerns about the program, and their students' concerns, were responded to quickly by the Mtelegence staff.

Integration of *Readorium* into classroom practices In order to integrate *Readorium* into the school day, most teachers took students to labs where all students worked on *Readorium* simultaneously. During that time teachers (90%) reported helping students with tech problems at some point; 73% shared student progress reports with students, and 55% helped students with comprehension issues.

Evidence of integration of *Readorium* content Eighty-two percent of teachers reported that students participated in general classroom discussions about the topics they were learning about in *Readorium*. Twenty-seven percent reported that students who read the same topics met in discussion groups and the same percent reported that students wrote about these topics. Sixty-four percent of the teachers reported that they overheard students conversing about the topics they were reading and 46% overheard students recommend topics to each other. Only 18% of teachers did not know whether students shared the information they learned.

Feasibility and Technology: Students

Students were asked whether *Readorium* was easy to use, whether it worked smoothly for them, how quickly they received responses to their online "bug reports" and if they were able to get help when they needed it, mostly with tech problems.

Students were able to work independently on the program: they agreed (81%) that *Readorium* was easy to use and that they were able to get help when they needed it (69%). Fifty-four percent said *Readorium* worked smoothly for them all or most of the time. Bug report problems were fixed quickly most or all of the time for 42%, while 38% had no opinion.

Readorium Student Motivation and Engagement Data

A premise of *Readorium* is that students, especially students who struggle with reading, often need to be motivated to read. Program features were built into *Readorium* for this purpose. Among the features that address motivation are topic choice and a reward system.

Student Motivation: Choice of Topics-Teacher Responses

Choice is cited in comprehension literature as a significant incentive for students to read. One hundred percent of the teachers surveyed allowed students to choose their topics.

Qualitative Data: A Sample of Teacher Comments Related to Student Motivation and Engagement
In response to a question asking "what is the most important thing your students got out of *Readorium*? "Motivation, confidence, the enjoyment of reading." "My 6th grade class really enjoyed working on the program and competing against other students." "I feel the students are more engaged in their reading and enjoyed working on the computer with the program. It built their confidence and motivation for reading." "MK was a high level reader that became extremely motivated. YA was a low level reader and ICS (in-class support) student who found the program motivating." "There were students who are motivated by viewing each other's scores for competition. This made them challenge themselves to move on in their topics." "(For) beginning and struggling readers…motivation and (*Readorium*) gets them engaged in topics they normally wouldn't enjoy."
Other comments from teachers: "There are a handful of students who hate reading, and because of this program they've become completely addicted to it." "This program just opens up a new world of reading to them (my students) using technology." "I just feel that this program is an amazing program; it's making a huge difference." "I honestly believe this program's changing kids lives." "They (the students) come in to the class every day and ask, "Are we going to the computer lab today?" "The kids love it. They love the program." "It (Readorium) engaged the students and (resulted in) conversations about various topics and knowledge of science (non-fiction text)."

Student Motivation: Choice of Topics-Student Responses

Students were able to choose their topics. Thus, students chose topics that interested them (69%) or were recommended by other students (12%) or simply chose them based on their order on the topic page order (32%). They agreed that they enjoyed reading more (53%), learned more (82%), were more determined to complete a topic series (71%), and felt more confident about reading (65%).

Student Motivation: Extrinsic Reward System-Teacher Responses

The Mtelegence staff encouraged teachers to actively endorse the program to the students and promote student use. Teachers who were interviewed in our surveys indicated that they motivated students by: offering rewards for students who earned the most *Readorium* money, posting the names of the top students in their classes, having inter-class competitions, sharing the class score report with the class, and sharing the individual score reports with students to motivate them to do better or to continue making progress.

Student Motivation: Intrinsic and Extrinsic Reward Systems-Student Responses

Intrinsic Rewards – 75% of students were motivated to do well in *Readorium* to become better readers, and 65% were motivated because they wanted to learn more about science.

Readorium Extrinsic Rewards – Readorium offers a myriad of extrinsic rewards. Students earn gold, bronze or silver *medals* based on the number of hints needed to answer comprehension questions. Eighty-two percent of the students reported that they were motivated to earn gold medals. They also earn *virtual money* and the rewards are greater if they answer successfully without help. Survey responses indicated

that students were motivated to be "millionaires" and use their rewards in the *Readorium Village* where they played "earning by learning" games (77%), viewed NSF videos in the *Video Venue* (50%), and read short science articles of special interest in the *Magazine Rack* (57%). Eighty-three percent reported that they were motivated to earn a place in the *Hall of Fame* and 80% checked the Hall of Fame frequently to ascertain their standing relative to other students. Students who were interviewed almost always knew the exact dollar amount they had earned to date and their position in the Hall of Fame. Some students reported that they were more careful answering questions so they could earn more money. One student commented that *Readorium* "helps you in life because you have to work to get money."

Students were also motivated by the manner in which the teachers approached the program. Sixty-one percent of students were motivated by their teachers sharing their *Student Progress Reports*; 55% of students were motivated by teachers offering rewards; 53% were motivated by teachers posting the names of students in the Hall of Fame; and 54% were motivated by their teachers grading *Readorium* assignments.

Readorium and Changes in Student Motivation: Teacher Responses
Teachers were asked about their perceptions of students' motivation to read during the field test for various ability levels. They answered "much improved or somewhat improved" as follows:
Advanced readers: 64%
Average readers: 73%
Struggling readers: 63.6%
English Language Learners: 20%
Classified students: 30%

Student Engagement: Teacher Responses: To keep students actively engaged with text, *Readorium* included the interactive features mentioned above as well as several others that were designed to keep students actively engaged with text. When teachers were asked: which features of *Readorium* seemed to be the most effective in keeping students engaged in the program, they responded as follows:

Earning money for Millionaire's Club and Hall of Fame: 100%
Earning gold medals: 80%
Playing strategy games and participating in challenges: 80%
Using the Village: 50%
Learning from strategy videos and raps: 40%

Qualitative Data: A Sample of Teacher Comments Related to Motivation and Engagement
"I feel the students are more engaged in their reading and enjoyed working on the computer with the program. It built their confidence and motivation for reading." "The most important thing students got out of Readorium is: Motivation, confidence and the enjoyment of reading." "There are a handful of students who previously hated reading, and because of this program they've become completely addicted to it." "They (the students) come in to the class every day, "Are we going to the computer lab today?" "They now seem so energized to pick up the books I have that are nonfiction in my classroom-more so since they started the program." (Regarding particular students for whom Readorium made a difference: "Self motivated students, with low reading levels. It showed them with time and practice they can do it." "There were students who are motivated by viewing each other's scores for competition. This made them challenge themselves to move on in their topics." (In response to question about the most important thing students got out of Readorium) "I feel the students are more engaged in their reading and enjoyed working on the computer with the program. It built their confidence and motivation for reading."

Student Engagement: Student Responses

Students responded positively regarding other features that helped them stay focused as follows: missing words (76%), *interactive vocabulary cards (79%), lightning round questions (79%), and* 76% of the students tried to avoid using hints so they could earn more money.

Qualitative Data: A Sample of Student Comments Related to Motivation and Engagement
(Getting money and medals, and other engagement features) "You know you've accomplished something. It makes you do more and do better." "It makes me want to work harder." "The medals make you feel proud once you complete an article." "I always go back (to try to answer questions correctly) for gold medals." "It's fun, you get to compete to get to the Hall of Fame. I'm motivated to do all the work and do it right." "Playing games encourages students to read. I didn't enjoy reading before as much as I do now." "The most important thing I got out of *Readorium* is that motivation and support can get you where you want to be and if you put your mind to it you can do it." "The most important thing I got out of *Readorium* was that I got to read more and I tried my best to get the questions right, so that I got a gold medal." "The most important thing that I got of *Readorium* was trying harder to do better on the questions and the reading to do better and to get in the millionaire's club." "Lightning rounds make you stop and think about what you have to do." "The questions in between paragraphs (lightning rounds), helps me understand what I read. Filling in missing words throughout the articles helps me stay focused." "I like the fill in words challenge. It helps even with your grammar. It helps you make sense."

Differentiation

Differentiation Features: Readorium provides differentiation features for both teachers and students. Teachers use the Teacher Resource Center to access different types of class and individual score reports in real time. They can use these reports to group students with similar difficulties (or strengths) and they can then access specific lessons in the Resource Center to target additional instruction for those students.

Readorium differentiates instruction for students by automatically adjusting to each student's skill level as they proceed. Text is continuously presented to students at their changing readability levels based on their success rate in answering comprehension questions independently in previous articles. Support systems that break up concept density are dependent on the skill level of each student.

The following are first the teacher and then the student responses to differentiation features.

Differentiation: Teacher Responses
When asked how often teachers used the *Readorium* score reports for specific purposes, 91% said they used them to differentiate instruction. When asked which student report features they found most useful, they said the following:

Overall class report: 91%
Individual Overall Student Report: 91%
Individual Strategy Competency Report: 73%
Class Strategy Competency Report: 55%
Individual Content Area Report: 55%
Class Content Area Report: 36%

In terms of using the teacher resources provided by *Readorium* to differentiate classroom instruction based on student reports, 36% felt that they did not have time to use the resources in the 8 week field test period. Fifty-five percent of the teachers used the classroom lessons and 28% used the strand templates.

Differentiation Responses: Student Responses:
The goal of automatically differentiating the text, and the support systems students receive, is to ensure that the program can meet individual needs and all students can experience success. If *Readorium* does this successfully students should perceive the text as easy to read and they should be able to understand the material presented.

Seventy-nine percent of students agreed with the statement "The text in the program was easy to read," Seventy-one percent agreed that they were "able to complete all or most *Readorium* activities successfully" and 69% agreed that *Readorium* helped them understand science.

Data on the Promise of *Readorium* for Improving Nonfiction Comprehension

Participating students in both the treatment and control groups were administered the Diagnostic Online Reading Assessment (DORA) both immediately prior to the 8 week field test period and immediately after completing the 8 week field test. All told, a total of 294 students from 18 classrooms and 5 different school districts participated in the randomized portion of the study and provided data on the DORA assessments. An additional 4 classrooms participated in the field test but did not provide usable data for analysis. These classrooms experienced substantial computer network problems on the day of DORA administration and so usable scores could not be retrieved.

In addition to the 294 students in the randomized portion of our study, 251 students in 10 classrooms from 4 school districts participated under the condition that the decision about which classrooms would receive the Readorium software was made by a school administrator. 152 of the students in this causal-comparative study were in the treatment condition and 99 were in the control condition.

Christopher Rhoads, PhD, University of Connecticut and his graduate assistant, John Madura, conducted two types of statistical regression analyses that utilized post-treatment DORA scores as the dependent variable. The first type was the "intent-to-treat" analyses. In these models, the primary focus is on the

impact of being randomly assigned to have access to the Readorium software. The second type of model was "instrumental variables" models. These models are sensitive to the fact that, while individuals were randomly assigned to have access to Readorium, there was substantial individual variation in the extent to which students utilized the software. Over the course of the 8 week study, some students read as few as 2 different topic strands within the software, while other students read as many as 40 strands. In a similar vein, some students spent as few as 2 hours with the software over the 8 week period while others spent over 60 hours. Therefore, they used structural equation modeling software to fit instrumental variable models where they assumed that the impact of being randomly assigned to the treatment condition was fully mediated by the number of topic strands completed (results where the number of hours engaged with the software was the intermediary variable were similar). All models utilized multi-level modeling techniques to account for the clustering of students into classrooms.

The analysis team fit intent-to-treat models that conditioned on DORA posttest scores and also models that did not. They also fit these types of models for important subgroups such as African-American students, Hispanic students, and students identified as gifted. All of these analyses produced similar results. The coefficient associated with the treatment assignment variable was virtually zero, and the p-value associated with that coefficient was very close to one. They concluded that being randomly assigned to have access to the Readorium software had no measurable impact on DORA scores. Output from the intent-to-treat analysis that conditioned on DORA pretest scores and used the entire student population is provided in Table 1.

Table 1
Effect of Treatment on DORA Posttest Controlling for DORA Pretest

Path	Standardized	Unstandardized	S.E.	p-value
Treatment --> Posttest	0.003	0.006	1.570	0.997
Pretest --> Posttest	0.994	1.017	1.170	0.385

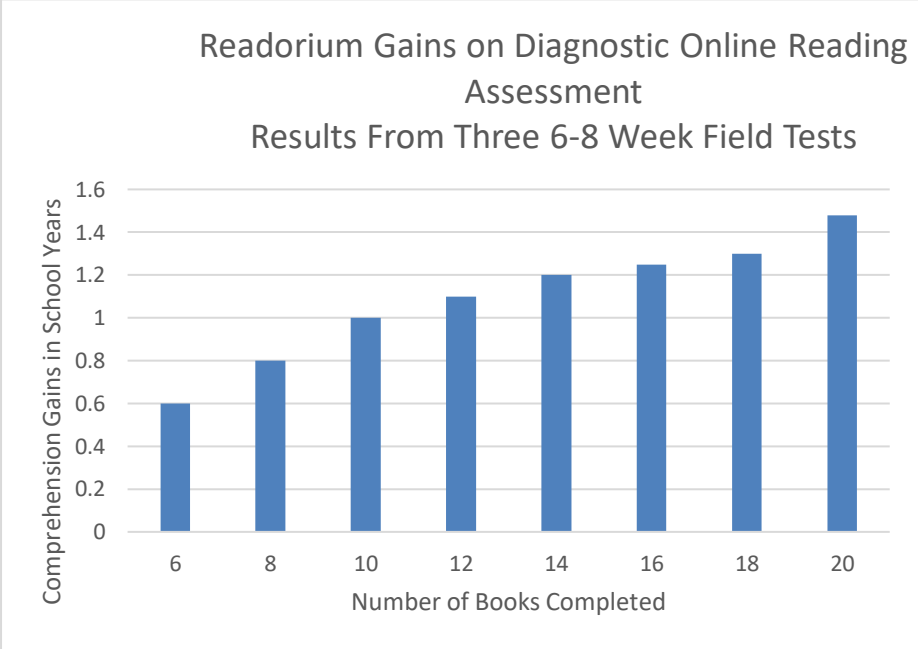
The story is somewhat different for the instrumental variable analyses. There was a *consistently positive correlation* between the number of strands completed and outcome DORA scores. Table 2 presents a representative result. The model presented there uses the random assignment variable as an instrument to estimate the causal effect of number of strands completed on DORA outcome scores. Similar models were fit that also conditioned on DORA pretest scores, with similar results.

Table 2

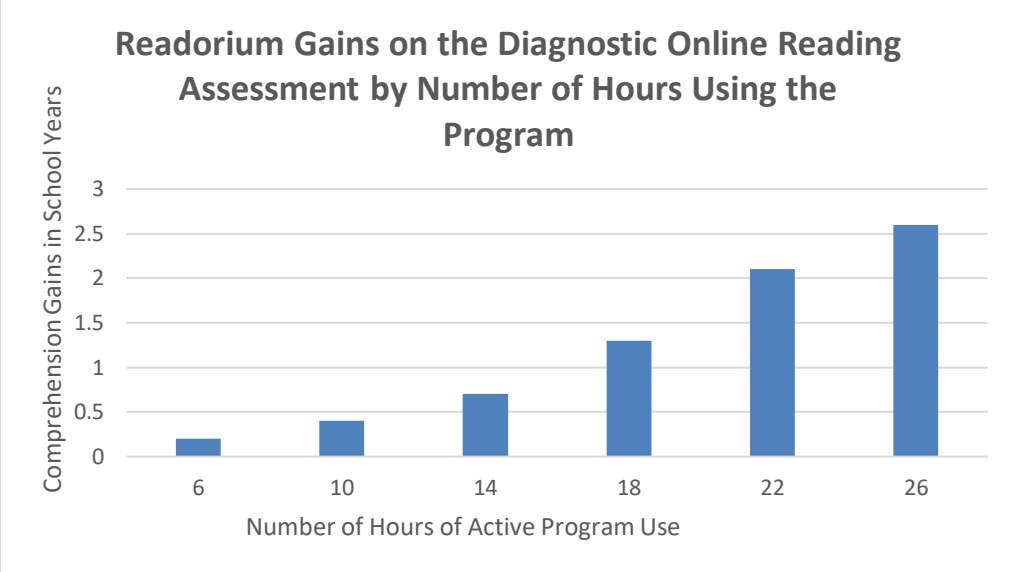
Effect of Treatment on Posttest Fully Mediated Through Number of Strands Completed

Path	Standardized	Unstandardized	S.E.	p-value
Treatment --> Number of Strands	0.942	5.772	0.444	< 0.001
Number of Strands --> Posttest	0.202	0.064	0.099	0.520

The following graph illustrates the correlation between the number of Readorium science books completed and the comprehension gain in school years.



The following graph illustrates the correlation between time spent actively engaged in the program and the comprehension gain in school years.



Teacher and Student Feedback on Additional Features Designed to Support Comprehension

Strategies: The heart of *Readorium* is to teach students the strategies necessary for understanding nonfiction text through interactive lessons and challenges, topic series that feature strategic thinking and questions that tap the understanding of these strategies. What follows are first the teacher responses and then the student responses by strategy in terms of their usefulness in comprehending nonfiction text:

Strategies: Teacher Responses
When teachers were asked the question: To what extent have you noticed, or have heard from other teachers, that your field test students now use the following strategies to comprehend text, they answered "frequently" or " sometimes" as follows:

Making Connections: 64%
Monitoring for Meaning: 36%
Using Context Clues: 55%
Using Graphic Features: 55%
Using Print Features: 55%
Determining Main Ideas and Supporting Details: 64%
Making Inferences: 46%
Making Sensory Images: 46%

Qualitative Data: A Sample of Teacher Comments Related to Student Strategy Use
"As a teacher, I think the strategies are the number one reason for the *Readorium* program, giving them the inferencing skills and so on." "They have a hard time getting these connections where the kids connect to the material itself, so they're getting there now. They're finding those connections and they are able to talk about it with each other, which is wonderful." "I keep checking about the reading strategies. Every day I go on the teacher reports and it's right there on our Smart board. So it challenges the students. If it's red (below 80%) they know they have to pick it up." The most important thing about *Readorium* was: "using text features." "Science knowledge and use of reading strategies." "They can use these strategies even when they go further with their education; hopefully, in college."

Strategies: Student Responses
Students felt that they used these strategies more often than teachers perceived that they did. When students were asked which *Readorium* strategies they found useful in reading, they either agreed or strongly agreed as follows:
Making Connections: 72%
Monitoring for Meaning: 66%
Using Context Clues: 74%
Using Graphic Features: 71%
Using Print Features: 61%
Determining Main Ideas and Supporting Details: 67%
Making Inferences: Inferring: 71%
Making Sensory Images: 72%

Qualitative Data: A Sample of Student Comments Related to Strategy Use and Features
"I had a blast with this section, but the best part is I love to read using sensory images." "I like the strategy raps. Even though you listen in a song you can remember the strategy." "I like the raps – fun to listen to and educating you at the same time." "Hangman helps you get the phrase and understand the strategy. Making Connections – you compare what you're reading to the real world."

Vocabulary is a key component of comprehension. *Readorium* explicitly address vocabulary word learning in order to enhance comprehension.

Qualitative Data: Teacher Comment Related to Vocabulary Features
"Sometimes they hear vocabulary words here (in *Readorium*) and then they hear vocabulary words in other classes, and they say, I just heard that one last night, and then they talk about the topic." In response to the question, "what are you learning from the program in science? "New vocabulary words" "Word Matching Mania helped with science vocabulary. You learn big words/new vocabulary words-it increases your vocabulary." "*Readorium* gave more experience with vocabulary – not just tell you what it is like a textbook."

Vocabulary: Students Eighty-one percent of students surveyed agreed that vocabulary cards helped them to understand text.

Qualitative Data: A Sample of Student Comments Related to Vocabulary Features
"In response to the question, "what are you learning from the program in science? "New vocabulary words" "Word Matching Mania helped with science vocabulary. You learn big words/new vocabulary words-it increases your vocabulary." "*Readorium* gave more experience with vocabulary – not just tell you what it is like a textbook." "*Readorium* is a great program. It helped me understand everything that I was reading. For example context clues, vocabulary words, and also pictures helped me a lot in understanding what I was reading." "…and the vocabulary helped me stay on track." "The vocabulary words were a big step forward in my own vocabulary; I now know more words than before." "Text features and vocabulary words helped me to understand the text." Referring to a particular article: "Throughout the article, the vocabulary cards really helped me out because some of the words are words I've heard of but didn't know the definition and some words were words that I have never heard of before. Now because of that my vocabulary has increased." "I also liked the vocabulary game it was very fun, an extra way to learn the words and a way to make extra money." "Vocab cards are very cool – you hear the definition and read the paragraph."

Support features, such as picture, captions, explanations of text, and hints to answer comprehension questions, provided by guides, help students who may struggle.

Teachers were not queried about the specific supports. However, 70% of students surveyed agreed that the hints to answer questions helped them to understand text. Sixty-one percent agreed that the strategy explanations by the Guide/Actor were helpful, while 54% agreed that the sections read out loud by the Guide/Actor were helpful.

Qualitative Data: A Sample of Student Comments Related to Support Features
"I like answering questions. I like the hints to get money. It's a fun way to learn." "The hints were helpful with answering questions." "The context is written in great detail and I really like the guides hints and explanations." "I thought … my guide was very helpful." "I really liked how you gave hints if you got the answer wrong on a question." "I liked the hints and suggestions that the man (guide) gave me, it made me understand the story better. "It helped me break up the article so I can understand the multiple choice, and questions." "I loved the programs and the hints when you get a question wrong. *Readorium* is awesome." "The hints lightning rounds and the questions were very helpful." "I truly liked *Readorium* and how much I learned. The context is written in great detail and I really like the guides' hints and explanations." "I think that the hints were very helpful during the problems because if you are confused those hints will help you get closer to the answer." "The content is written in great detail and I really like the guides hints and explanations." "The pictures and captions helped me make a visual picture of what I had just read." "It's different because *Readorium* has captions and pictures. . .that help you." (Compared to a textbook) "instead of just telling you what it's like (*Readorium*) gives you videos, pictures, and examples." "They (guides) are great – they help you with the first section and if you don't get it they help you. It gives me comfort." "*Readorium* helps you more (than a book) because a guide guides you through topics and helps you." "The guides tell you to go back and read the heading. They explain the questions to you."

"Guides make you interested and give background information." "The guide shows you how to think through a story." "My guide was helpful and even tried saying a few corny jokes that made him a bit more relatable."

Perceptions about Student Comprehension: Positive perceptions about improvement in comprehension can motivate students to work through the program.

Perceptions about Student Comprehension: Teachers
Eighty-two percent of the teachers surveyed agreed that their students read nonfiction text with greater understanding after using *Readorium.*

When asked about reading performance and overall performance for their students in various subgroups their responses were as follow:

Subgroup	**Reading Performance Much/Somewhat Improved**	**Overall Performance Much/Somewhat Improved**
Advanced Readers	70%	80%
Average Readers	91%	91%
Struggling Readers	82%	91%
English Language Learners	71%	50%
Classified Students	67%	50%

Perceptions about Student Comprehension: Students
Seventy percent of students agreed that *Readorium* helped them understand science.

Qualitative Data: A Sample of Student Comments Related Comprehension
"Before I wasn't as good a reader. I wouldn't comprehend anything." Now I can use context clues (and other strategies); I can use it in my English class to comprehend. It is helping my grades a lot. I can use skills on tests. I'm starting to see a difference." "*Readorium* makes sure you understand what you read." (When comparing *Readorium* to reading a book):"*Readorium* is better – it's more fun. You learn more. The questions get you into it." "*Readorium* has helped me a lot with understanding what I read." "I learned a lot about Rainforests and the different topics mentioned in this article. I now have background knowledge on this topic series, breaking up the text helped me understand the topic better. I LOVE THIS PROGRAM, THANK YOU *READORIUM*." "Context clues and vocabulary helped me understand the text." "In the past, I didn't understand much about what different types of space rocks do. Now I can talk about it to my peers and family members."

Transferability is a major goal of *Readorium.* Students should be able to apply the strategies and skills to any text and, secondarily, to understand and be able communicate about content, i.e., their new learning in science.

Transferability: Teacher Responses

According to 82% of teachers surveyed, students shared science information learned in the program during general science discussions. Sixty-four percent were made aware of sharing by overhearing student conversations and 46% said students recommended topics to other students. Twenty-seven percent also included meetings with students who read the same topics and written responses to topics.

Qualitative Data: Teacher Comments Related to Transferability
"I see them talking about the topics in class, which is very interesting to me. They have a hard time getting these connections where the kids connect to the material itself, so they're getting there now. They're finding those connections and they are able to talk about it with each other, which is wonderful." "I see transference to other reading. As I am talking to other teachers, the social studies teacher and the reading teacher, they are talking about the kids using new techniques they haven't used before." "The kids have made connections with the content of some of the topics and they are able to transfer it to other classes." "I believe (*Readorium*) is helping. They now seem so energetic to pick up the books I have that are nonfiction in my classroom. More so since they started the program."

Transferability: Student Responses

Sixty-nine percent of students agreed that they think about *Readorium* strategies when they read other texts.

Qualitative Data: Student Comments Related to Transferability
"It (*Readorium*) helps you increase your reading. Making connections and looking at graphic features helps you understand." "*Readorium* helps me learn to use strategies to read books." "It (*Readorium*) helps with comprehension – it helps in other classes. I read more fluently. "I can use it in my English class to comprehend. It is helping my grades a lot. I can use skills on tests. I'm starting to see a difference." "*Readorium* helped on a test – I used context clues – I re-read words around a word." "*Readorium* has information we can use. Science is everything – eating, breathing... It is even in our religious book, the Koran. *Readorium* helps show that (science is everything.) *Readorium* made me very interested in science." "It is helping my science grade. Big Delicious Earth is helping in science class." "I'm enjoying science and remembering science."

Recommendations for Readorium

Teachers: All the teachers surveyed would recommend *Readorium* to their schools and colleagues.

Qualitative Data: Teacher Final Comments and Recommendations
"The love of reading is coming back."
"Yes,(I would recommend it) if implemented consistently I believe a group of underperforming readers would benefit from such a program."
"Yes, I would recommend *Readorium*. My students looked forward to going to computer lab each week and learning about some new, possibly disgusting, science topic. I would overhear my students share information about what they have read, and in turn, those students couldn't wait to get back on *Readorium* and read the articles their classmates told them about."
"I just feel that this program is an amazing program; it's making a huge difference."

Students: Seventy-two percent of students would recommend *Readorium* to other students and 73% agreed that there should a *Readorium* program for other subjects, such as Social Studies, Health and Math.

Qualitative Data: Student Final Comments and Recommendations
"I liked it and I'm sure that this will help other students with L.A. and science and such."
"I think you are doing a great job with helping students with this program, keep up the good work."
"The program was really a great way to help students learn about nature."
"I would recommend *Readorium* to other students. It helps you increase your reading."
"I would recommend *Readorium* to other students. It's fun and entertaining. They would have fun. They would probably learn more, have fun and gain knowledge."
"I would recommend *Readorium* to some of my friends who don't like to read."

Suggestions for Future Iterations of Readorium

Qualitative Data: Teacher Recommendations for Future Iterations of *Readorium*
"Perhaps more pop culture related items"
"Not so much for reluctant readers - but for all"
"More strategy games"
"With a longer time line, say 8 months, I believe even the most reluctant reader would eventually comply, assuming that they are encouraged and prepared."

Conclusions

After analyzing the qualitative and quantitative data, our research results indicate the following.

Feasibility and Usability: All treatment teachers found the program both feasible and usable in an educational setting. They all felt that their own concerns, e.g., tech problems, questions, and students' concerns, were responded to quickly by the Mtelegence staff. Teachers integrated Readorium into the school day by using lab computers and working with individuals on any comprehension problems or technical problems that arose. Most teachers (82%) reported that students shared the information learned from Readorium articles during class discussions, and the majority of teachers overheard students speaking about the information they were learning with their peers. Only18% of teachers did not know whether students shared the information they learned. Teachers shared the Score Reports with their students and they felt that these reports helped them make students accountable for the work they were doing.

Eighty-one percent of the students agreed that the program was easy to use. The majority of students felt that the program worked smoothly for them. Students found the program fun and felt that they were able to get help when they needed it.

During the testing period several sites encountered unexpected school-based problems that impacted the amount of time some students used the program, how many topics they completed, and how well the system worked from a technological standpoint. Our field test requirement was for treatment classes to use the program for a minimum of two class periods a week (for a total of 80 minutes per week) for at least 6 weeks over the testing period, and students were asked to read a minimum of six science series over this time frame. All schools (the administrators and teachers involved) agreed to these requirements before the field test began. The tech requirement sheets were sent to the school computer coordinators and to all treatment class teachers. All schools were also sent an online *Readorium* sample to test *Readorium*'s compatibility the school's technology system, and all schools ran the initial test successfully.

Motivation and Engagement: The Engagement and Motivation features of Readorium produced the desired results. All treatment teachers talked about how motivating the program was in interviews and on their free-responses in the surveys they completed. One teacher said that the most important thing that her students got out of the program was "motivation, confidence, and the enjoyment of reading." Teachers attributed student motivation and engagement to topic choices, competition, and the fact that students received the level of text and support they needed as they used the program.

Students said they were motivated by both intrinsic rewards and extrinsic program features. Three quarters of the students reported that they wanted to become better readers. Sixty-five percent were motivated because they wanted to learn more about science.

Students were also highly motivated by Readorium's features. Over 80% wanted to earn gold medals for answering questions correctly. The vast majority wanted to earn as many Readorium dollars as they could and earn a place in Readorium's Hall of fame. Eighty percent of the students checked the Hall of Fame frequently to ascertain their standing relative to other students. Over three quarters of the students enjoyed the "earning by learning" activities in Readorium's Village.

Students also found the engagement features effective. They thought that the word fill-ins and the lightning round questions kept them focused and held them actively engaged with the text.

Promise of Readorium to Impact Student Nonfiction Comprehension

There was a consistently positive correlation between the number of strands completed and outcome DORA scores, as well as a consistently positive correlation between the numbers of hours students used the program and the outcome DORA scores, indicating that program use has a potentially positive effect on student comprehension.

Teacher and Student Feedback on Readorium Features Designed to Support Comprehension Strategies: Both students and teachers found Readorium's strategy lessons and challenges effective in aiding comprehension. The students enjoyed and remembered the strategy raps and liked the strategy challenges. They named strategies that were especially helpful to them in their free responses. They more consciously used sensory imaging, making connections, inferring, using graphic and print features, as well as employing word learning techniques learned in the program to understand all text. Teachers also commented positively about students' use of strategies learned in *Readorium* to comprehend other text.

Vocabulary: Readorium's vocabulary features also seem to be effective. Students enjoyed the vocabulary games and interactive cards, and eighty-one percent of students surveyed agreed that vocabulary cards helped them understand text.

Text Leveling and Support Systems: Both teachers and students found Readorium's text leveling and support systems effective. Almost all students found the text they received easy to understand. Sixty-one percent agreed that the strategy explanations by the Guide/Actor were helpful. Seventy percent of students thought that the hints to answer questions helped them to understand text, while more than half agreed that the sections read out loud by the guide were helpful. More than three-quarters of the students agreed that they were "able to complete all or most *Readorium* activities successfully" and that *Readorium* helped them understand science.

Transference: The vast majority of students felt that they were better readers because of the Readorium program, and many commented about how they used the specific strategies and word learning skills they learned in the program to understand outside text. Eighty-two percent of teachers surveyed said that students shared science information learned in the program during general science discussions. Eighty-two percent of the teachers also agreed that their students read nonfiction text with greater understanding after using the program. Teachers also commented that the teachers who had these students for other subjects also noticed a difference in their abilities to make connections to new text.

Seventy-two percent of students would recommend Readorium to other students and 73% wanted a Readorium program for other subjects. All the teachers surveyed would recommend Readorium to their schools and colleagues.

Unanticipated Benefits: There were some unanticipated benefits from the program. *Readorium* was designed to primarily be an instrument that raises reading comprehension, not necessarily an instrument that increases scientific knowledge. However, both students and teachers commented that students were learning more science from *Readorium.*

Another unanticipated benefit of *Readorium* was the range of students who benefited from the program. *Readorium* was designed primarily for struggling readers, but the feedback from both students and teachers indicate that *Readorium* is beneficial to both on-level and above-level readers as well. About three quarters of the teachers said that the program also benefitted average readers and approximately two- thirds said it benefited advanced readers. Based on these results, and the fact that *Readorium* adjusts to each individual's reading level, we would now suggest that *Readorium* can be useful to a wider market,

and that it would benefit all students. We also recommend that teachers use the score reports to determine specific student weaknesses and that they use the resources provided to target instruction to different students' needs.

Our original ideas changed continuously as a result of conducting this project. The basic premise of the project (and the research upon which it was built) remained the same, but many features were changed or added based on the feedback we received from each of the field tests. These include student suggested features to increase engagement and motivation, as well as teacher suggested features to enhance usability, feasibility, and integration with instructional existing practices

Recent Awards and Publications

Awards

Readorium won the 2018 International Reimagine Gold Award for K-12 Education, Readorium won the 2016 National CODiE Award for Best Reading/English/Language Arts/Instructional Solution, and was a 2017 CODiE finalist in the category of Best Cross-Curricular Solution. Readorium was a 2016 ED Tech Digest Cool Tool Finalist, received the Trendsetter Award for innovative content by the Software and Information Industry Association, and won the 2016 International Reimagine Bronze Plaque for K-12 Innovation, Readorium is also recommended by the National Science Teachers Association.

Publications:

Ed Tech Digest: February 23, 2016 *Using Adaptive Technology to Increase Science Comprehension* by Harriet Isecke, CEO and Founder of Readorium
Florida Education Matters: March 2016: Readorium: Read Engage Understand by Harriet Isecke

Education Research Quarterly: Volume 37, Issue 1 September 2013 *Nonfiction Reading Comprehension in Middle Schools: Exploring an Interactive Approach* by Evelyn Wolff, PhD, Harriet Isecke, Christopher Rhoads PhD and John P. Madura, University of Connecticut.