Digital Promise Global

Designing for Learner Variability:

Examining the Impact of Research-based Edtech in the Classroom

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Learner variability recognizes that all students differ and that these differences matter for learning (Pape, 2018). In other words, the personal background of students, their health and psychological wellbeing, as well as their cognitive strengths and challenges, describe who they are as learners. In a recent survey commissioned by Digital Promise Global's Learner Variability Project (LVP), "Learning in the 21st Century," findings show that approximately eight in 10 adults agree that learner variability exists. The burgeoning field of learning sciences research supports this impression.

THE POWER OF EDTECH MAY BE IN THE WAY THAT TECHNOLOGY CAN BE USED TO TAILOR LEARNING ENVIRONMENTS AND INSTRUCTION.

In order to meet the diverse needs of each learner, LVP curates current research into a whole-child framework of evidence-based factors and strategies to disseminate through its freely accessible web app, the Learner Variability Navigator. Further, LVP partners with educational technology (edtech) creators to help use this research to infuse their products with supports for each learner's needs.

These supports, or strategies, can help tailor instruction when applied in edtech. Though edtech is widely available, there is limited evidence on the general impact that technology has on improving learning outcomes for students. One analysis reviewing impact studies of edtech (Escueta et al., 2017) found little causal evidence of improved learning outcomes when looking at the impact of the general use of edtech. There was, however, evidence for the benefits of adaptive learning systems, that is, edtech tailored towards learners' individual needs.

Thus, simply providing technology may not be sufficient to improve learning; rather, the power of edtech may be in the way that technology can be used to tailor learning environments and instruction.

LVP Partners with ReadWorks

In 2017, LVP launched a partnership with the nonprofit literacy organization ReadWorks, whose mission is to bridge the gap between research and practice in reading comprehension instruction (Tare, Nobles, & Xiao, 2018).

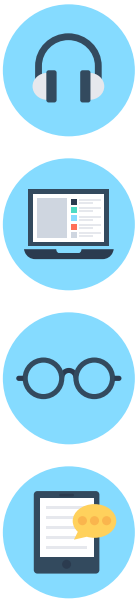
On its digital platform, ReadWorks provides free resources to K-12 teachers, including a library of curated nonfiction and literary articles, reading comprehension and vocabulary curricular supports, assessments, and teacher resources. ReadWorks has a wide network, with 88 percent of all K-8 public and charter schools in the U.S. having a teacher who has used ReadWorks in the 2018-2019 school year, potentially reaching over 15 million students (as of July 2019, per ReadWorks). As such, partnering with ReadWorks has the potential to impact a vast number of students.

The LVP-ReadWorks partnership began with an assessment of the ReadWorks digital platform, with the goal of further applying learning sciences research (curated into LVP factors and strategies) relevant to reading comprehension in elementary school. Teachers can assign articles to students in their classes to be read on the ReadWorks digital platform. Thus, recommendations were made to ReadWorks to develop features for this student-facing part of the platform based on strategies that address a variety of learning needs, such as helping students focus on the article content.

LVP worked with ReadWorks to incorporate the development of many of these features into their platform. Our collaboration is unique—typically, few edtech products engage with research when building out their platforms, but rather only conduct evaluations afterward (Tripathy et al., 2018; Vaala et al. 2015).

Recommendations Based on Learning Sciences

After the initial assessment, LVP suggested product features to ReadWorks that would support student access and engagement with the content on the platform. These features are intended as scaffolds, bolstering strengths and mitigating challenges students may face based on the key learner factors underlying reading success, which include attention, working memory, vocabulary, and vision. The accompanying product features included, among others, audio, split screen, text magnification, guided reading strip, paragraph numbering, and article annotation.



While there is limited research on these features in the context of a digital platform, the strategies they are based on have been studied in empirical and practitioner-based literature and suggest potential benefits for learners. Further, it is important to note that much of the research has looked at the impact of edtech on average (i.e., across all students) when certain supports may benefit only a few students in certain contexts. Below, we outline some of the existing research behind these features, with details on the study populations where available.

Audio

Research has shown that audio supports can benefit student engagement and learning for students with different needs. For example, use of audiobooks can lead to higher interest in reading among English language learners, and a higher likelihood of students practicing reading on their own (Koskinen et al., 2000). In addition, for students with reading disabilities, audio support during sustained silent reading is related to increased reading fluency (Esteves & Witten, 2011). Text-to-speech audio supports have also been shown to be particularly helpful for students who have poorer reading comprehension (Disseldorp & Chambers, 2002). These findings suggest that audio can support a variety of learners in many of the key areas of reading success including vocabulary development, engagement, and reading fluency.

ReadWorks gives teachers the option to enable audio support for their students, allowing students to listen to the article read aloud. Teachers can enable audio either for particular students or for their whole class. The audio is either human-read or computerized text to speech of the written passage. While ReadWorks had begun implementing the audio support feature before their collaboration with LVP, its expansion to all articles was prioritized once the value of this support was highlighted based on the research.

Split screen

In order to support students' working memory and attention, we proposed that ReadWorks add a split screen option which displays both the passage and comprehension questions simultaneously. Use of this feature reduces students' need to recall information from the passage when responding to questions, thereby presumably reducing cognitive load—that is, reducing the load on students' working memory and similar cognitive processes (Al Nadabi, 2015). This feature is supported by research suggesting that the split screen format allows students to focus only on the relevant information and to more efficiently navigate and process the reading material (Jarodzka et al., 2015).

Visual reading aids

Visual reading aids provide students with choice in their experience viewing and interacting with the reading material and can support attention, focus, engagement, and comprehension. The text magnification feature, for instance, allows students to adjust the size of the passage text, which can help them in different ways. For example, while larger text has been shown to increase reading fluency for younger children and some children with dyslexia (O'Brien et al., 2005), other research has found that older or more skilled readers show improved comprehension when reading smaller text (Katzir et al., 2013).

Other visual aid features that were added include a guided reading strip, which grays out all but a single line of text and may help students who have challenges focusing or keeping track of where they are in the text. Paragraph numbering may also help students navigate longer passages, find and communicate evidence from the passages, and facilitate communication with teachers and classmates. Though these benefits have been seen in the classroom, more research is needed on who these features may best support as well as their implementation on a digital platform.

Annotation

Online annotation tools, including highlighting and note taking, similarly allow students to keep track of important parts of the text and to take notes on their reading. Highlighting text can be a useful visual aid to quickly find key information. To date there is little research on the impact of digital annotation, though there is some promise in the findings thus far. Researchers Lu and Deng (2013) found that online annotations, including highlighting and note taking, fostered active learning by allowing students to locate and integrate evidence and provide explanations. In addition, actively highlighting text on paper has been shown to benefit comprehension performance when answering questions related to the highlighted text, for making inferences about the passage, and for comprehension of difficult, compared to easier, passages (Dunlosky et al., 2013).

With the exception of the audio support, the described features are always available for all students through the article interface (Figure 1). Together the features represent a suite of options to support certain aspects of learner variability. Students with varying strengths and challenges may use these tools to support their reading. Accordingly, we do not expect that all students will need and use the same supports, or even that an individual student will need the same support all of the time. As such, a critical component of the LVP-ReadWorks partnership is to take individual differences into account in the investigation of the use and impact of these features on the digital platform.

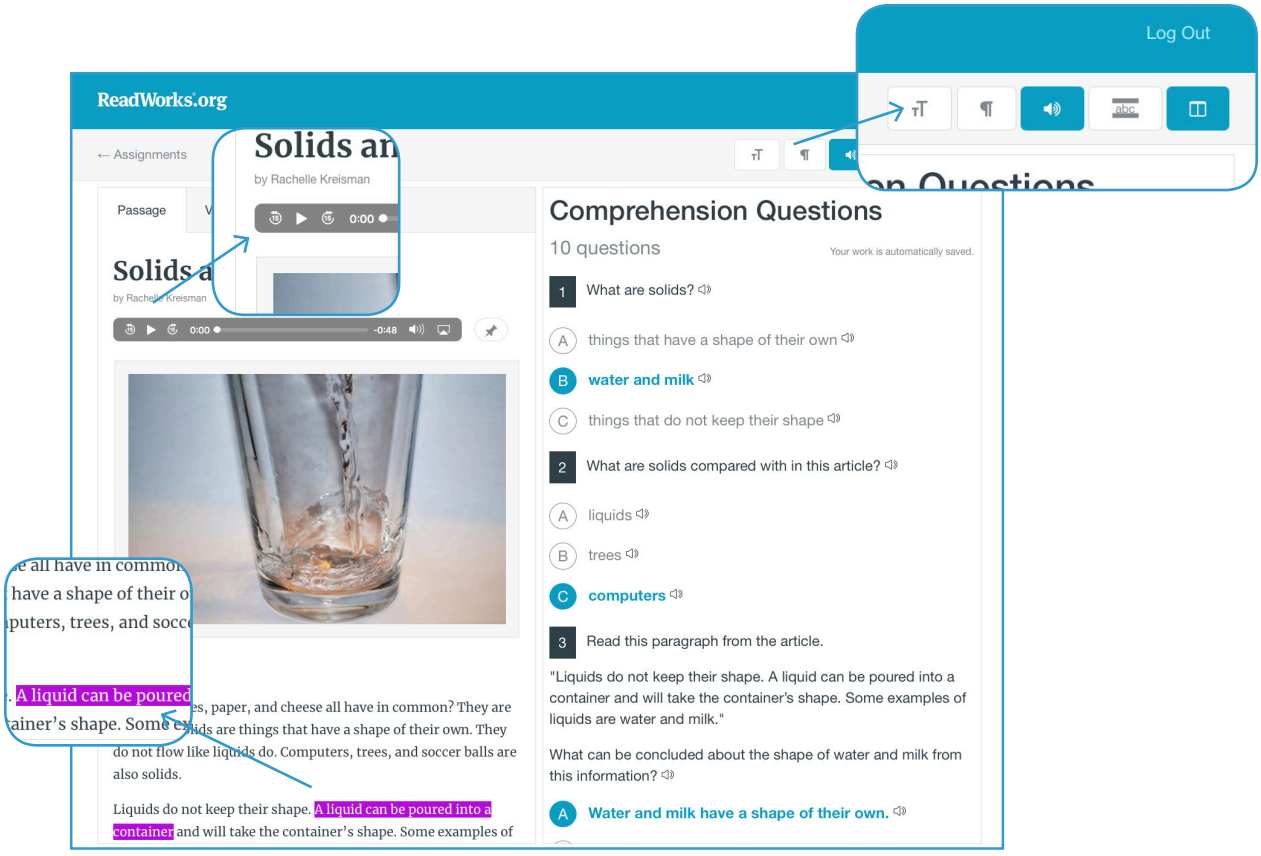


Figure 1:

Screenshot of ReadWorks' student interface, which highlights new features including audio supports, split screen, annotation, and visual reading aid options

Use and Impact of Learner Variability Supports

The Learner Variability Project partnered with ReadWorks to assess the relationships among feature implementation, use, and teacher and student behavior. Though many edtech products engage in some user testing, most do not have the internal resources to undertake this type of rigorous investigation (Tripathy et al., 2018). Examining teacher and student reactions and behavior in response to the feature implementation is critical to establishing how the features are used and how they might be supporting learning. This level of investigation was possible as a result of the combined resources of the LVP and ReadWorks partnership.

We proposed a model of these relationships (Figure 2) and investigated the validity of the model through a mix of qualitative and quantitative research methods to gain insight into the mechanisms by which students may benefit (ter Beek et al., 2018).

We examined these relationships at multiple levels in order to best capture the trends; these included (1) a high-level national survey, (2) an initial examination of the use of ReadWorks in a school district, and (3) an analysis at the level of feature use on the platform.

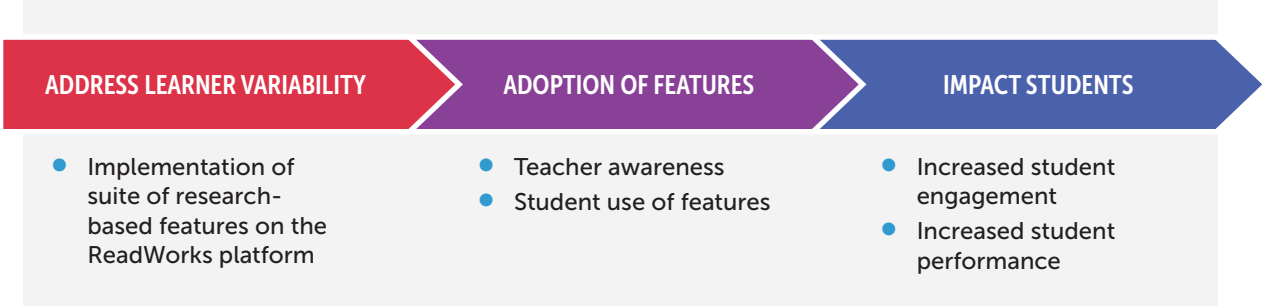


Figure 2:
Proposed model of impact of designing for learner variability

Level One: National Survey of ReadWorks Subscribers

The first level of assessment examined ReadWorks use by teachers and school-based specialists from across the country who subscribe to ReadWorks. In October 2018, an online survey was emailed to approximately 500,000 active subscribers, probing their awareness and use of 15 features supported by the LVP partnership, including those described above. Of the 11,408 responses we received in one week, 75 percent were K-12 classroom teachers and 21 percent were school-based specialists (e.g., reading coaches, special education teachers, librarians). For this report we were interested in the use of ReadWorks in a school setting and therefore limited our analysis to these school-based educators. We will use the term "teachers" to describe this group within the context of the survey.

For each feature, respondents were asked: (1) whether they knew about or had noticed it on the ReadWorks website; (2) whether they thought it could support students' learning; (3) whether they have used it or encouraged their students to use it; and (4) whether they had observed it support students' learning.

For the six features described above, we observed several trends as shown in Figure 3. For features other than audio, which was the most known feature, we saw that more teachers reported thinking that a feature could support students' learning than actually knew it existed on the platform.[1] For all of the features, many more teachers reported knowing a feature existed than said they had tried it or encouraged a student to try it.[2]

Finally, when teachers had tried a feature, the majority of them reported that they observed it supported students' learning. Together these results suggest that more outreach is needed with teachers to encourage them to try features in their classrooms. That many teachers report positive impact on students' learning when they know about and use features suggests that students are benefiting from feature use.

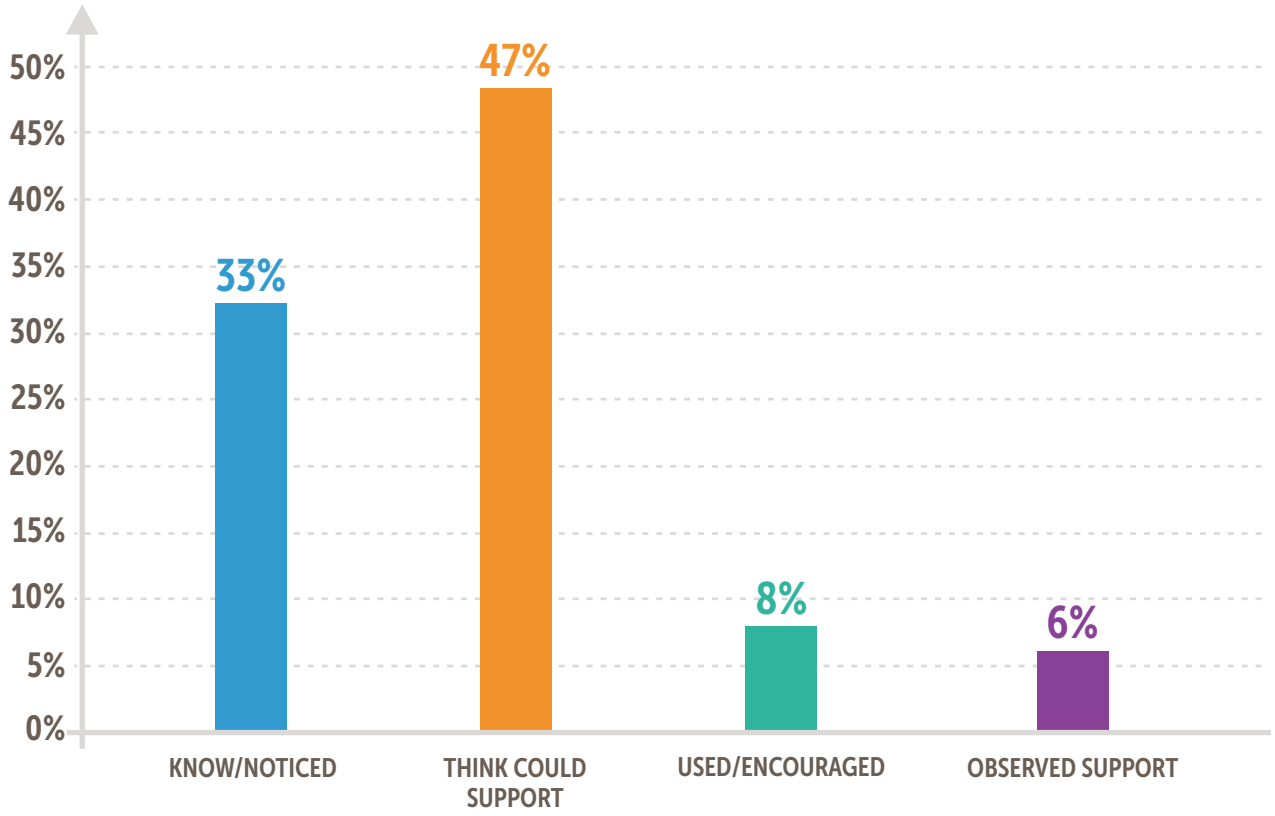


Figure 3:
Teachers' responses to survey questions averaged across targeted features

[1] These proportions were significantly different when tested with a 2-proportion Z test ($X^2(1) = .414.76$, $p < .001$).
[2] These proportions were significantly different when tested with a 2-proportion Z test ($X^2(1) = 2840$, $p < .001$)

Additional evidence of teachers' enthusiasm for the features came from two overarching questions about the suite of features. Of the respondents who had tried at least one of the features on our survey, 89 percent responded that they are likely to assign *more articles* on ReadWorks and 82 percent said that they are likely to assign *higher-level articles* on ReadWorks as a result of the features available to aid students. These results suggest that the features may encourage teachers to challenge students and maintain high expectations for their performance.

TEACHERS' RESPONSE TO FEATURES

89% ARE LIKELY TO ASSIGN **MORE ARTICLES** ON READWORKS

82% ARE LIKELY TO ASSIGN **HIGHER-LEVEL ARTICLES** ON READWORKS

Finally, we asked teachers to provide examples of how any of the features have supported their students' learning, including any relevant student characteristics. These open-ended responses were coded for (1) the features listed, (2) the student population mentioned, and (3) the type of support that the teacher indicated the feature provides. Codes were applied to responses until saturation was reached (i.e., the point at which analyzing additional responses did not reveal new information). In total, content codes were applied to 1,716 responses from Grades K-6 teachers and specialists. Figure 4 depicts a word cloud of the codes that were applied to their responses.

The most frequently coded feature from these responses was the audio supports. Teachers reported that this

Figure 4:
Word cloud of teachers' coded responses (text size reflects frequency of code application; larger text = more frequent)

feature supported students with their reading comprehension and argument and discussion skills, and that it primarily aided populations of below-grade readers, English language learners, and special education students. The split screen and annotation features were also frequently mentioned as supporting students' argument and discussion skills. From these responses, it is apparent that teachers use many of these features to support a variety of student needs, and even more *think* that these features could support these needs.

> **"I use these features to differentiate learning for students. My class is a diverse group with a reading level range of Grade 3 to 8."**
>
> *Classroom teacher, Grade 6*

> **"The guided reading strip has also helped students to better focus on their reading without being distracted by large amounts of text."**
>
> *Classroom teacher, Grade 3*

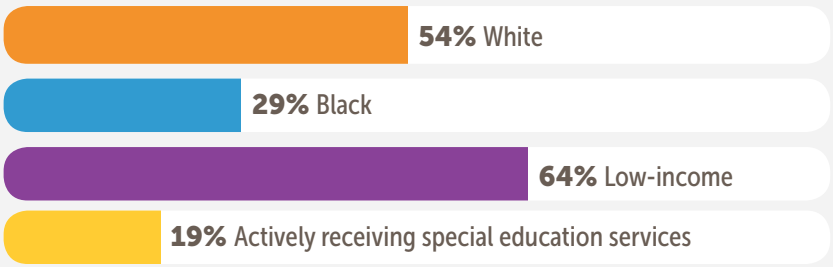
Level Two: ReadWorks Use in the Classroom

While these national survey data provide a high-level view of teachers' awareness of and response to the features, we also need to dig further into students' use and response to the features to determine how they relate to behavior and learning. To do this, in the fall of 2018 we partnered with a school district that had a high use of ReadWorks in order to study the individual differences in how teachers and students used the platform. In particular, we partnered with a rural school district in the South, focusing on their elementary schools' use of ReadWorks.

In addition to the data on teachers' and students' use of ReadWorks and its features, we also examined data provided by the district on student characteristics, including their standardized scores on the Renaissance STAR reading assessments, their special education status, and free/reduced price lunch status. These data indicate some of the types of learner variability that exist and potential sources of students' different strengths and challenges in the classroom.

School Profile

1857 Students Completed ReadWorks Assignments



82 Teachers
Made ReadWorks Assignments

1 to 1
Student to Digital Device

For example, Figure 5 shows the wide range of individual students' STAR Lexile scores within each grade, demonstrating the variability along this dimension, and the importance of meeting students where they are to help them continue to grow. Ultimately the teachers' goal is to assist each student in improving their reading comprehension, not just boost the average test scores.

Our initial analyses examined how teachers assigned ReadWorks articles. We found that students tended to be assigned articles that have a higher difficulty (based on Lexile level) than the students' STAR Lexile level, such that on average, the Lexile level of assignments was around 375 points higher than the Lexile level of the student.[3] Students completed about six assignments (median) on ReadWorks over the five months of the study. In examining how use of ReadWorks was related to changes in students' STAR test scores from the beginning to the middle of the school year, we found that greater STAR score growth was positively related to completing more assignments on ReadWorks, completing harder assignments on ReadWorks, and having a higher accuracy on ReadWorks multiple choice comprehension questions.[4]

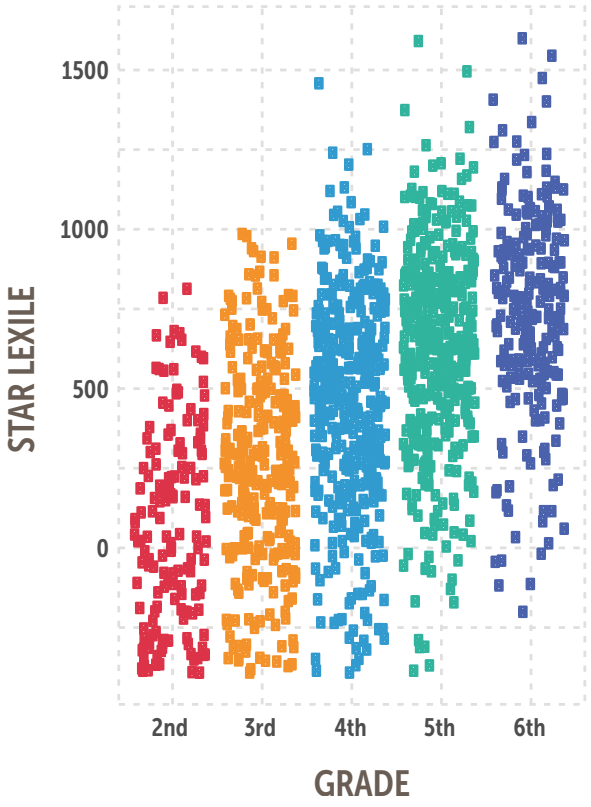


Figure 5:
Distribution of students' STAR Lexile score by grade (each dot represents an individual student)

[3] The difference between student and assignment Lexiles was estimated using a mixed-effect linear model which included a random intercept by student and both random intercept and slope by grade (t = 4.7, $p < .01$; 95% confidence interval of 215 - 535 points).

[4] These effects were estimated using a mixed-effects linear model that also included fixed effects of free lunch status and beginning student Lexile level, and random effects of teacher on the intercept and slopes of lunch status, assignment difficulty, and multiple choice accuracy. Analyses found significant relationships between STAR Lexile growth and: number of assignments (t = 2.8, df = 123.8, $p < .01$); difficulty of assignments (t = 3.7, df = 149.8, $p < .001$); and multiple choice accuracy (t = 7.3, df = 47.6, $p < .001$). Note that for these analyses, students who began at a Lexile of BR200 or lower were excluded, given the status of these students as very beginning readers, for a final N of 1,099 students.

Level Three: Analysis of Feature Use

Students' use of the ReadWorks product features described above was analyzed to determine whether particular populations of students used them and how that use related to student behavior. Though each of these features has its own potential benefits, together they are able to provide support for a variety of learner needs—because of that, we focused our analysis on use of the features collectively, rather than use of individual features.

We found that 92 percent of students had used at least one of the LVP-supported product features over the course of the study and that 75 percent of assignments were completed with feature use. The most commonly used feature was the audio, followed by the split screen, which saw increased use over the first few months of the school year.

We also examined whether any individual differences in student characteristic data related to differential use of the features (e.g., lower STAR scores, active special education status, lower income); however, we did not find any differences in feature use between the student groups. Thus, it was not the case that only students who were labeled as needing additional support used the features, suggesting that students with varying strengths and challenges potentially

92% **OF STUDENTS USED AT LEAST ONE FEATURE IN THE STUDY**

benefited from feature use. The average rate of whether or not a student tried a particular feature varied significantly from teacher to teacher,[5] which is consistent with the view that teachers play an important role in enhancing students' experience when using edtech.

We next examined how feature use related to students' engagement and performance on the assignments. One measure of student engagement within the platform was their rate of attempting the multiple choice comprehension questions associated with an article. On average, students attempted the questions 78 percent of the time, dipping down to 68 percent when an assignment was hard for a student (as measured by the gap between student and article Lexile levels). We found that when students used at least one feature, their rate of multiple choice question attempts went up to 89 percent, and strikingly, stayed at this 89 percent level, even when attempting difficult articles (Figure 6).[6] Use of the features was also related to a slight increase in multiple choice accuracy, particularly for easier articles.[7]

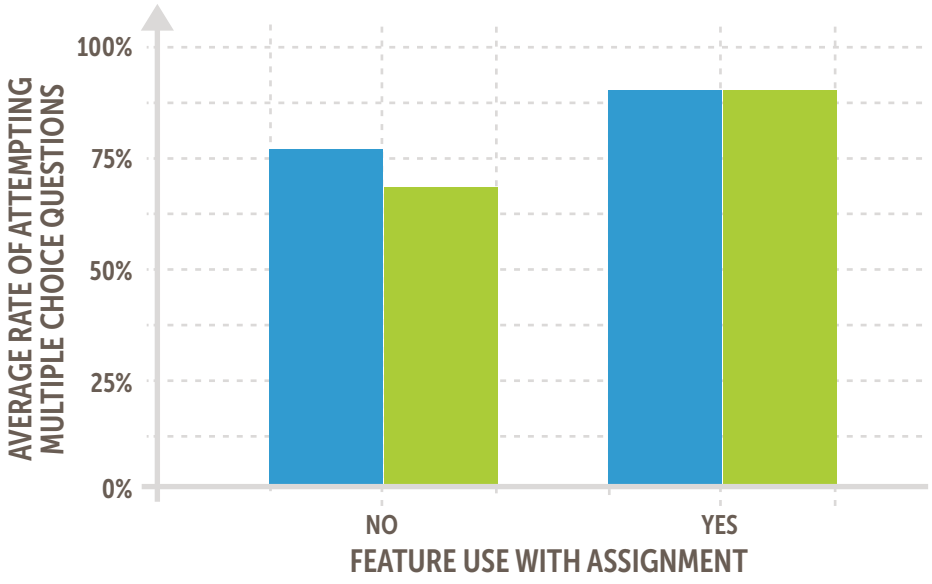


Figure 6:
Students' rate of attempting multiple choice question given article difficulty and feature use

Though we cannot make claims about the direction of this relationship due to the nature of the study, the findings are consistent with the theory of change outlined in the earlier model (Figure 2) that students' use of features supports their engagement with assignments, in this case responding to questions that they may not have otherwise.

Additionally, increased use and performance on the ReadWorks platform generally was related to students' growth on standardized tests over the school year. Thus, designing inclusive student platforms may allow more students to take advantage of the learning opportunities offered by edtech, though more research is needed to determine the true nature of these relationships.

RESEARCH-BASED SUPPORTS FOR LEARNER VARIABILITY CAN IMPROVE LEARNER ENGAGEMENT WITH EDTECH.

> **"The audio is invaluable for students with reading disabilities. It allows them to participate as their peers do."**
>
> *Special Education teacher, Grades K-5*

Analyzing Expansion of Feature Access

Most of the features that were implemented support student choice and appear as options on the student-facing ReadWorks platform. One feature, audio, is only available to students if their teacher has enabled access when assigning an article. This means that the choice to play the audio version of the article is limited to students whose teachers have provided that support. We did not find any particular pattern in the school district data indicating why teachers had assigned audio to particular students and not others. To explore how greater access to this feature related to teacher and student behavior, we worked with ReadWorks to change access to the audio for the users in our target school district. ReadWorks changed the default access to the audio support so that teachers no longer had to actively enable it, but rather could disable it if they did not want their students to have it. This change in the default setting resulted in an increase in audio support availability from 72 percent to 99 percent of assignments. More students also made use of the feature, with the proportion of students who played audio in any of their assignments rising from 68 percent to 84 percent.

[5] In a mixed-effects linear model of rate of feature use, the variation in feature use due to teacher was estimated to be a significant component of the model (X^2 = 368.03, df = 1, p < .001), such that on average the rate of feature use varied from teacher to teacher by around +/-17.5%.

[6] We fit a mixed-effects logistic model of rate of multiple choice attempts, excluding students on the extreme low range of Lexile (BR200 and below, total number of students = 1,365, total number of observations = 14,879). In this model, both feature use and article difficulty (as measured by the gap between student and article Lexile levels) predicted rate of attempts (z = 14.7, p < .001 and z = -7.1, p < .001, respectively). As described in the main text, there was a significant interaction between feature use and article difficulty (z = 6.7, p < .001), with an effect size such that the effect of feature use was large enough to cancel out the impact of a 300-400 point gap in Lexile scores (i.e., 1 standard deviation).

[7] For students and articles at average Lexile levels, a mixed-effect linear model estimated that students' multiple choice accuracy was around 2.5% higher when they used any feature (t = 3.6, df = 9,788, p < .001). Interactions were significant such that the effect of feature use was larger for lower-Lexile students (t = -2.7, df = 11,053, p < .01), and larger when the difficulty (Lexile gap between student and article) was lower (t = -2.1, df = 11,359, p < .05).

Key Findings and Lessons

Several findings from our partnership with ReadWorks support the conclusion that successful application of research-based strategies to support diverse learners requires efforts by multiple stakeholders. Key takeaways which emerged when considering the findings from all of the analyses include:

1. Targeted Professional Development

Our survey findings show that while in most cases almost half of teachers thought that the listed features could support student learning, many fewer actually knew about or had noticed the features on the ReadWorks website. Even fewer had used or encouraged their students to use them. However, when teachers had used the features, they observed learning improvement and thought they were effective.

> **"I would like more tutorials on the different features...if you could model how some of these features are used. Sometimes teachers do not have time to truly dive into this great website and use to its fullest potential."**
>
> *Classroom teacher, Grade 3*

We also saw from the student data that a student's teacher is a strong predictor of students' feature use, even for features that are always available on the student-facing platform. Together, these results indicate that professional development for teachers that specifically encourages understanding and use of these features, perhaps through coaching or examples from other teachers, is needed.

2. Empowering Student Autonomy

> **"I find these features helpful for students when I am working in small groups, and students are working on their own. Students have support when I can't help them."**
>
> *Classroom teacher, Grades 3-4*

Our school-based data show that in general, all students, including those who had greater needs, used the features at similar rates. Students also used a variety of features. Having the student-facing options available means that students can choose to use whichever feature they need in the moment. A key finding was that increasing access to and encouraging the use of features, such as audio support,

may increase student engagement and reduce barriers to learning, as we found when students attempted questions when using features, essentially eliminating the effect of article difficulty. In fact, teachers commented on how these features enable greater independence in students.

3. Continuous Assessment of Feature Implementation

Our experimental study of the audio supports on ReadWorks showed that when audio was available to more students, more students used it. Thus, continuous re-evaluation of the ways that features are implemented may be a valuable source of information for product developers. These manipulations may inform how their users interact with the platform and suggest ways to reach more learners through user-centered research.

Conclusion

Our studies, using both qualitative and quantitative data, provide insights into the effectiveness of the digital implementation of several features that support learner variability and that currently have limited existing research. Previous summaries of the state of the science have found that "because personalized learning is composed of so many interrelated strategies, considerable additional research will be needed to sort out the fine details of which strategies, and in which combinations, are most effective for which students" (Pane, 2018).

Examining feature use and engagement at the student level represents a first step in demonstrating how teachers and students may incorporate product features to meaningfully tailor instruction through edtech. While further research is needed to determine how features such as these affect learning, our findings shed a promising light. Teachers in the study, for example, report that these evidence-based features increased student access to content in the ReadWorks platform. Many students also used the features to increase their engagement in schoolwork—a central goal for all involved in the education process and an essential component for learner success.

Suggested Citation

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ReadWorks.org

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