# Learning Design and Research Base for Edmentum Exact Path

October 2021

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## Introduction

Today's students eagerly expect, and often have the need for, digital learning environments. As the sophistication of educational technology has expanded, many teachers have come to rely on online learning, whether to capture and analyze real-time student performance data, or to deliver individualized content in a blended classroom. We saw this effect in the 2020–21 school year when schools were forced to close their physical locations during the coronavirus pandemic; virtual tools and educational technology became a major delivery mechanism and a key support.

Technology continues to be utilized by more and more educators as a meaningful tool for instruction. Although technology will never be as important as teachers, educators have embraced the additional opportunities technology provides to set up their students for success. Engaging digital content has expanded what teachers can do within a traditional classroom or blended learning environment, and multiple implementations confirm the power of digital content to enable instruction in a virtual setting on a large scale. Furthermore, schools and districts have been able to utilize digital educational tools to reach students who have not had success in traditional school settings or who require more flexibility in setting, schedule, or instructional pace. Data gathered from digital content serves a key role in continuity planning for the future.

Edmentum develops research-based digital educational solutions and tools to support teachers in creating successful student outcomes, no matter the educational setting. The roots of the company trace back to the early 1960s and the University of Illinois at Urbana-Champaign, under the name PLATO. The company created what most experts agree was the first authentic computer-assisted instructional system designed for widespread use (Dear, 2017).

That first digital learning system was a milestone, not only because it was computer-based, but also because learning scientists designed it. PLATO embodied revolutionary instructional principles that incorporated leading insights in education and psychology. It featured a number of innovations useful for instruction, including digital graphics overlaid with text and animation—both essential to quality computer-based education. Later, adding audio was a key feature to reaching students for whom reading had been a barrier to understanding.

PLATO grew to include:

- opportunities for social learning with teacher-student interaction
- a rigorous curriculum
- sound assessments
- personalized learning strategies to increase student motivation and achievement

Founded in innovation, we are committed to being educators' most trusted partner in creating successful student outcomes everywhere learning occurs.

Today, principles behind the PLATO system are the groundwork for Edmentum Exact Path—an adaptive learning platform providing individualized instruction and diagnostic assessment, designed to support teachers as they differentiate instruction for their students. What has remained constant for more than 50 years is the priority Edmentum places on educator needs and student outcomes. Over the years, the research community at large, including educational psychologists, practitioners, learning scientists, and philosophers of education, have continued to research and expand the principles of learning theory, which are then rigorously applied to Exact Path.

Today's educators operate in a variety of learning environments, from brick-and-mortar schools to virtual learning, and everything in between. Teachers create supportive and engaging communities and develop relationships that foster learning. Their impact on students is wide-ranging, including teaching academic knowledge and skills, developing critical thinking, and helping students to develop into moral people and good citizens. Edmentum programs honor the role of teachers as critical influencers of student learning—a point highlighted in John Hattie's meta-analysis of more than 1,200 studies (Hattie, 2009, 2012, 2015). Charles M. Reigeluth, who described the differences between learner- and teacher-centered technology, also stressed the importance of teachers in providing instructional support in the learner-centered model and acting as a bridge between technology and complementary hands-on resources (Reigeluth, 2014).

> Educational researcher John Hattie provides research-based answers for the question: "What educational practices have the greatest impact on students?

Schools are turning to technological solutions, including online courseware, to provide teachers with additional tools to meet the needs of a wide range of different learners. Educators also view technology as a way to anticipate and prepare for the needs of a technology-inclusive future. Edmentum partners with educators, making it easier to provide individualized learning for every student through easy-to-use technology, high-quality content, and actionable data.

This paper will discuss:

- the needs of today's learners and educators
- the six research-based learning design principles of Exact Path
- the role of Exact Path in school learning environments

## Who Are Today's Learners?

*Self-paced*, *independent*, *tech-integrated*, *active*, *diverse*, and *impatient* are some of the adjectives that describe today's students. Traditional learning environments of the past do not match the needs of many of these learners. By understanding the specific needs of today's learners, educators can better prepare for and teach these learners.

Recent work by University of Arizona educational researchers (Seemiller & Grace, 2016, 2019) indicates that students who are in school now and who will be entering school in the coming years share some common characteristics and a common context that shapes their worldview.

Seemiller and Grace describe today's students as *tech-integrated*, compared to the previous generation whom they describe as *tech-savvy.* Because current students have been immersed early and often in technology—cell phones, tablets, and smart devices—and have information available instantly through the internet, they tend to expect technology to integrate and improve their day-to-day lives. They approach new objects as technological in nature even if they aren't sure how they are used. For example, kindergartners are frequently confused by a desktop computer with a mouse. They've sometimes been observed pointing the mouse toward the computer screen like the more familiar television remote control.

Seemiller and Grace found characteristics of tech-integrated learners that can be well served by online delivery of learning experiences. Tech-integrated learners can benefit from the following qualities of online learning:

**Active learning.** This generation's work style tends to be active and investigation-focused. Self-directed, online work enables that interaction style.

**Independent work.** The individual nature of technology has helped students become accustomed to independent learning. This approach doesn't preclude lessons where students work collaboratively in groups, engage in discussion, and give feedback. But the modality of online learning is uniquely suited to independent work not bound by location, space, and time.

**Individualized pacing.** The current generation of students prefers self-directed work and tends to view teachers as facilitators of learning, rather than transmitters of knowledge. Today's learners are motivated by milestones. It's extremely difficult for teachers to manage a large class of students all working at their own pace on the content they are ready for at that moment. Technology supports teachers in providing more highly-individualized instruction than possible without it. Materials that can be customized to fit the learner's individual needs allow teachers to provide key milestones to guide student pace.

## Who Are Today's Educators?

Today's educators recognize that the needs of their students are more diverse than ever, which makes the requirements of the teaching profession more demanding than ever. Most teachers are on the road to embracing technology that helps manage data, support instruction, and enable individualization.

In many school systems, technology has fundamentally restructured teachers' roles in education as well as the way students understand teachers and interact with them. In generations past, teachers were considered the sole source of knowledge for their particular subject area, and students had few other ways to easily access information. But today's world is flooded with a plethora of easily accessible information, and the job of teachers is no longer limited to providing every detail of instruction about a topic. Rather, today's educators often act as facilitators, helping students learn how to evaluate and use the information they access. Teachers are also critical in building relationships with students: understanding them as whole-learners and using their connection to influence and motivate. By both facilitating learning and building relationships, teachers meet students where they are instructionally, building a bridge to improved learning outcomes and "just-right" experiences and opportunities. Technology helps to ensure that all of this occurs in the appropriate way at the best time for each student.

In classrooms with many students, it's challenging and unsustainable for teachers to manually provide individualized instruction for each learner. Digital learning tools can be used to facilitate effective personalized learning. As discussed earlier, the thoughtful and deliberate integration of technology into classrooms amplifies teacher effectiveness by offering the power to efficiently do more. Teachers can utilize technology to assign individual practice, grade student work, monitor progress toward meeting key milestones, and communicate student learning progress with families. Teachers are eager to support students based on individualized needs. When used appropriately and innovatively, technology provides teachers the tools to meet the individual needs of larger numbers of students effectively and in a sustainable way.

## Exact Path Meets Today's Needs

Every skill in Exact Path is designed to meet the needs of today's teachers and learners. Many students need the opportunity to independently access engaging digital content on their own timing under the guidance of a supportive educator. At the same time, educators are looking for tools to more efficiently support the individualized needs of a wide range of learners. Exact Path provides the tools to meet these needs.

### Addressing Today's Learner

**Individualized learning progression adapts based on assessment data, which ensures a personalized learning path.** Exact Path supports efficiency of learning for students as they advance in an individual learning progression based on their current learning opportunities. Learners move through content at their own pace and demonstrate mastery of skills via a Progress Check before advancing to the next learning opportunity in their progression. If the Progress Check data shows learners need more instruction, the student learning path changes to match instruction to meet those needs.

**Dynamic, interactive, digital content engages students.** Learning is best when students are actively engaged. Exact Path uses a variety of research-based practices to keep learners engaged as they move through their learning progression.

### Supporting Today's Educator

**Teachers are supported in addressing the needs of all students through automated differentiated instruction.** The varying needs of each learner are complex and challenging for an educator to manually account for. Exact Path is an automated tool that provides skills data, differentiated instruction, and progress monitoring to support teachers in addressing each unique student's learning opportunities.

**Data and reports powerfully inform instructional decisions.** Real-time student performance data is presented with clear visualizations and is easily accessible through dashboards. At a quick glance, the dashboard provides information about which skills students have mastered and which students are currently practicing. Teachers can use the data from Exact Path to impact their instruction, increasing learner success.

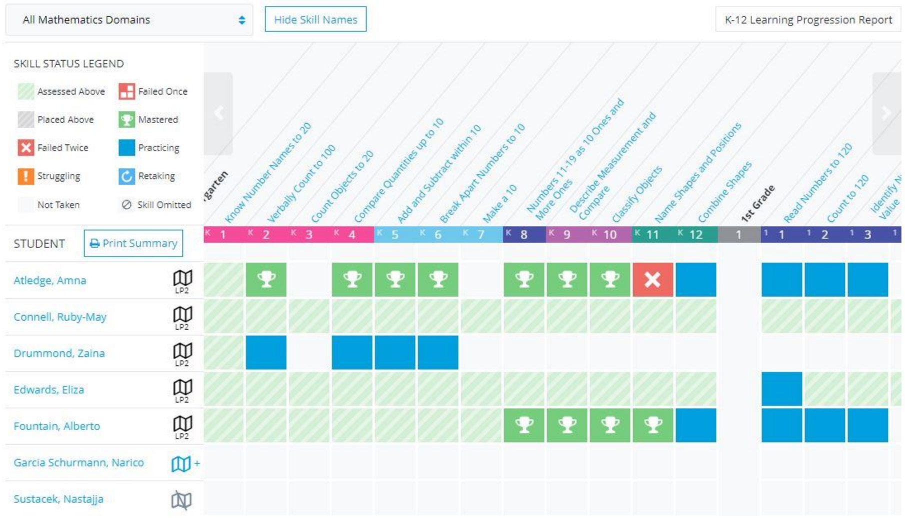



*Figure 1. Exact Path's Knowledge Map shows real-time student performance data, color-coded for at-a-glance understanding.*

**Flexible assessments keep educators in charge.** Edmentum assesses aptitude and achievement in many ways. The initial Diagnostic Assessment helps to determine key opportunities for learning. The results generate an individualized placement within each subject area domain of the learning progression. The ongoing Progress Checks confirm how students are progressing through their learning paths as they master the skills. This robust range of assessment techniques makes Edmentum's assessments useful, accurate, and flexible.

**Flexible assignments allow teachers to customize student learning.** Exact Path allows educators to assign material to learners in addition to what they encounter in their learning paths. Teachers can use data from Exact Path assessments, outside assessments, or observation to align materials to unique learner needs.

## Research-Based Design

Educational psychologist John Carroll (1989) proposed that intelligence can most accurately be defined as the amount of time it takes a person to master a task. This notion called attention to the implicit belief that all learners should master cognitive tasks in the same amount of time.

In practice, what is gained by uniformity of time constraints in learning is efficiency in mass-educating students. The belief was that the collective could be held back by struggling learners. A uniform time constraint is interpreted as saying that there are fast and slow learners whose abilities are fixed at birth.

However, by removing the necessity of uniformity in lesson, sequence, and time, Edmentum has a working model for individualized learning.

These are three principles of the individualized learning model:

1. Every learner receives lessons appropriate to their level of development.
2. Every learner receives lessons sequenced in a flexible way to accommodate personal progress.
3. Every learner receives lessons paced based on their individual needs.

Individualized learning allows every student to receive assignments tailored to their level of learning readiness. Students are given the time they need to achieve mastery, and when given that time, most students in the classroom are expected to cross the mastery finish line.

Figure 2 shows two visions to illustrate the effect of fixed versus variable transformations of scores on a normal distribution.

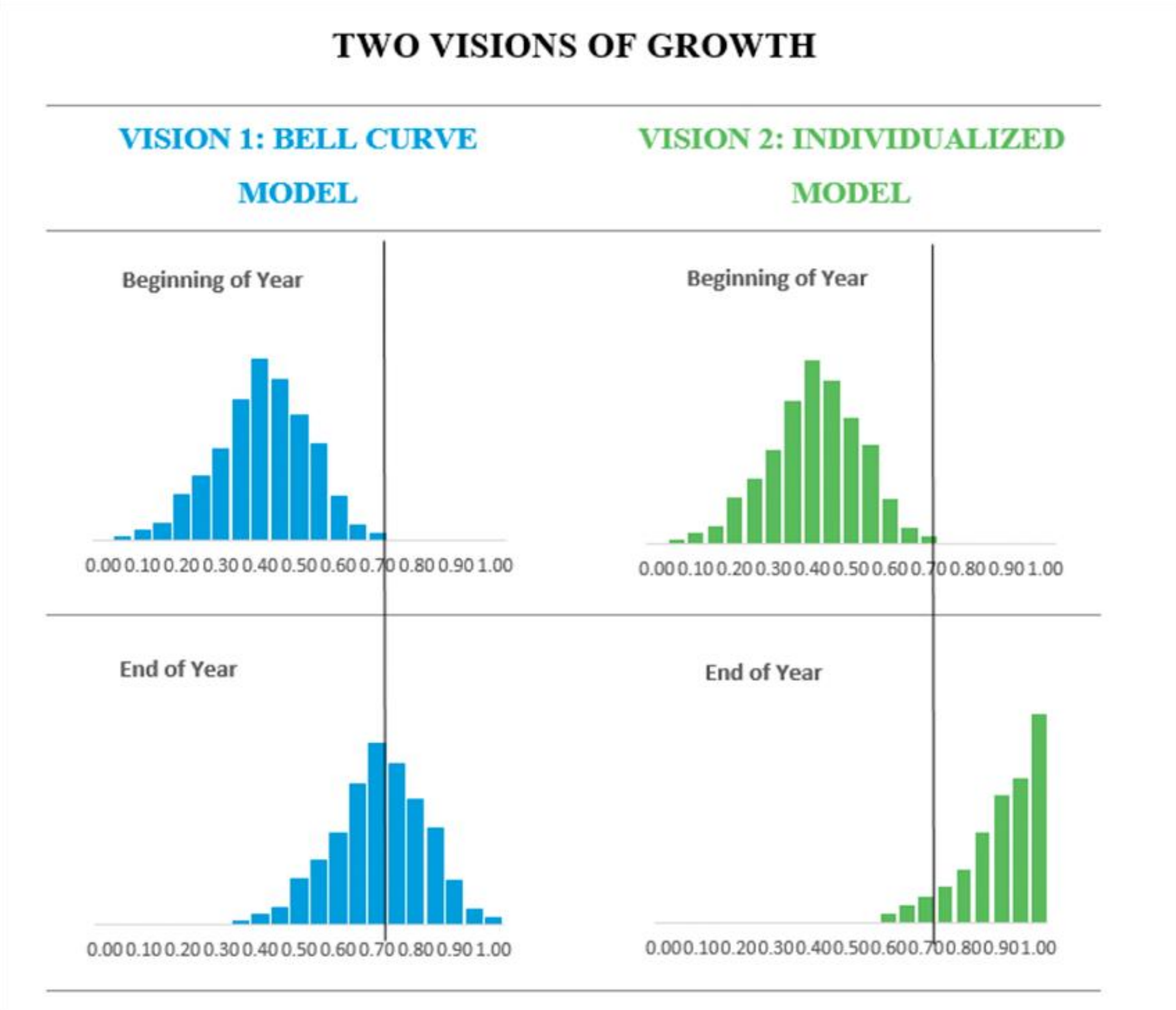



*Figure 2. The individualized model allows for differentiated rates of learning.*

Vision 1 shows the expected pattern of growth when (1) a uniform curriculum is applied to the whole class, and (2) the classroom is managed under the constraint that the average rate of learning suffices for all. In more technical terms, when you add a constant to scores in a normal distribution, the new distribution has the same shape but is shifted. Quick-learning students cannot accelerate the pace, and students who need more time cannot hold the pace back. All students progress, but virtually all learners who were at the top of the class at the beginning of the year cross the proficiency line, while most of the learners at the bottom of the class remain at the bottom.

Vision 2 shows the growth pattern when (1) a differentiated curriculum is prescribed for each student, and (2) differentiated rates of learning are recognized and accommodated for each student—therefore, self-paced learning is built into the classroom. In Vision 2, we see that almost all students are envisioned as achieving proficiency. As above, we can view this in more technical terms by saying that we multiply each score in the distribution not by a constant but by a variable that depends on a particular student's diagnosis.

Note that this is not just a strategy to bring the lowest-performing students to the top, though that is indeed a desirable outcome. It is a strategy that also challenges the mid-range and top-performing students to move outside their comfort range to achieve the advanced excellence of which they are capable.

## Research Into Practice

Individualized learning looks good in theory. But does it work in practice? Can educators use these principles to narrow achievement gaps? It appears so. In this section, we will focus on significant findings in this area.

The RAND Corporation (2014) performed a study on the effectiveness of personalized learning, which is an extension of individualized learning. First, the researchers observed schools that appear to be vanguards in this model. From these observations emerged a list of common approaches used in personalized learning:

- Learner profiles of each student's individual strengths, needs, motivations, and goals that help the teacher find ways to reach children in a way that is meaningful to them personally and individually.
- Personal learning paths in which each student is placed on a customized path of instruction that responds to and adapts to where they are right now in terms of readiness.
- Competency-based progressions in which a student is given clearly defined goals and is repeatedly assessed on progress toward these goals until mastery is attained.
- Flexible learning environments in which the classroom can be shaped and designed to accommodate the differentiation in levels of student readiness.

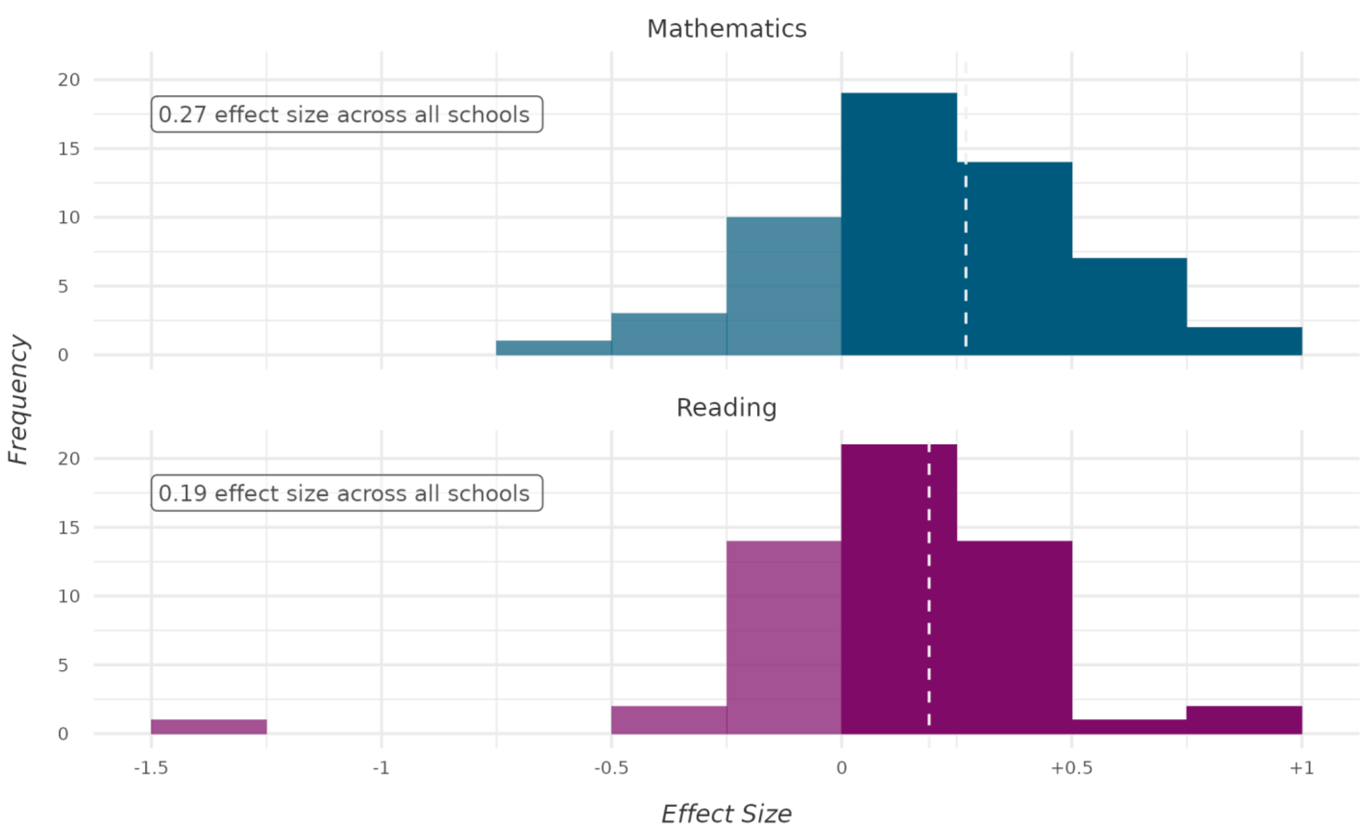
The study went on to measure the schools' success in reading and mathematics gains over two school years as compared to a control group of schools, using the Northwest Evaluation Association's Measures of Academic Progress (MAP).

The experimental group performed better in both mathematics and reading. The effect size for math was .41, which in practical terms suggests that a student in the 50th percentile of the control group would have performed at the 66th percentile in the personalized learning (experimental) group. The effect size for reading was .29, which translates into a treatment effect that would lead from the 50th percentile rank to the 61st percentile rank.

Like much of the research in mastery learning over the past 50 years, this study unveiled an exciting trend: The lowest-performing students in the schools had the greatest gains. This is precisely what the individualized learning vision sets out to do.

Pane, Steiner, Baird, and Hamilton (2015) continued the RAND study described above and expanded the treatment sample to 62 schools. They used the same methodology as the earlier study and found that the growth trends increased after a two-year follow-up, though the effect sizes decreased slightly. Figure 3 summarizes the results of the study. It gives a strong sense of the magnitude of effects across schools. Certainly, this learning framework is an approach that holds exciting possibilities for the future.

**Summary of Pane, et al. (2015) Study of Personalized Learning**




**Data Source**: *Pane et al. (2015)* Continued Progress: Promising Evidence on Personalized Learning.

*Figure 3. Study results showed that schools (K–12) using a personalized approach performed better in both mathematics and reading than those that did not.*

# Exact Path Learning Design Principles

In this section, the specific components of Exact Path are evaluated based on the rigorous learning-science research conducted over the last 50 years. Six learning design principles provide the foundation of Exact Path's learning methodology. Each principle is rooted in theory, best practice, and research.

### Adaptive, Individualized Learning

Tailor learning to each student by providing instruction at the appropriate level, sequence, and pace.

### Assessment-Driven Mastery Learning

Focus on efficient learning. Students show mastery of key content via assessment, invest time on not-yet-mastered content, and proceed through learning new content at their own pace.

### Deliberate Practice and Immediate Feedback

Offer intentional and aligned practice to support increasing levels of understanding. Provide immediate feedback and coaching to improve student success.


### Explicit Instruction and Scaffolding

Delivery of content begins with explicit instruction, then using a scaffolded approach, students move toward independent application.

### Active, Engaging Learning

Involve learners in responding to and manipulating information while they learn—ensuring involvement in building understanding and minimal passive reception of information.

### Subject-Area Best Practices

Engage learners and build understanding by using research-based best practices and instructional strategies.

## Adaptive, Individualized Learning

Adaptive, individualized learning is personalized learning that adjusts as the student progresses to continually meet evolving student needs. Research conducted by RAND (2014) found that there are four consistent approaches to successful personalized learning.

**Learner Profiles.** These profiles provide in-the-moment data to educators on each student's progress, including strengths, needs, and current goals.

**Personal Learning Paths.** These customized learning paths adapt based on the student's learning progress.

**Competency-Based Progression.** Continual assessment of student progress allows students to advance when mastery is demonstrated.

> **Adaptive, Individualized Learning**
>
> Tailor learning to each student by providing instruction at the appropriate level, sequence, and pace.

**Flexible Learning Environments.** Students' needs are key to the design of the learning environment, providing flexibility in pacing, sequencing, and learning space to meet those needs.

### How Exact Path Applies the Adaptive, Individualized Learning Principle

**Diagnostic Assessment develops the learner's profile and identifies necessary learning opportunities within each subject domain, providing customized learning.** Once the learner completes the Diagnostic Assessment, Exact Path generates an individualized learning path for that learner. The individualized learning path allows the student to efficiently work through only the skills for which they have not yet demonstrated mastery.

| Skills | Learning Path 1<br>Started: 1/9/2020 | Learning Path 2 (Active)<br>Started: 3/22/2020 |
|---|---|---|
| $^{1}$1 Sounds in Words | Assessed Above | Assessed Above |
| $^{1}$2 Phonics and Word Analysis 1 | Assessed Above | Assessed Above |
| $^{1}$3 Syllables | Mastered 2/13/2020 | Assessed Above |
| $^{1}$4 Blending Sounds | Mastered 2/27/2020 | Assessed Above |
| $^{1}$5 Reading Fluently | Failed 2/27/2020 | Assessed Above |
| $^{1}$6 Word Categories | Mastered 3/5/2020 | Assessed Above |
| $^{1}$7 Connections Between Words | Mastered 3/5/2020 | Assessed Above |
| $^{1}$8 Using Context | Mastered 3/5/2020 | Assessed Above |
| $^{1}$9 Asking and Answering Questions | Not Completed 3/8/2020 | Mastered 4/9/2020 |
| $^{1}$10 Retelling Stories | Not Completed 3/8/2020 | Failed 4/9/2020 |
| $^{1}$11 Central Message and Lessons | Not Completed | Mastered 4/30/2020 |
| $^{1}$12 Characters | | Practicing 5/3/2020 |
| $^{1}$13 Setting | | Practicing 5/3/2020 |
| $^{1}$14 Major Events | | Struggling |
| $^{1}$15 Asking About Informational Texts | | Assessed Above |

*Figure 4. Individual learning paths are color-coded to indicate where the student stands in terms of mastery of each skill.*

**Progress Checks assess student mastery of skills and adjust flexible learning paths to deliver content on prerequisite skills, called Building Blocks, to fill knowledge gaps.** Exact Path's adaptive algorithm will expand a student's learning path if progress-check data reveals they are struggling to master a skill. A Building Block skill is added to the student's learning path to scaffold prerequisite skills with instruction that will support them in mastering the current skill within their learning path.

**Alternative content can be delivered to students when a skill is retaught, so learners get a fresh second chance.** If a student does not demonstrate mastery of a specific skill in their learning path after initial instruction, the student is provided the necessary Building Blocks to fill any knowledge gaps. When the student has succeeded with these Building Blocks and is ready to return to the current skill in their learning path, alternative content is delivered to provide the student a fresh opportunity to practice the skill before demonstrating mastery in the next Progress Check.

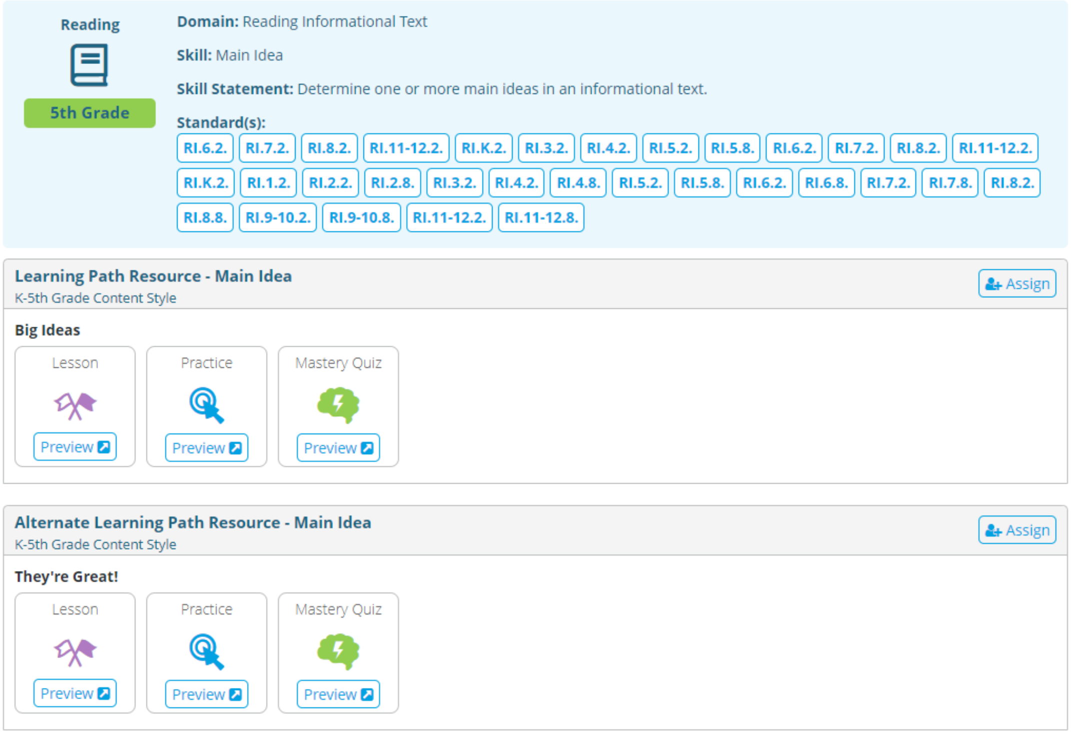



*Figure 5. Grade 5 Reading—If a student does not master main idea with the module "Big Ideas," they will get Building Block material and then revisit main idea with the module "They're Great!"*

## Assessment-Driven Mastery Learning

Mastery learning, which has also been called competency-based learning, focuses students on content that they have not yet mastered and enables learners to work at their own pace to master new concepts. It establishes an efficient investment of learning time because learners spend less time on what they already know while efficiently investing time on what they need to master (Le, Wolfe, & Steinberg, 2014). Mastery learning supports the positive message that every child, given enough time and the right approach, can learn well-defined skills to the level of mastery (Anderson & Krathwohl, 2001).

**Assessment-Driven Mastery Learning**

Focus on efficient learning. Students show mastery of key content via assessment, invest time on not-yet-mastered content, and proceed through learning new content at their own pace.

A key feature of mastery learning is that students progress through learning objectives at their own pace, demonstrating mastery through timely assessments that reflect instruction as they work. Assessments provide information to allow teachers to make decisions that best suit each learner. This ensures that the pace of instruction matches what each student is ready to learn (Haynes et al., 2016; Le et al., 2014).

## How Exact Path Applies the Assessment-Driven Mastery Learning Principle

**Diagnostic Assessment identifies skills that learners have already mastered and those which they still need to master, so their learning time is invested in achieving mastery.** The Diagnostic Assessment is an adaptive test that presents a series of items curated for each learner to quickly home in on each learner's appropriate placement in each subject. Each student response provides data the algorithm uses to choose the appropriate next assessment item.

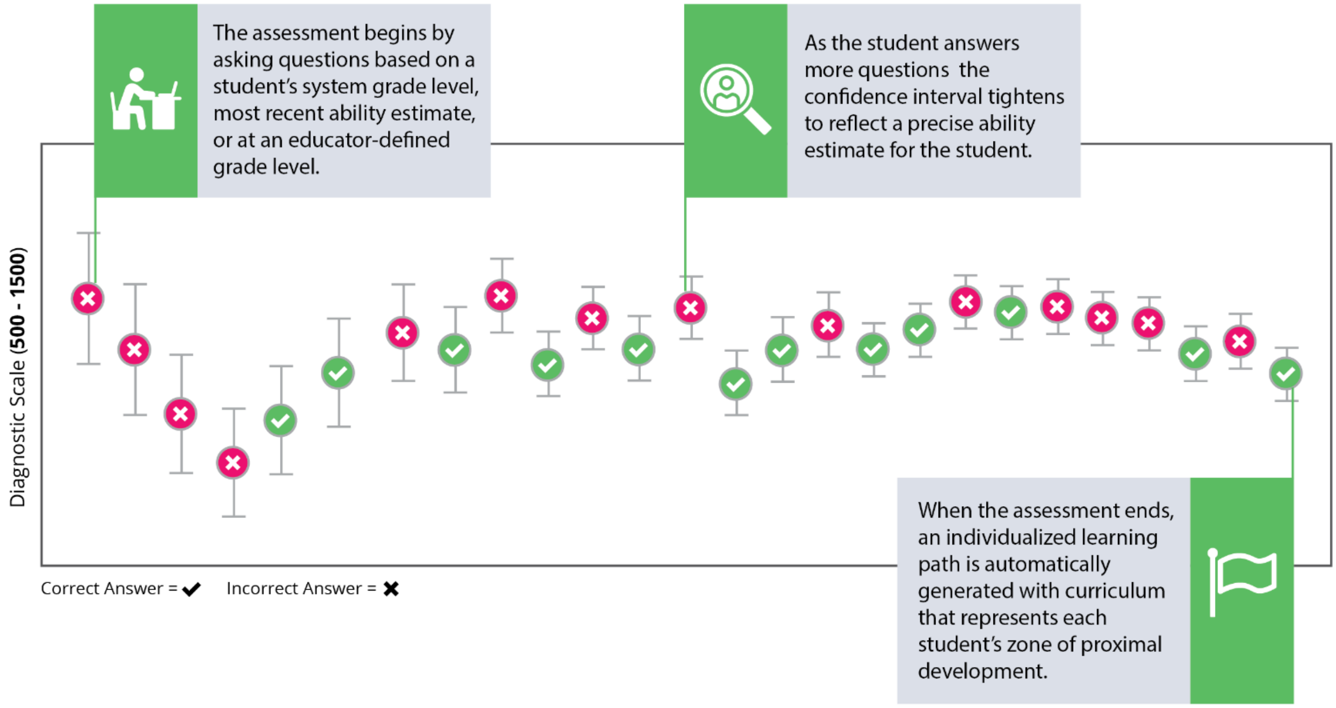



*Figure 6. This is the path one Diagnostic Assessment takes to identify one student's placement.*

**Progress Checks provide data on student progress through the learning progression, so needed adjustments are understood.** Progress Checks are assessments integrated into student learning paths as students advance through their individualized learning progression. The Progress Check informs the learning path algorithm to provide appropriate instruction and scaffolds for each learner. It also provides data for educators, learners, and parents about the student's growing mastery.

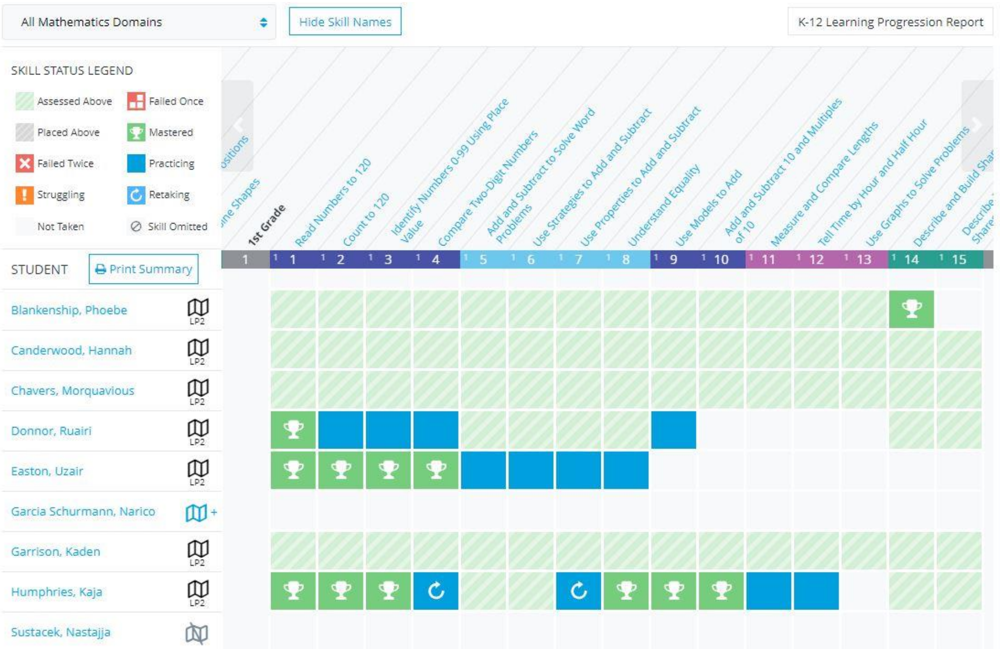



*Figure 7. This Knowledge Map shows students' math performance, placed by Diagnostic Assessment and measured by Progress Checks.*

**Backward design ensures a powerful relationship between goals, instruction, and assessment.** Edmentum begins with carefully chosen skills and then defines the assessment experience that will best measure what students know and are able to do. Each assessment goal defines a learning experience that drives towards the ability to perform well on the assessment ultimately demonstrating mastery of the learning objective. This approach to instructional design is known as *backward design* (Wiggins & McTighe, 2005). Competency-based student progress, or the practice of defining progress based on mastery instead of a fixed amount of time, has been identified as one of the five essential design features of personalized learning (Lee, 2014).

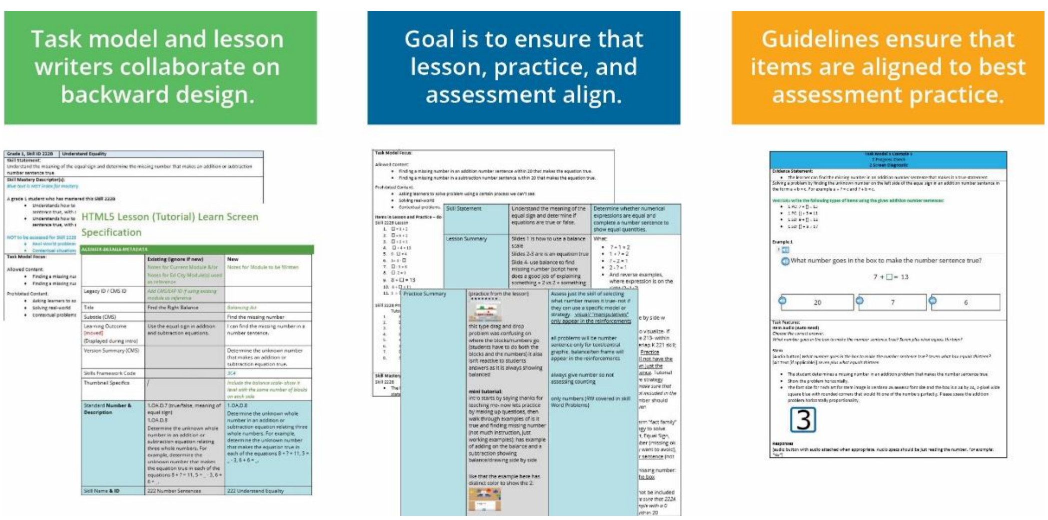



*Figure 8. Edmentum learning and assessment designers collaborate to create objectives, assignments and the instruction that scaffolds student learning success.*

**Rigorous instruction is based on alignment with research-based standards to focus on important concepts and drive performance.** Carefully chosen learning objectives are aligned to research-based standards to support mastery and preparation for high-stakes assessments.

**Learners have control over time, place, and pace of learning, which supports them to impact their own learning.** The flexibility inherent in digital curriculum makes it possible for learners to work any time and any place. Exact Path allows students to speed up when they understand material and slow down or repeat material when they need more time to understand.

## Deliberate Practice and Immediate Feedback

Deliberate practice refers to intentional, highly-structured, and sustained student effort that impacts knowledge and skill acquisition and retention. The learning curve relies on the link between practice, reinforcement, immediate feedback, and performance (Campitelli & Gobet, 2011; Hattie & Yates, 2013). When learners engage in deliberate practice, they are motivated by a compelling desire to improve. Therefore, they exert the effort to practice until they master the content. Hattie's research shows students' deliberate practice is a powerful influence on student achievement because initial learning can be consolidated from surface knowledge to long-term memory (Hattie, 2009; Hattie & Yates, 2013). Hattie cites Van Gog, Ericsson, Rikers, and Paas (2005) who argued that deliberate practice requires students to think and focus more as they participate in relevant, challenging practice activities during which they receive feedback and correct errors (Van Gog et al., 2005).

**Deliberate Practice & Immediate Feedback**

Offer intentional and aligned practice to support increasing levels of understanding. Provide immediate feedback and coaching to improve student success.

As students practice newly acquired skills, there is a need for feedback on their performance. Research by Opitz et al. (2011) demonstrated that immediate feedback produced significantly larger gains in performance. Immediate feedback provides students in-the-moment information on how they performed on the practice item.

### How Exact Path Applies the Deliberate Practice and Immediate Feedback Principle

**Focused practice sessions after completion of lessons ensure students immediately apply what is learned.** Once a learner completes the lesson, they are taken to a practice session. The practice session includes several items focused specifically on the skill taught within the lesson. The practice session gives students an opportunity to immediately apply their learning with sustained focus on using new understandings. The number of practice items is dependent on the complexity of skill.

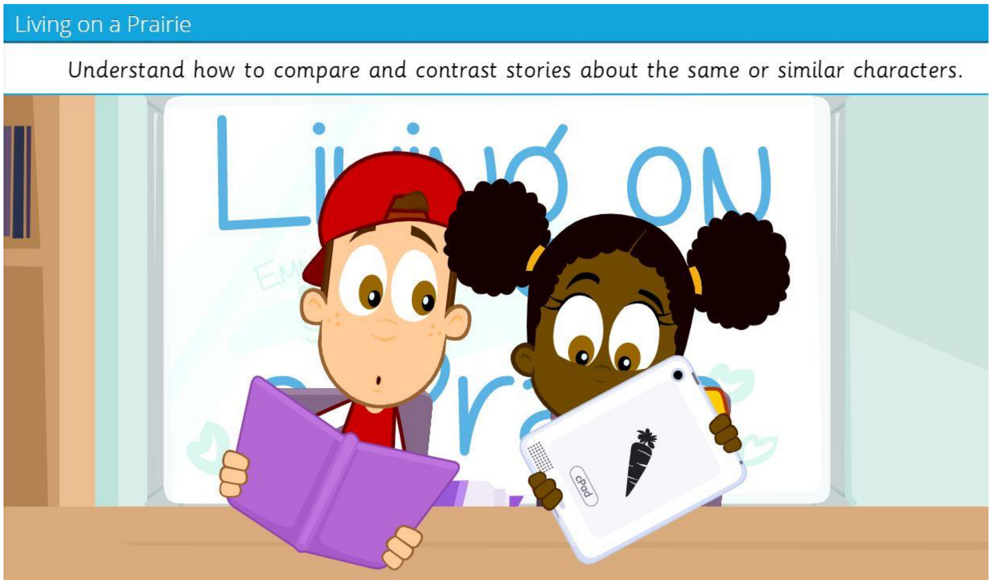



*Figure 9. The student-facing objective for the Grade 3 module "Living on a Prairie" aligns to standards that require learners to compare and contrast stories that include the same or similar characters.*


*Figure 10. This student dashboard shows the lessons and their associated practices.*

**Immediate feedback is provided after each response, so that the learning is continuous.** Practice items are aligned to the lesson instruction and the assessment items students will access after completion of the skill. The practice items allow learners to apply new knowledge and receive immediate feedback to gain deeper levels of understanding. The immediate feedback for incorrect responses is scaffolded to encourage student learning. After an initial incorrect response, students are given a brief reminder of the instruction and can attempt the item a second time. If the learner inputs a second incorrect response, an explanation of the correct answer is provided. This type of immediate feedback encourages students to learn from their mistakes and successes.

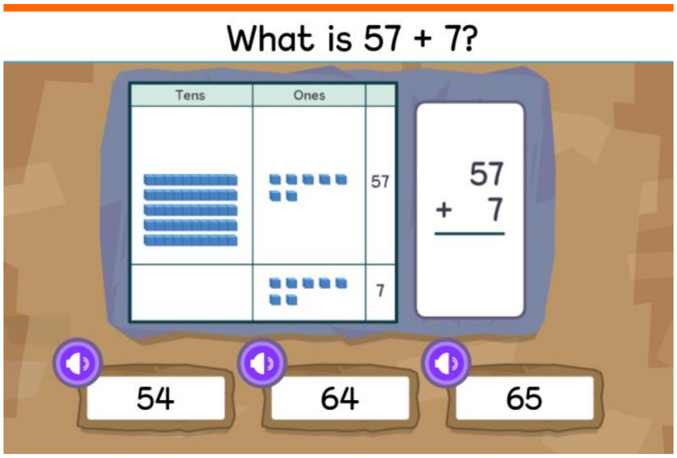



*Figure 11. Grade 1 practice item 1st Attempt—Incorrect. Immediate Scaffolded Feedback Provided. In this case, the learner gets a hint about making a ten.*


*Figure 12. 2nd Attempt— Incorrect. Immediate Scaffolded Feedback Provided. In this case, the learner gets a full explanation.*

**Practice items are constructed carefully to support and build mastery.** Item types are selected for the best pairing of the skill and the demonstration of mastery. Items are put in order to build from basic foundation to application of higher-level learning. This sequencing includes the appropriate level of rigor to allow students to understand and improve their mastery.

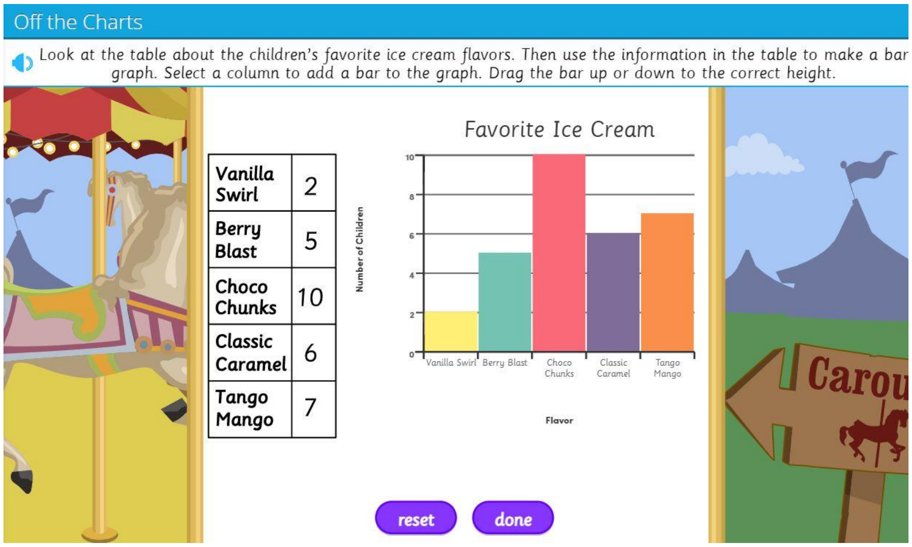



*Figure 13. In a Grade 3 math practice item, students build a graph from a data set by using a select-and-drag item feature.*

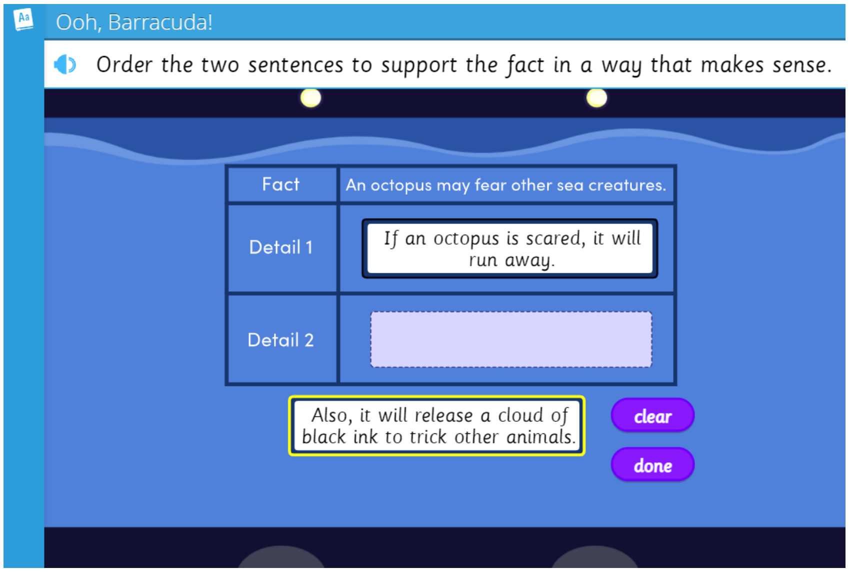



*Figure 14. In a Grade 3 writing practice item, students use a drag-and-drop feature to order details in a way that support a given fact.*

## Explicit Instruction and Scaffolding

The term *explicit instruction* refers to a "group of research-supported behaviors that are to design and deliver instruction in order to provide needed supports for successful learning through clarity of language and purpose, and reduction of cognitive load" (Hughes, Morris, Therrien, & Benson, 2017).

Instructional scaffolding is a process in which instructional supports provide aid to students in mastering content until they can independently apply new skills and strategies (Dickson, Chard, & Simmons, 1993; Rosenshine & Meister, 1992). Scaffolding is particularly important when students first encounter new material; as they develop a mastery of the content, supports can be gradually removed as learners develop skills to complete work independently.

Hattie writes “scaffolding is essential for cognitive development as students move from spectator to performer after repeated modeling by adults” (Hattie, 2009). He based this conclusion on the work of Rosenshine & Meister, who found that implementation of scaffolded instruction had a very high effect size (.74) regardless of who was delivering the instruction, student grade level, or number of students in the instructional group (Rosenshine & Meister, 1994).

**Explicit Instruction and Scaffolding**

Delivery of content begins with explicit instruction, then using a scaffolded approach, students move toward independent application.

Research by Vygotsky describes a zone of proximal development, in which the level of difficulty or challenge is balanced with a learner’s level of proficiency so that the work of learning isn’t too difficult or too easy. When learners are assigned content in which they are proficient, working on it presents little challenge for them, and they become bored or apathetic. When learners are insufficiently proficient with material and it is presented in a way that is difficult or challenging, they become anxious or feel that they can never be successful with their work. When learners are outside of this optimal learning zone (the zone of proximal development), the time they are investing is not productive. Scaffolds are additional learning supports that can move learners into more challenging material in which they are not yet proficient. The scaffolds help learners achieve an appropriate level of productive struggle (Vygotsky, 1978).

## How Exact Path Applies the Explicit Instruction and Scaffolding Principle

Exact Path is designed to provide learners with the explicit instruction and scaffolding they need to successfully master each skill. Each new skill in the learning progression is introduced with clear and explicit instruction. Critical aspects of each skill build upon one another with strategic scaffolding, eventually positioning students to be able to master content and independently apply the skills and strategies.

**Clear skill statements and objectives keep both educators and students focused on what is being learned.** The learning progression consists of a series of skills, which are stepping-stones of learning. Edmentum applies research to determine the correct sequence in which to present skills.

The content of each skill is reflected in a short skill statement, which provides teachers insight into what each student is learning. Each Exact Path lesson or practice opens with a student-facing learning objective, so both learner and educator know the goal of the lesson. Instruction and assessment are developed using backward design to ensure learners meet the learning objective and have a fair opportunity to demonstrate mastery because assessment mirrors instruction.

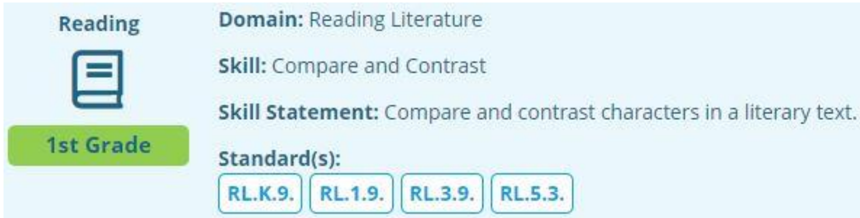



*Figure 15. This Grade 1 Skill Statement clarifies the goal of the skill for teachers.*


*Figure 16. At the beginning of each lesson and practice, the learning objective which is written in student-friendly language, helps learners understand the goal of the lesson and practice. This lesson, "Twin Tales," addresses the skill "compare and contrast."*

**Instruction is broken down to address well-defined skills.** The introduction of new content is carefully managed to avoid cognitive overload (Archer & Hughes, 2011). The lessons proceed in bite-sized instructional chunks. Visuals and manipulatives are carefully curated to support learning without overwhelming students.

**Direct instruction and modeling of skills and strategies support learner success.** The skills that each student encounters on their learning path are first presented as a lesson. In the lesson, the Exact Path characters discuss and model specific strategies to solve the skills-related problem they encounter. Visuals, virtual manipulatives, and animations support the character dialogue and reinforce the learning. This combination provides powerful direct instruction of the new skills and strategies.

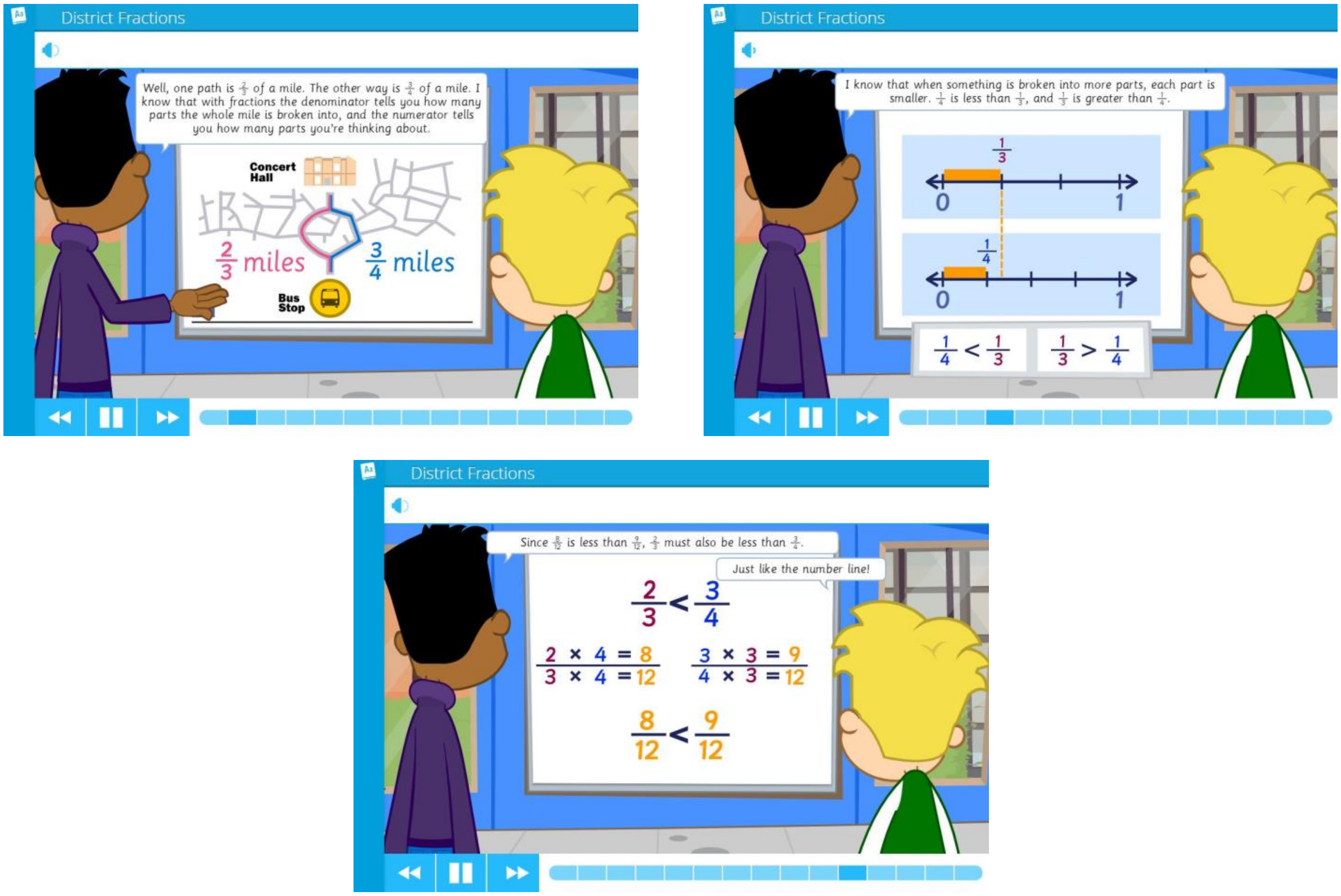



*Figure 17. In this Grade 4 lesson, characters model and discuss different strategies for comparing fractions.*

**Embedded practice items throughout the lesson encourage student engagement.** As students move through the lesson, practice items are embedded at key learning points within the content to check student understanding as they progress. Feedback is provided based on student response, with additional support and instruction given to students who demonstrate misunderstandings.

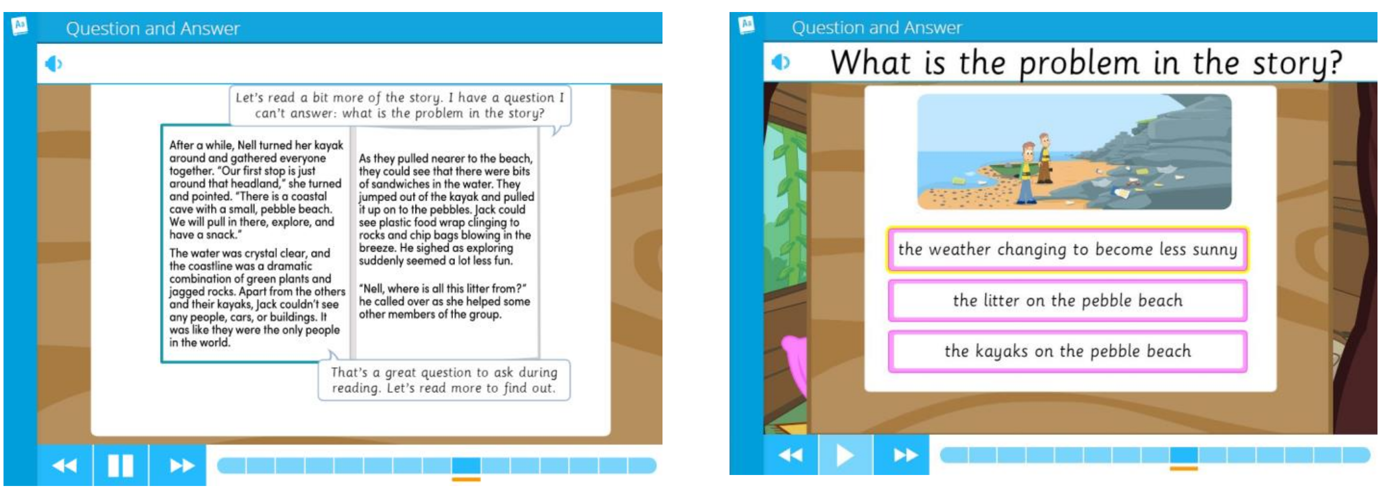



*Figure 18. In this Grade 3 lesson, students answer skill-related questions to monitor understanding as they progress.*

**The gradual release of responsibility model systematically moves learners from guided to independent work.** Each section or phase of the content delivery of the skill described above is built to gradually move students from observing how the skill or strategy is used to using the skill or strategy independently, assuming an increasing responsibility for learning with each step.

## Active, Engaging Learning

Active learning is an instructional method that involves students in responding to instruction, encouraging them to manipulate information and interact more deeply during the learning process. Active learning contrasts with the traditional lecture format, in which a teacher delivers information to a classroom of students who passively receive it (Bonwell & Elson, 1991). Techniques that encourage active learning tend to be better at promoting higher-level learning and skills.

Hattie's meta-analysis shows that as students become active in the process of their own education, learning outcomes improve. Learners "reach the stage where they become their own teachers, they can seek out optimal ways to learn new material and ideas, they can seek resources to help them in this learning, and when they do they can set appropriate and more challenging goals" (Hattie, 2009). Hattie references Kember & Wong's findings that active and passive learners have different ideas about good teaching, with active learners preferring enthusiastic teachers who use a variety of instructional methods and encourage student interaction within class (Kember & Wong, 2000).

**Active, Engaging Learning**

Involve learners in responding to and manipulating information while they learn— ensuring involvement in building understanding and minimal passive reception of information.

### How Exact Path Applies the Active, Engaging Learning Principle

**Interactivity in lessons engages learners.** A variety of learning experiences across the skills motivates students and enhances thoughtful learning. Multiple representations and ways of interacting with content help learners develop rich understandings. Check for understanding is embedded frequently within lessons. Students apply recent learnings, get immediate feedback on their responses, and use visual and audio supports to address misunderstandings. Active learning helps keep the learners focused on the skill and confident to keep going further in the program.

**Contextualized examples and applications make learning relevant.** The skills and strategies within each module are applied to contexts that promote real-world application. This gives meaning and purpose behind learning the skills presented to them within their learning progression.

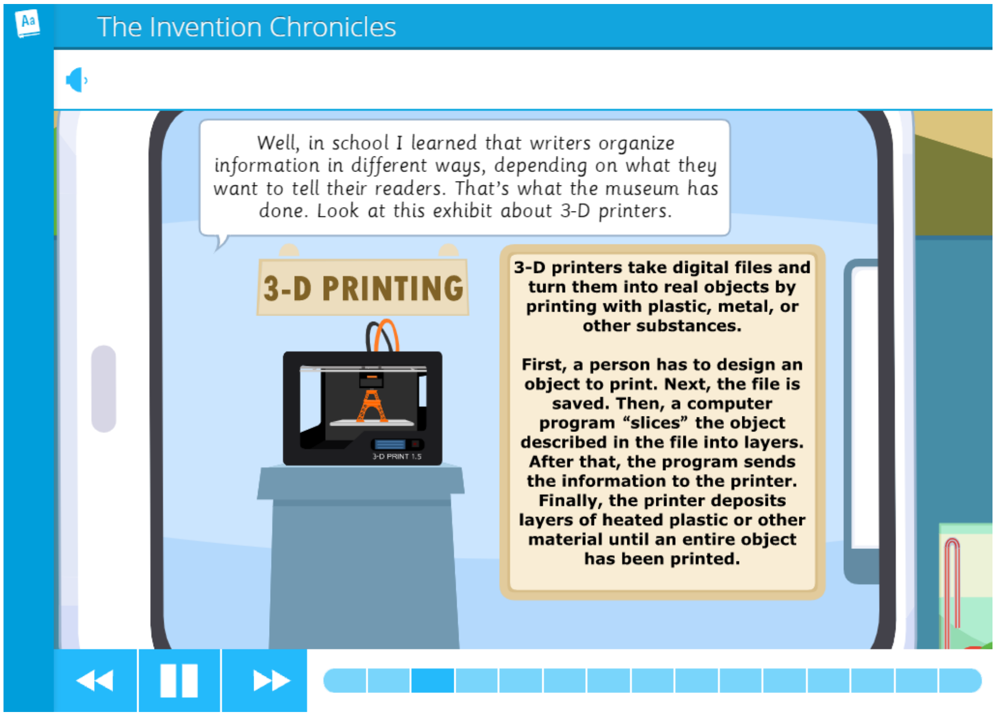



*Figure 19. This Grade 4 lesson applies learning of informational text structures to understanding information presented at a museum.*

**Technology-enhanced items keep learners engaged in practice.** Exact Path uses a variety of item types to provide learners with diverse experiences in learning skill content. Using different item types, including but not limited to drag-and-drop, number selector, and hot spot items, engages learners by avoiding fatigue or boredom.

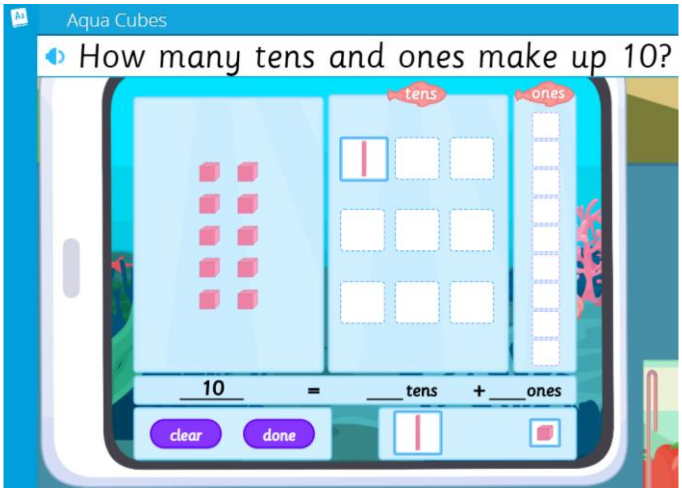



*Figure 20. This Grade 1 item allows students to drag and drop virtual manipulatives to model tens and ones.*

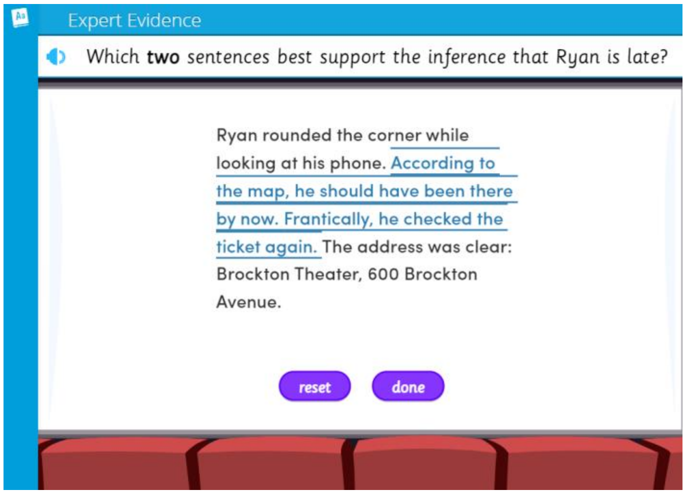



*Figure 21. In Grade 4 practice, students use hot text functionality to select the text evidence that best supports the inference.*

**Diverse character sets engage learners.** Exact Path introduces learners to a variety of diverse characters along their learning path. By seeing characters who represent themselves and the world around them, learners identify with the characters, see themselves reflected in the content, and engage better with those characters.

*Figure 22. Exact Path K–5 has a diverse cast of characters.*

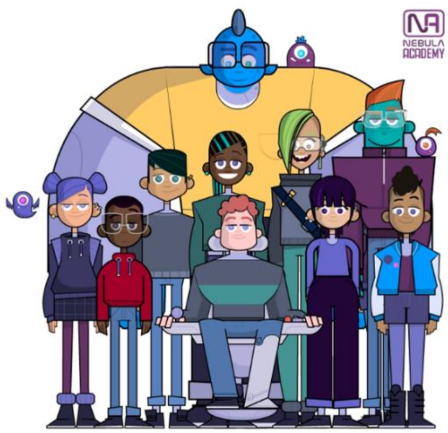



*Figure 23. Exact Path 3–5 includes diverse characters who are a bit older to engage students in the intermediate grades.*

## Subject-Area Best Practices

Exact Path subject area instruction is designed on a foundation of subject-specific best practices research. The underlying Reading and Mathematics research is described with examples that illustrate how these proven best practices are incorporated into Exact Path.

**Subject-Area Best Practices**

Engage learners and build understanding by using research-based best practices and instructional strategies.

# Reading Pillars

Teaching reading with efficacy relies on the application of scientifically-based reading research (SBRR) to curricular practices to ensure that students have the best possible opportunity to learn to read. SBRR came into the educational limelight about 25 years ago. The U.S. Congress created the National Reading Panel in 1997 to study best practices in response to a perceived reading crisis in the country. The Panel's report, released in 2000, was backed by scientific data and has been hugely influential on the research that has come since then. The panel called for reading practice in the nation to be supported by SBRR and raised the expectation that reading research should align more closely to the scientific method in order to quality as SBRR.

Based on the report, there is now general consensus about key reading skills—or elements of reading.

**Phonological Awareness.** Phonological awareness is the ability to hear and manipulate sounds in words and includes the important subset of phonemic awareness, in which learners are able to manipulate individual sounds. These are oral language skills, not associated with word meaning, but critical precursor skills to decoding. Adams (1990) described the five levels of phonological awareness, and her seminal work continues to guide educators in understanding how to move learners through the phonological awareness continuum today. Phonological awareness is not limited to the sounds we hear in words; rather, it includes a broader understanding of elements of spoken language, such as word awareness, syllable awareness, rhyming, and onset/rime (initial consonants/ending word sounds) segmenting and blending.

**Phonics.** Research shows that phonics instruction should be explicit and systematic, beginning with letter-sound relationships and blending those sounds to form words, known as the process of decoding text. Sound-spelling patterns also support learners in using known letter patterns to decode new words. Alphabetics, sound-spelling patterns, orthographic awareness, decoding, and word-part analysis (morphology) are all subskills under the phonics umbrella. Children must also learn sight words (both decodable and irregularly spelled high-frequency words), and experts such as Ehri (2014) unequivocally state that this learning must occur side-by-side with phonics instruction. As phonics skills increase, learners begin to automatically recognize words, a skill known as *automaticity*, which underlies the building of reading fluency.


**Oral Reading Fluency.** Fluent readers are confident and expressive, who read accurately, at a steady rate, and with prosody (expression). Automaticity frees brain power to work on reading fluency as learners begin to independently engage with texts. Reading fluency can't happen without phonological awareness and phonics instruction. Yet fluency does not necessarily follow these skills and needs to be modeled, practiced, and discussed explicitly.

**Vocabulary.** As readers become more fluent and gain morphological knowledge (Kirby et al., 2012), they then become able to rapidly acquire new vocabulary. Research suggests that vocabulary is most effectively taught in the context of what students are reading. However, effective vocabulary instruction requires more than just incidental definitions of words. Word meanings need to be directly taught with multiple exposures to build opportunities to explore the depth of new vocabulary items and use them in context (Biemeller & Boote, 2006). Broader vocabulary knowledge supports better reading comprehension, which is the ultimate goal of all reading instruction.

**Comprehension.** Understanding texts—and engaging meaningfully with texts to learn about ourselves/others and to tap into greater resources of knowledge—is the purpose of reading instruction within the English language arts discipline. Reading comprehension is the bedrock on which a student's academic success is built both in secondary and higher education. It is a student's ability to not only understand the surface-level of meaning contained within a text, but to understand multiple layers of meaning based on inference, author's point of view, and a critical analysis of the arguments and evidence a writer uses.

In initial phases of learning to read in K–3, phonological awareness and phonics comprise a large component of instructional time, at which point they taper off and segue into word analysis skills. While reading fluency instruction and assessment begins generally in the latter half of first grade, it receives most emphasis in Grades 3–5 when educators work to ensure that students are on a proper trajectory for developing lifelong reading skills. As students move into the secondary grades, reading fluency continues to be measured, but is a focus primarily for students whom we suspect have reading difficulties.

This brings us to an important concept underpinning the instruction of phonological awareness, phonics, and reading fluency, known together as reading foundations skills: these skills are constrained—that is, once mastered, they offer no further growth opportunities. Vocabulary and reading comprehension skills, on the other hand, are unconstrained. We can continue to grow in these skill areas throughout our lifetime (Paris, 2005). This is why it is so critical to help learners master the first three skill sets by placing them on a continuum that best suits their needs and learning styles, so that they can soar into deep comprehension of texts as they continue in their reading development.

Exact Path offers just this type of continuum. Its diagnostic testing, individualized learning path, and regular progress monitoring checks that result in any needed adjustments to the path, are ideal for learning reading foundational skills. These same elements also serve to appropriately scaffold learners as they grow in vocabulary and reading comprehension skills.

We will next look at what SBRR indicates about best practices in each of the key elements of reading and explore how Edmentum has applied this science to the content and instructional architecture of Exact Path.

## Phonological Awareness

### What the Research on Phonological Awareness Says

Phonological awareness was identified as the first element of scientifically-based reading research (SBRR) instruction by the National Reading Panel in 2000. This decision is upheld by subsequent research. For example, in 2008 the National Early Literacy Panel's report stated that phonological awareness remains a strong predictor of later literacy. Additional studies continue to show that phonological awareness is necessary for decoding words and for vocabulary acquisition (Moats, 2009). Systematic instruction in phonological awareness has also been linked to increased print awareness, and it has proved successful in closing and even overcoming the reading foundations achievement gap between children from low-income homes and their peers from high-income homes (Lefebvre et al., 2011).

Best practices for phonological awareness instruction center around introducing learners to frequent lessons that are brief in duration—no more than two or three activities per session (Moats, 2010). Phonological awareness instruction should begin with larger sound units—for example, sentences and syllables—and move slowly to individual phonemes. Students should orally produce the sounds as part of the preferred "say-it-and-move-it" cycle of tracking sounds by the use of sound boxes[1] (Blachman, 2019).

### How Exact Path Applies the Research on Phonological Awareness

Phonological awareness learning occurs in 11 reading foundations modules across grades K–1 content in Exact Path. As shown in Figure 24, The modules are presented in a carefully ordered sequence based on research. The modules start with basic phonological awareness tasks, then move to those that are increasingly complex.

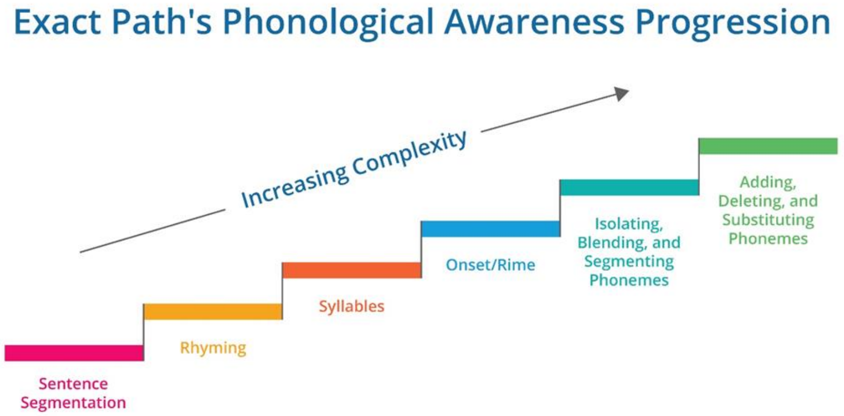



*Figure 24. Exact Path's Phonological Awareness Progression*

Exact Path takes students through this sequence efficiently, allowing individual learners to move quickly as they are able and to slow down as they demonstrate need. Each component in the phonological

[1] Sounds boxes are also known as Elkonin boxes, which require students to move a marker as they hear each sound in a word. In a digital environment, students click on a box as they hear each sound in a word, therefore involving the kinesthetic experience of moving and clicking the mouse.

awareness modules is brief in duration, as best practices suggest, whether learners are viewing tutorials, practicing, or demonstrating mastery through assessment.

Finally, Exact Path phonological awareness lessons use the "say-it-and-move-it" instructional model in key areas in which it is beneficial to learners. For example, in the lesson "Fishing for Sounds," learners use sound boxes to break apart words into the specific sounds they hear and then blend those sounds together again into a word.

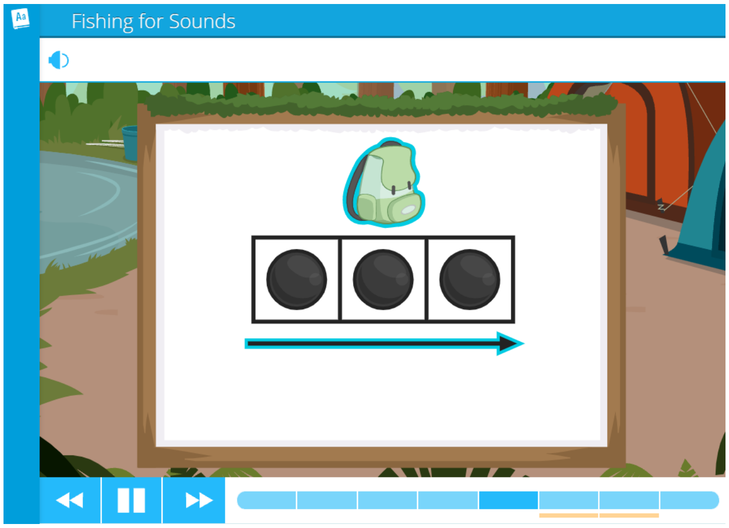



*Figure 25. The kindergarten skill "individual sounds in words" uses research-based sound boxes.*

# Phonics

## What the Research on Phonics Says

Today's researchers agree that phonics instruction should be explicit and systematic. Mesmer & Griffith (2005) describe key characteristics of this type of instruction as follows:

- Direct instruction and learner practice emphasize specific phonics concepts in a sequenced and systematic way that exposes learners to the basic elements of the English orthographic code. As the code is mastered over time, learners store written words in their memory, quickly recalling their pronunciations and meanings.
- Instruction is founded in letter-sound relationships, and practice includes decodable text.
- Learners articulate sounds of letters in isolation and then blend isolated sounds, building towards using letter-sounds to build words.

Evidence abounds that phonics instruction leads to improved reading. Ehri et al. (2001) released a meta-analysis of 38 phonics research studies dating back to 1970 as a follow-up to the National Reading Panel's 2000 report. The conclusion stated: "[S]ystematic phonics instruction proved effective and should be implemented as part of literacy programs to teach beginning reading as well as to prevent and remediate reading difficulties." More recently, a meta-analysis undertaken by British scholars reached a similar conclusion: "Since there is evidence that systematic phonics teaching benefits children's reading accuracy, it should be part of every literacy teacher's repertoire and a routine part of literacy teaching" (Torgerson, Brooks, & Hall, 2006).

Best practices in phonics instruction take into account the umbrella view of this foundational skill. The related grouping of print concept skills—print awareness, sight (high-frequency) words, and word analysis skills are integrated into decodable texts so that they occur in the context of phonics practice, a best practice. For example, a text is considered decodable if up to 50% of the words are taught sight (high-frequency) words.

Systematic phonics instruction generally puts sight-word instruction at regular internal intervals after some phonics skills have been taught and practiced. This sequential phonics-sight word integration is based on the idea that orthographic mapping skills make sight word learning easier, and these skills are not accessible until learners have achieved proficiency in phonemic awareness and phonics (Kilpatrick, 2015). In putting theory to the test, instructing phonics before sight words with integrated practice in a study with students at risk for learning disabilities created a slight advantage over providing sight word instruction prior to phonics instruction (McArthur et al., 2015).

In teaching print concepts, the use of e-books has been found to be an effective mode of instruction. Improved performance in concepts of print was shown for typically developing children who used e-books rather than print books, but the effect was even more pronounced for children at risk for learning disabilities (Shamir & Shlafer, 2011). A subsequent eye-tracking study showed that children spent more time looking at print in electronic storybooks, which improved their print awareness (Liao et al., 2020).

## How Exact Path Applies the Research on Phonics

Exact Path is built around a clearly defined scope and sequence that outlines grapheme-phoneme correspondences. Exact Path makes systematic phonics instruction easy with lessons that have an explicit focus on mapping an individual letter, or combination of letters, with its appropriate sound. Here's an example from the lesson "Letter Wheel."

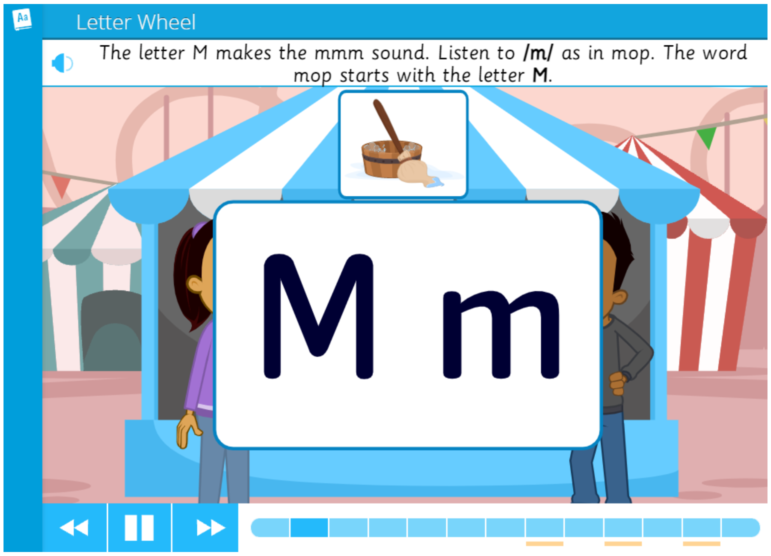



*Figure 26. Systematic phonics instruction begins in kindergarten with explicit lessons like this one.*

A recent study of systematic phonics instruction showed that many teachers do not feel entirely confident with the procedures associated with high-quality phonics instruction (Flynn et al., 2021). So the ease of use represented by Exact Path is very helpful for teachers who need support in this area. Lessons and practice in letter-sound correspondence are effective tools to support teachers as students build phonics skills that will enable them to read words with greater automaticity. Regular progress monitoring assessment helps students stay on track to master all element of phonics—including letter-sounds, blends, digraphs, and vowel teams—by providing reteaching and specific scaffolding based on mastery data.

Per best practices, decodables are woven into Exact Path as letter-sound correspondences and other phonics skills are mastered. Each Exact Path e-book appears with a cover and pages that turn to mimic the act of reading a print book. This ensures that students gain knowledge of print concepts and book-handling skills while also gaining the advantages research associates with use of e-books with learners. Figure 27 shows the cover and sample pages from the decodable book entitled *Come and See.*

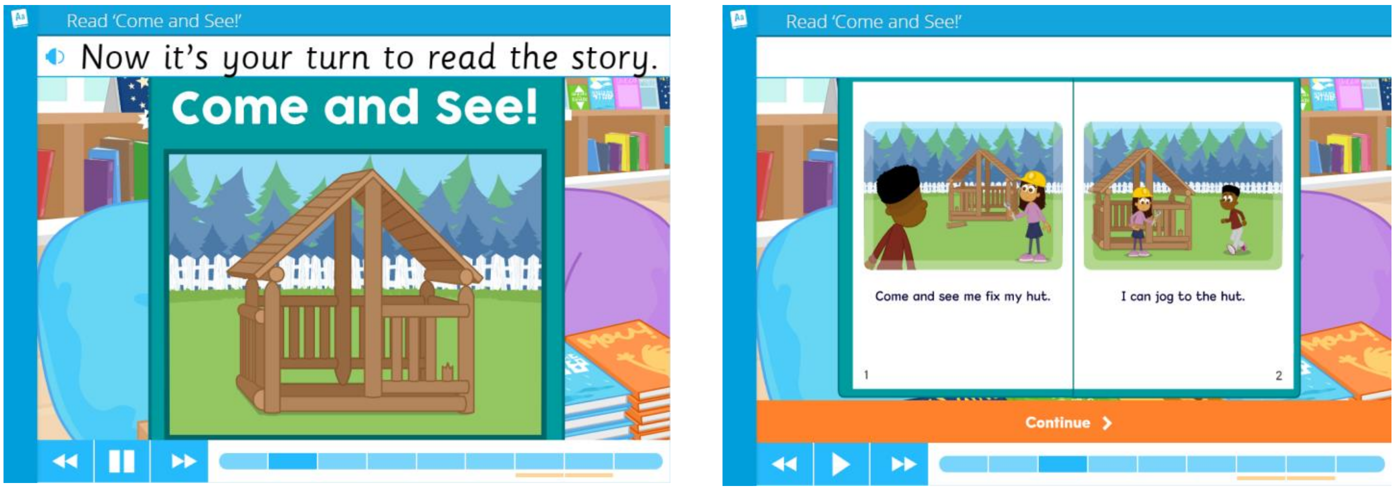



*Figure 27. Beginning in kindergarten, e-books are aligned with decodability skills for learners.*

Many of the instructional activities within Exact Path aim to build reading automaticity by providing instruction in an increasing bank of sight (high-frequency) words. Lessons focused on sight-word acquisition were built according to the research on orthographic mapping, or how sound-letter mappings are bound in memory. This research shows that sight-word instruction is most powerful when students can see the words spelled, hear the pronunciation, and have visual clues to the meaning simultaneously. This helps create bonds in memory that aid retention of the word in a student's memory (Ehri, 2014).

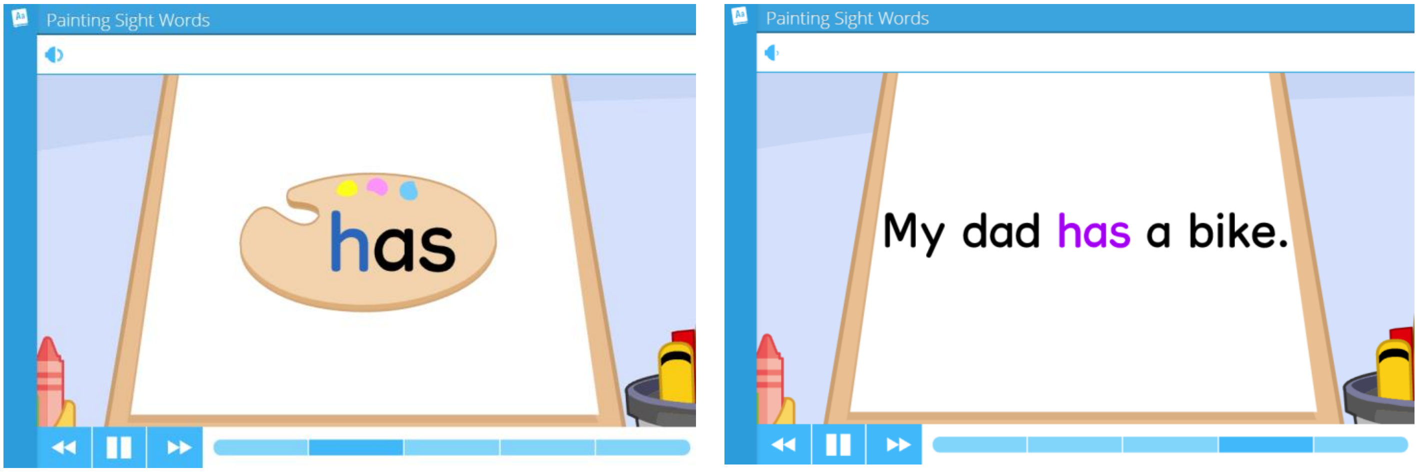



*Figure 28. Students regularly practice sight words, as shown in these screens from Grade 1.*

At Grades 1 and 2, word analysis skills are introduced in a systematic way via syllabication instruction. First grade syllabication lessons include these syllable types: open, closed, Vowel-consonant-silent e (VCe), vowel teams, and *r*-controlled vowels. The words decoded using syllabication are limited to words with just two syllables.


*Figure 2. Grade 1 syllabication instruction includes open and closed syllables.*


*Figure 30. VCe, vowel team, and* r*-controlled vowel syllables are also included in Grade 1.*

In second grade, students receive a brief review of open and closed syllables followed by VCe, vowel team, *r*-controlled vowel, and *-le* words. Three-syllable words are introduced in second-grade modules.

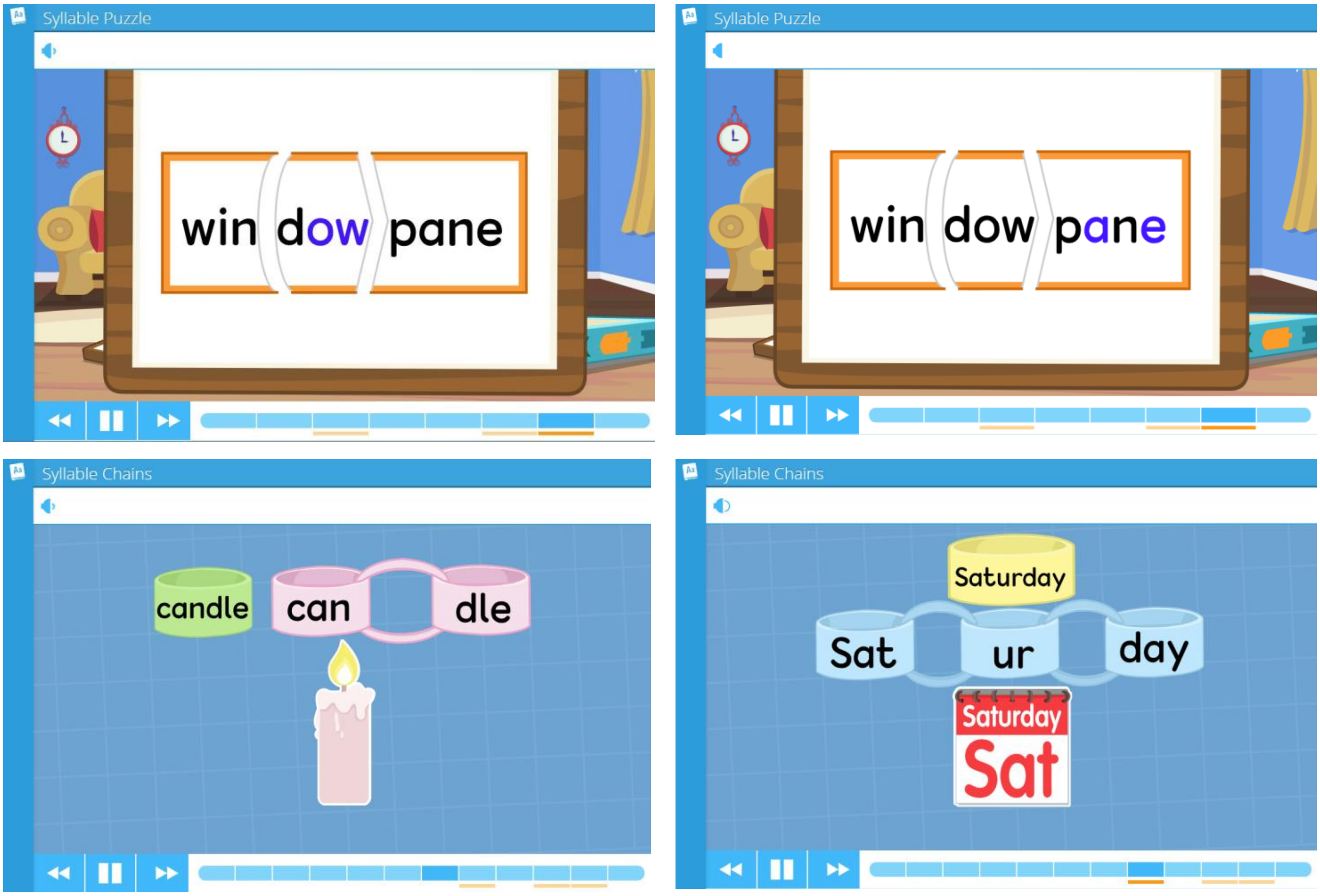



*Figure 3. Grade 2 syllabication instruction extends to three-syllable words.*

# Reading Fluency

## What the Research on Reading Fluency Says

Fluency has received a lot of research attention since the National Reading Panel named it one of the five critical sets of reading skills. As a recent synthesis of the research shows, there is agreement on how to do appropriate fluency instruction, practice, and assessment (Padeliadu & Giazitzidou, 2018).

Instruction must involve modeling of fluent reading and fluency rate goal-setting. Students should be cued to focus on speed, prosody, and comprehension during reading, not just one of these skills in isolation (Yang, 2006). Students should also be taught to preview text before reading and to scan for key words (Lee & Yoon, 2015; Morgan et al., 2012).

Best practice in fluency instruction promotes repeated readings (Stevens et al., 2016). In the synthesis cited above, ideal practice includes four readings of a text. Variations of repeated reading—including varied practice reading, choral reading, echo reading, shared reading, and performance reading—are also effective. For assessment, words correct per minute (wcpm) is generally acceptable as the best measure (Hasbrouck & Tindale, 2006). Generally, acceptable rates begin at 60 wcpm (for foundational readers engaged with decodable texts) and scale up to 120 wcpm as students at the fourth-grade level read connected texts. The texts used for assessment should be at a student's independent reading level, which means they can accurately read 95% of the words in a text.

One consistently strong voice in the fluency arena, Kilpatrick, reminds practitioners that fluency can only follow proficiency in phonemic awareness and phonics. Fluency bridges from foundational skills to comprehension and is, therefore, the "gateway to comprehension" (Kilpatrick, 2015). The placement of fluency in the reading continuum is, therefore, important. When beginning readers struggle with fluency, they should be directed back to more foundational skills practice.

## How Exact Path Applies the Research on Reading Fluency

Because Exact Path uses regular progress monitoring assessments, it offers an accurate early warning system when learners are struggling with fluency lessons. Students are automatically placed into precursor foundational skills following assessment if they fail to master their current skills.

The Exact Path fluency lessons offer several of the features of effective fluency instruction and practice. In early fluency learning modules, students are cued to use punctuation marks to help them read with expression and to read in a manner reflecting their conversational pace and expression. They are also coached with tips for reading difficult words. The reading is first modeled, and then students are asked to read the same text alone. Once the independent reading is accomplished, the student is reminded of the helpful tips for fluent learning that have been applied.


*Figure 32. Exact Path characters have conversations that bring metacognitive skills to life for learners.*

In the instructional portions of later fluency models, students are cued to skim a text to determine what it is about, find unfamiliar words, and learn how to pronounce them. They are also coached to set a purpose for reading. Each of these skills is modeled by the characters in the learning modules before they model applying fluency skills while reading text. Finally, the characters remind students why engaging in multiple readings of the same text is helpful.

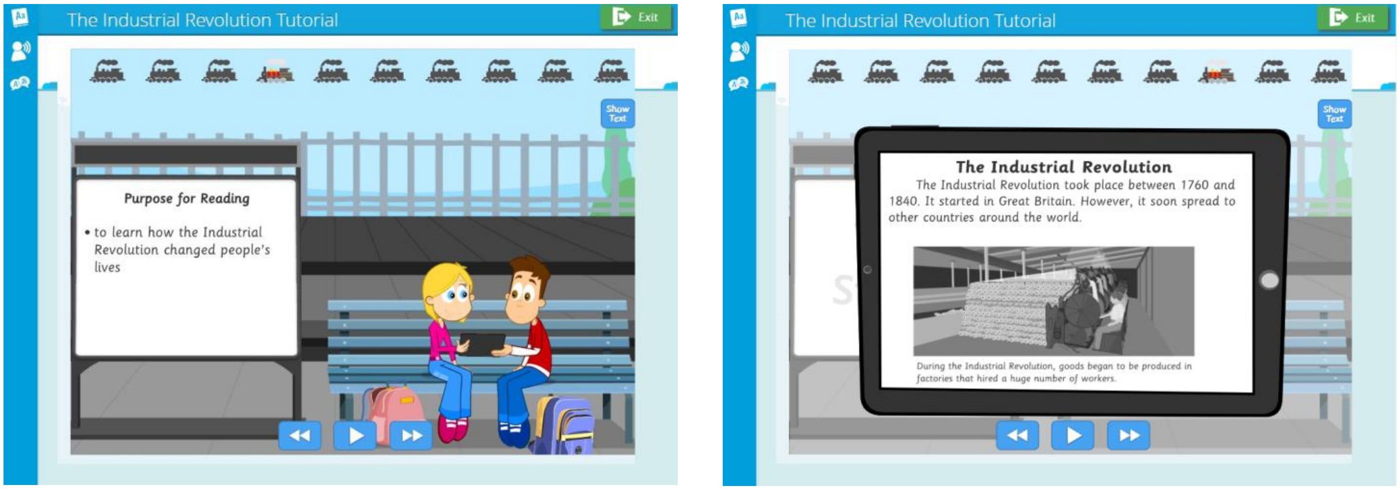



*Figure 33. The Grade 5 "Industrial Revolution" module teaches research-based fluency skills.*

In the practice portions of the modules, students are given varied reading opportunities. For example, in the "Industrial Revolution" module, students read additional texts with strong correlations to the model text on the same subject. They are asked to use the strategies modeled for them as they prepare to read and then to practice fluently reading these texts multiple times. They are cued up front and fully supported along the way.

## Vocabulary

### What the Research on Vocabulary Says

Just as fluency is a bridge between foundational skills and comprehension, increasing a student's vocabulary supports developing comprehension of increasingly complex texts. Why is that so? Knowing more words goes hand in hand with having a greater level of background knowledge—a critical component of reading comprehension.

At the same time, the more a student reads, the greater the opportunity for exposure to new words (Duff et al., 2015). So here we find ourselves in the "chicken and egg scenario." Should we give students more words in isolation, or should we have students read more to find new words? This is an instance when looking at meta-analyses of the wide range of vocabulary reading research work can help to provide an answer.

A recent meta-analysis of 36 studies showed two outcomes supported by evidence. The first is that teaching target words within texts supports comprehension of that text. Secondly, active engagement with words has a greater impact on student learning than simply accessing definitions through reference material (Wright & Cervetti, 2016). So the evidence seems clear that the best vocabulary work for fluent readers is done during engagement with text.

Increasing research attention is being given to the idea that listening to texts is an important avenue for lifelong vocabulary gains. Within elementary classrooms, the value of reading aloud to students has long been understood. In a society that increasingly consumes information delivered orally via podcasts, audiobooks, and other media, the topic deserves deep exploration.

## How Exact Path Applies the Research on Vocabulary

Exact Path vocabulary lessons offer a balanced blend between morphological analysis and word study contextualized in reading texts. Students dive deeply into word analysis skills to help them figure out unfamiliar words, but they are also helped to use context clues while reading to figure out the meanings of unknown words. Exact Path context clues learning modules offer both literary and informational texts, linked by theme. Explicit instruction is provided on context clues, then students apply it while reading texts.

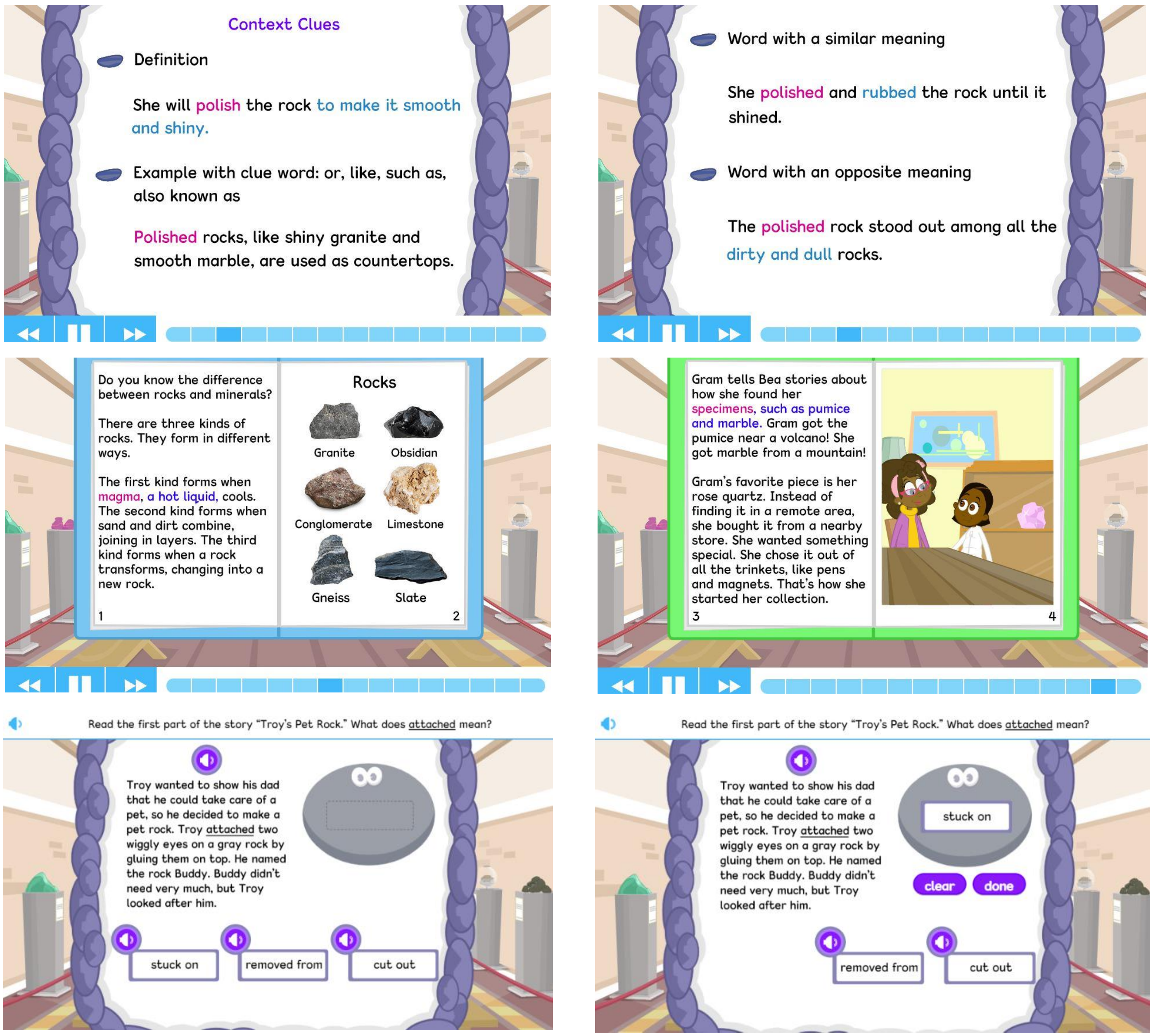



*Figure 34. The Grade 2 module "Context Clues Rock!" shows Exact Path's balanced approach to vocabulary development.*

From Exact Path lessons like these, students learn more than simply the skills and strategies presented. They also discover that they can learn exciting new words while reading and that they should not be deterred by encountering words they do not know.

## Reading Comprehension

### What the Research on Reading Comprehension Says

Reading comprehension is so complex that the educational field struggles to agree on a definition for it. The National Assessment of Educational Progress (NAEP) Reading Framework Committee did settle on this definition in 2009: "an active and complex process that involves understanding written text, developing and interpreting meaning, and using meaning as appropriate to type of text, purpose, and situation" (U.S. Department of Education).

Due to the many components of, and approaches to, reading comprehension, each year the research in the field flourishes, making it difficult to stay abreast of the latest findings. Fortunately, regular efforts are made to synthesize the research and point to promising practices that help young readers become more successful at comprehending texts.

For example, at the end of the chapter "The Development of Children's Reading Comprehension" in the *Handbook of Research on Reading Comprehension,* Paris & Hamilton (2009) make practical suggestions about how to improve children's reading comprehension, based on the survey of research they present:

- Teach background knowledge.
- Teach text vocabulary in the context of larger ideas and themes.
- Teach comprehension strategies that lead to metacognition while reading.
- Engage and motivate children to read.

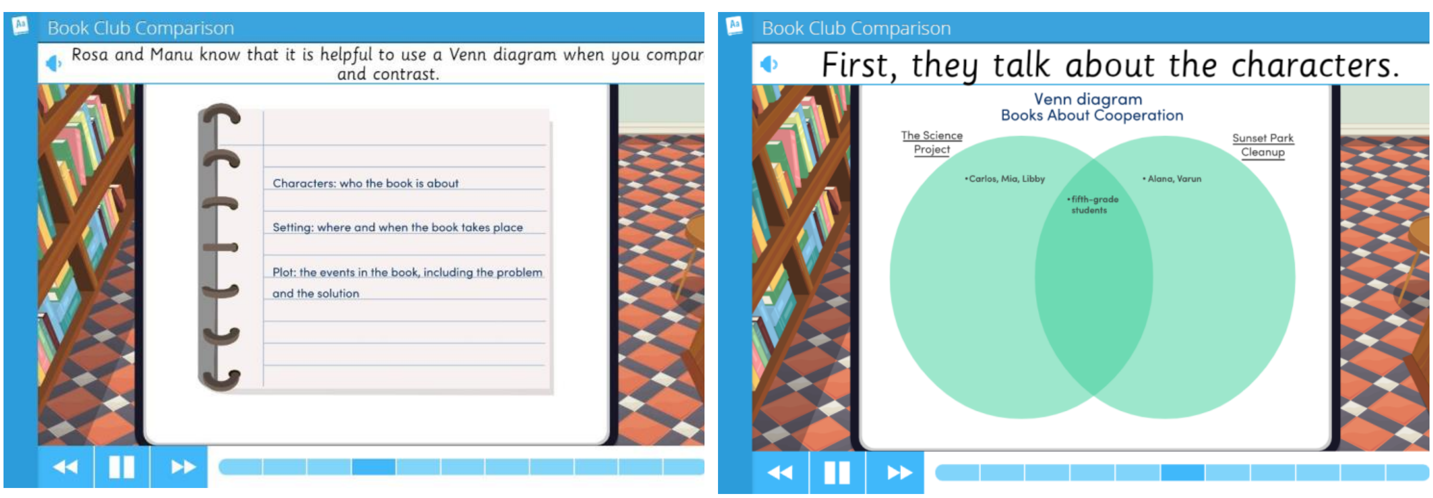
Following a broad survey of research, Elleman & Oslund (2019) make a similar summary statement about the conditions in which reading comprehension flourishes: "An early and sustained focus on developing background knowledge, vocabulary, inference, and comprehension monitoring skills." McNamara & Kendeou (2011) drive home the important point that reading comprehension scaffolding is most important *as reading unfolds.* In other words, what is taught must be accessible during the act of reading.

Focusing on the role of technology in increasing students' reading comprehension ability, Waxman et al. (2003) conducted a meta-analysis to see the effects of digital instruction. They found that teaching and learning with technology has a small yet significant, positive effect when compared to traditional instruction. Kamil & Chou (2009) state in their chapter of the *Handbook of Research on Reading Comprehension* that in general, technology has been effective in teaching reading comprehension skills focused on strategy and metacognition. This could be because technology allows assistance to occur in real time during text reading.

## How Exact Path Applies the Research on Reading Comprehension

Exact Path lessons provide reading comprehension strategy instruction followed by coaching during reading. To keep fluent learners engaged, Exact Path characters also converse about how they are applying the reading strategies, which offers strong modeling of metacognition.


*Figure 35. In the kindergarten module "Question Time!" Exact Path characters ask and answer questions while reading a story.*



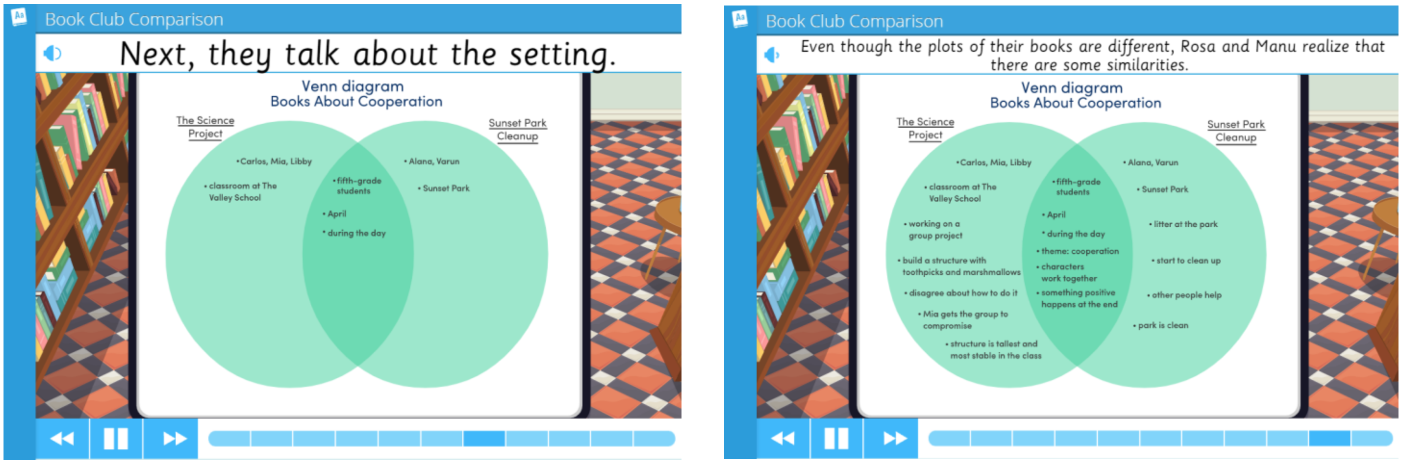



*Figure 36. In the Grade 5 module "Book Club Comparison" learners see how Exact Path characters model the use of a Venn diagram.*

Learners are asked to apply comprehension skills during instructional modules *and* in a separate practice component with feedback. Exact Path keeps track of how students are performing as they answer questions and responds intelligently to determine how students should progress through the module and along their learning path.

As students move from the tutorial portion of the module to the practice component, the progression follows a gradual release methodology. The scaffolds of explicit instruction and modeling offered in the tutorial are systematically removed as students move through various types of practice, gradually shifting responsibility for learning and applying newly gained skills to the student. By building student independence, the software supports their learning in becoming independent readers.

## Mathematics Pillars

A strong grasp of certain mathematical foundational skills is a necessary underpinning for student success and progress in mathematics learning and knowledge. Exact Path Math is designed around five fundamental foundations:

- Conceptual Understanding
- Reasoning and Problem Solving
- Mathematical Models and Representations
- Mathematical Communication
- Key Math Skills

The following sections will describe the research base underlying each foundation and provide highlights of how those pillars are addressed in Exact Path.

### Conceptual Understanding

#### What Research on Conceptual Understanding Says

Research supports the effectiveness of the Concrete-Representational-Abstract (CRA) progression of math instruction. CRA builds math understanding by a progression of instructional experiences. The progression moves from Concrete (using manipulatives) to Representational (using models, diagrams, and other pictorial representations) to Abstract (the numbers and symbols that many people consider to be math). Students experiencing instruction along this progression are best able to develop the skills for mental and symbolic mathematics (Furner & Worrell, 2017).

A 10-week CRA intervention for kindergarten students showed students in the intervention group fared better than those in the control group, who did not receive CRA instruction. Not only did the students in the CRA group show more growth in number sense from the pre-test to the post-test 10 weeks later, but the benefits of following the progression stayed with these students into Grade 1 (Sterner, et al., 2020).

The realm of conceptual understanding includes number sense, which is often "used loosely to refer to an intelligible view of number implied or grasped rather than expressed" (Ghazali, et al., 2021). This meta-analysis identified five number-sense themes: number composition, number identification, magnitude of number, arithmetic operations, and judgment making.

### How Exact Path Applies the Research on Conceptual Understanding

Setting the stage for conceptual understanding, including number sense, is an area in which Exact Path excels. When appropriate, modules move through the stages for development from concrete to pictorial to abstract. For example, we see this approach in kindergarten when adding whole numbers.

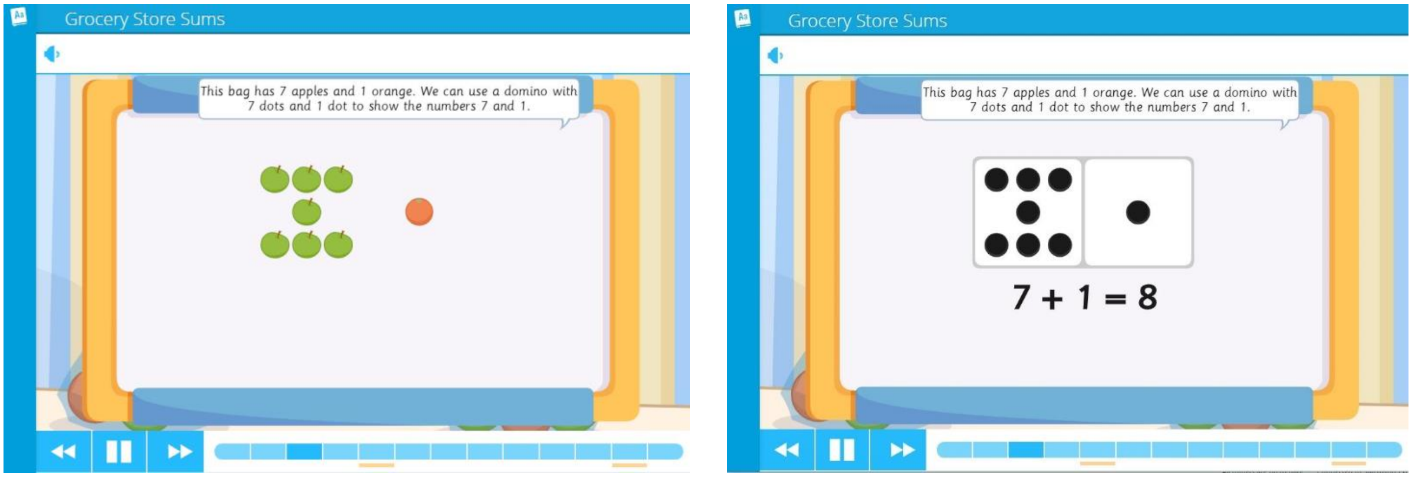



*Figure 37. The kindergarten lesson "Grocery Store Sums" uses concrete objects (apples, oranges) to show addition. Dots on a domino provide a representational model of the same addition scenario, and finally, students are shown the abstract representation of the equation.*

## Reasoning and Problem Solving

### What the Research on Reasoning and Problem Solving Says

Students need to develop problem-solving skills at a young age because these experiences are the building blocks for more complex mathematical problem-solving tasks. Problem-solving skills, which include reasoning, are used in all grades and across all subject areas as well as tied to standardized test scores (Woodward, et al., 2012), according to the What Works Clearinghouse (WWC). WWC outlines several recommendations to help students gain competence in problem solving, including teaching how to use visual models, exposure to a variety of problem-solving strategies, and recognition of math concepts and notation.

In addition, the four-step problem-solving model—understand the problem, devise a plan, carry out the plan, and review/look back (Polya, 1957)—is still relevant today. Research on Polya's method continues to show significant impact to learning outcomes in low- and moderate-achieving students (Lee, 2017).

Problem solving and reasoning are often intertwined. Jeannotte and Kieran (2017) clarify that the processes involved in mathematical reasoning include generalizing, conjecturing, identifying a pattern, comparing, classifying, validating, justifying, proving, and exemplifying, which is similar to Polya's problem-solving model.

## How Exact Path Applies the Research on Reasoning and Problem Solving

Students are presented with problem-solving opportunities throughout Exact Path, but this exposure is not limited to traditional problem-solving scenarios. Take, for example, this Grade 5 module about finding the volume of a rectangular prism. To set up the problem, the student is shown how to use a visual model as WWC recommends. Then, they implement Polya's four-step problem-solving model: First, the student is walked through understanding the problem. Next, a plan to use layers of cubes is described. Finally, the problem is solved and there is a chance for the student to review the process and answer the question about the volume of the tank.

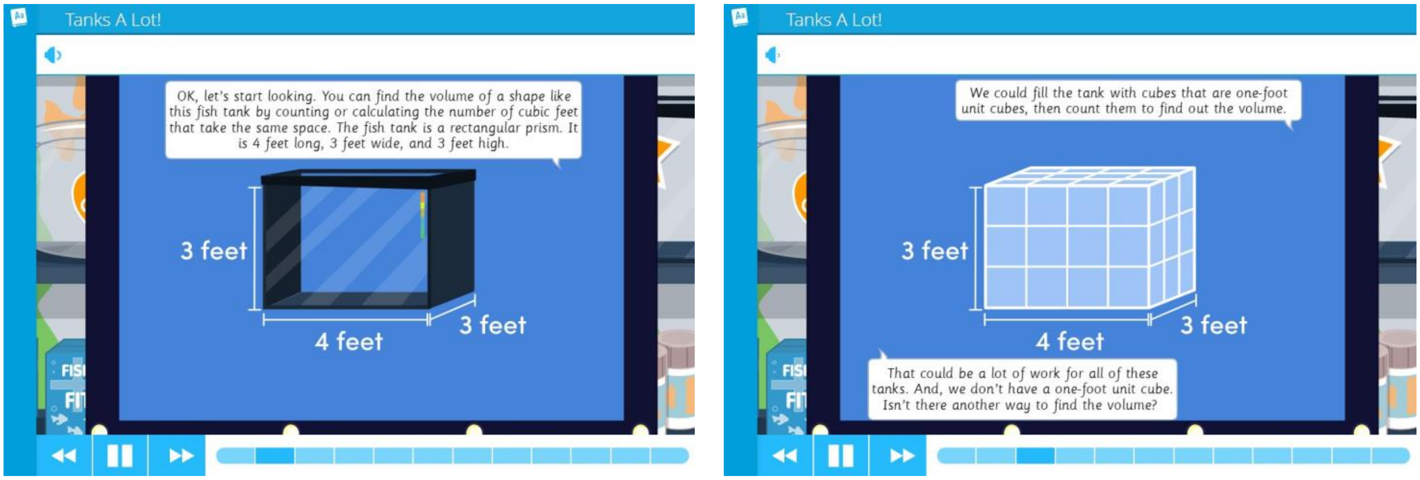



*Figure 38. The first step in Polya's problem-solving process is to* ***understand*** *what the problem is asking. In Grade 5, "Tanks a Lot," the student needs to find the volume of a fish tank shaped like a rectangular prism.*

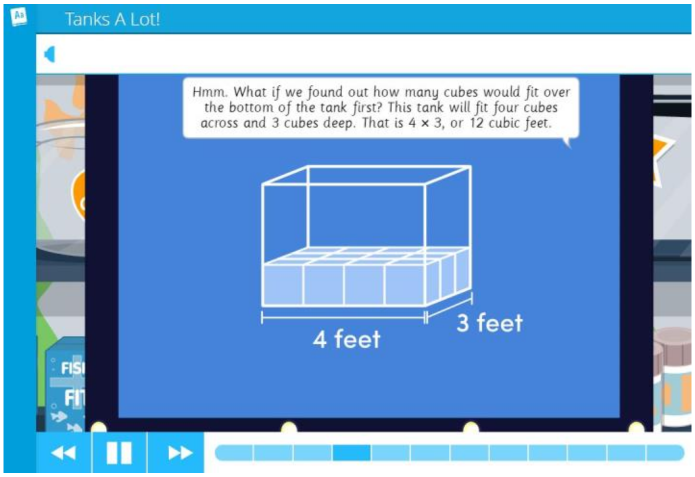



*Figure 39. The second step in Polya's process is to* ***make a plan*** *for how to solve the problem. Here, the student is shown how to find the number of cubes that will cover the bottom of the tank, and then multiply that number by the number of layers of cubes that are needed.*

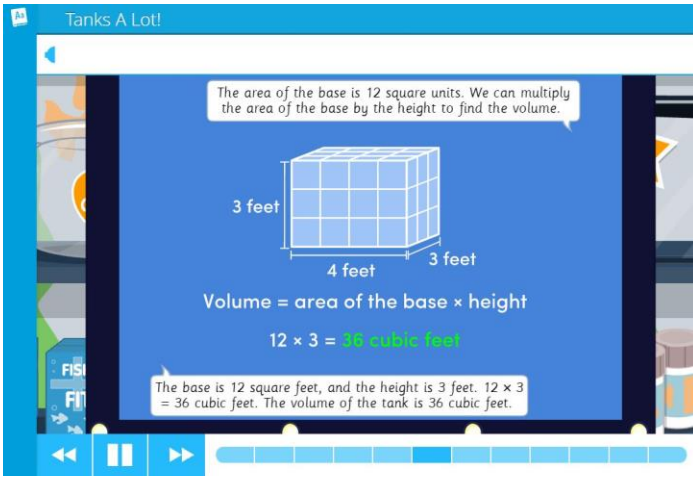



*Figure 40. Finally, Polya's process has the problem-solver* ***carry out the plan*** *and* ***look back*** *on their answer. We see that the volume of the tank is equal to the area of the base multiplied by the height of the tank.*

## Mathematical Models and Multiple Representations

### What the Research on Mathematical Models and Multiple Representations Says

Mathematical understanding is more accessible to students when they are presented with a variety of models and representations. Most mathematics instruction depends on standard models and representations used to teach mathematical concepts, such as base-ten blocks to teach place-value concepts and arrays to teach multiplication. Appropriate layering of a variety of representations can deepen learning without confusing learners.

Children begin to notice connections between concrete and abstract representations as early as preschool (Hassinger-Das, et al., 2015). However, using mathematical models and representations should not be limited to students who are just beginning their math journeys. In a study using neuroimaging, researchers found that both children and adults process mathematics tasks in an area of the brain associated with a network of visual pathways, and even when models and pictures are not present, the brain still visualizes the mathematics (Boaler, et al., 2016). Representations can be internal visualizations or external pictures, models, or diagrams, and can be either ideas or tangible ways to show understanding, from concrete objects to written words and symbols (Pape & Tchoshanov, 2001).

### How Exact Path Applies the Research on Mathematical Models and Multiple Representations

Exact Path uses a variety of models and representations in instruction, practice, and assessment. In Grade 1, for example, addition is represented with base-ten blocks as well as with symbols. In Grade 4, both a part-of-the-whole fraction model and number lines are used to represent finding equivalent fractions.

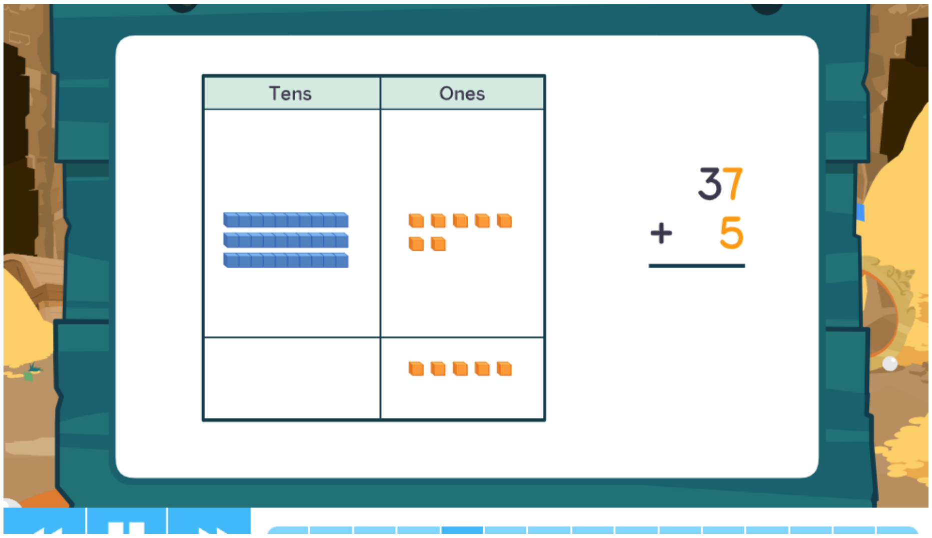



*Figure 414. In Grade 1, addition is represented with base-ten blocks (hands-on) as well as with numbers and symbols.*

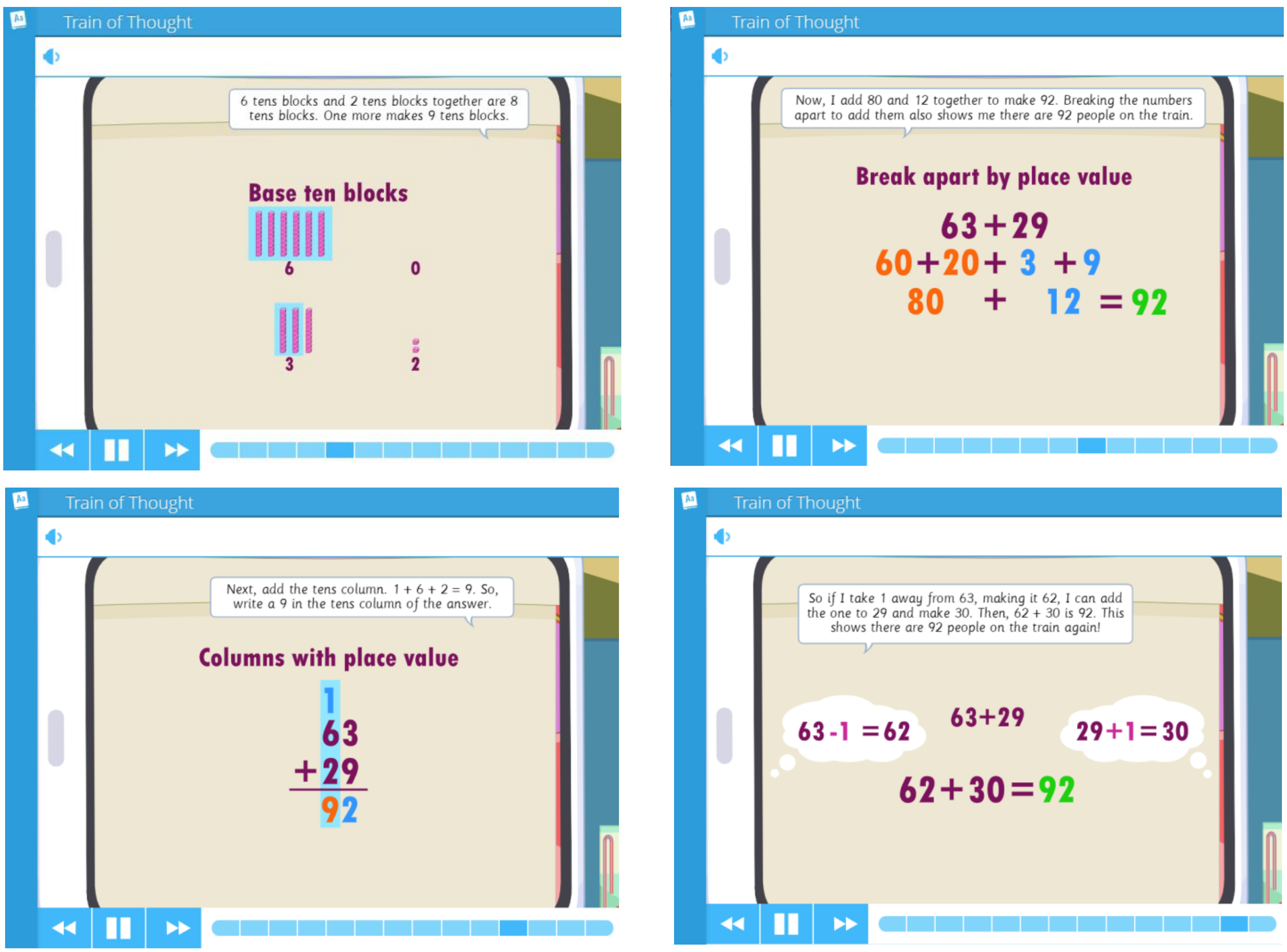



*Figure 42. In the Grade 2 lesson, "Train of Thought," a variety of ways to add 2-digit numbers is presented—using base-ten blocks, breaking apart numbers, using the algorithm, and applying the compensation strategy to add mentally.*

## Mathematical Communication

### What the Research on Mathematical Communication Says

Vocabulary and mathematical language are important parts of mathematical communication. Mathematical reasoning is a form of communication, either internally or with others, which supports making mathematical inferences based on given information or understanding of underlying mathematical concepts (Jeannotte & Kieran, 2017). This type of communication occurs, for example, in the areas of generalizing to arrive at conclusions, conjecturing, identifying patterns, comparing, and classifying (Hassinger-Das, et al., 2015).

The use of clarifying and specific words and diagrams is indicative of strong mathematical communication skills, while simply using a symbol to define a math term does not necessarily demonstrate understanding of a concept. For example, about half of Australian eighth-year students in one study could associate the division symbol (÷) with the term *divide*, but only about a quarter of the students could explain the concept of division (Miller, 1993).

### How Exact Path Applies the Research on Mathematical Communication

Math instruction does not happen without mathematical communication, and every module in Exact Path consistently uses mathematically correct, clear, precise language, terminology, and diagrams for communication, with an emphasis on using the correct terminology as early as is developmentally appropriate.

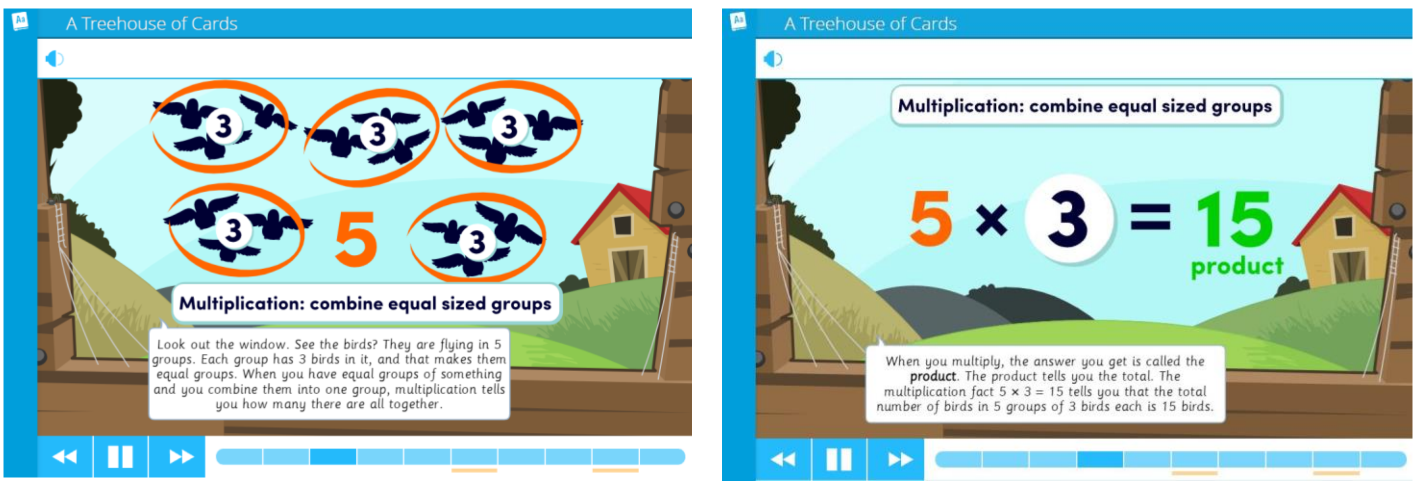



*Figure 43. Students experience mathematically correct terminology (multiplication, combine, equal sized groups, product) in the Grade 3 lesson, "Treehouse of Cards."*

## Key Math Skills

### What the Research on Key Math Skills Says

In its 2008 report, the National Mathematics Advisory Panel (U.S. Department of Education) made what are now widely accepted recommendations for math curricular content, including that a "focused, coherent progression of mathematics learning, with an emphasis on proficiency with key topics, should become the norm in elementary…school mathematics curricula," and a "major goal for K–8 mathematics education should be proficiency with fractions (including decimals, percents, and negative fractions), for such proficiency is foundational for algebra." The panel went on to propose three areas that should be addressed to build a good foundation for algebra: Whole Numbers, Fractions, and Aspects of Geometry and Measurement.

**Whole number concepts.** These underpin basic number sense and build the foundations for mathematical properties used in algebra and beyond. Concepts include counting, ordering, and comparing. The basics of number sense are rooted in expressing value, counting, estimating, and performing simple operations with whole numbers. These basics are the building blocks for understanding place value, how whole numbers can be composed and decomposed, and for the meaning of the basic arithmetic operations of addition, subtraction, multiplication, and the four mathematical operations (U.S. Department of Education, 2008).

**Fraction Concepts.** The National Math Panel (U.S. Department of Education, 2008) found that "difficulty with the learning of fractions is pervasive and is an obstacle to further progress in mathematics and other domains dependent on mathematics, including algebra. It also has been linked to difficulties in adulthood, such as failure to understand medication regimens." For this reason, fraction concepts should be introduced right away—as soon as students know their arithmetic facts and have a strong understanding of whole number concepts. The panel cautioned that students' ability to describe and perform operations with fractions does not guarantee they understand fraction magnitudes. Therefore, the panel further recommended continuing to build conceptual knowledge of fractions along with computational skills in problem-solving contexts.

In 2018, the Common Core Standards Writing Team published their recommendations for how students' instruction in and knowledge of fractions and fraction concepts should progress. The concept of "fraction" is built upon fraction language and moves to fraction notation, as related to measurement as well as parts-of-a-whole and number line diagrams. Fraction computation begins with the concept of equivalent fractions before students learn addition and subtraction of fractions followed by multiplication, and finally division. All of this prepares students for future work with fractions, including using multiplication as scaling, ratios, and study of rational numbers.

**Some Concepts of Geometry and Measurement.** When it comes to geometry and measurement, the National Math Panel (U.S. Department of Education, 2008) stressed that certain concepts, such as area and splitting a geometric figure into equal parts, are foundational for future mathematics concepts.

The Common Core Standards Writing Team (2013) addressed this by categorizing the top three elementary geometry goals as 1) geometric shapes, components, properties, and categorization; 2) composing and decomposing geometric shapes; and 3) spatial relations and spatial structuring. From there, in later grades, students will be able to make scale drawings and solve real-world problems involving surface area, angles, volume, and more.

## How Exact Path Applies the Research on Key Math Skills

Whole numbers, fractions, and geometry are all prominently featured throughout Exact Path. Below are just a few examples of how Exact Path supports these key math skills.

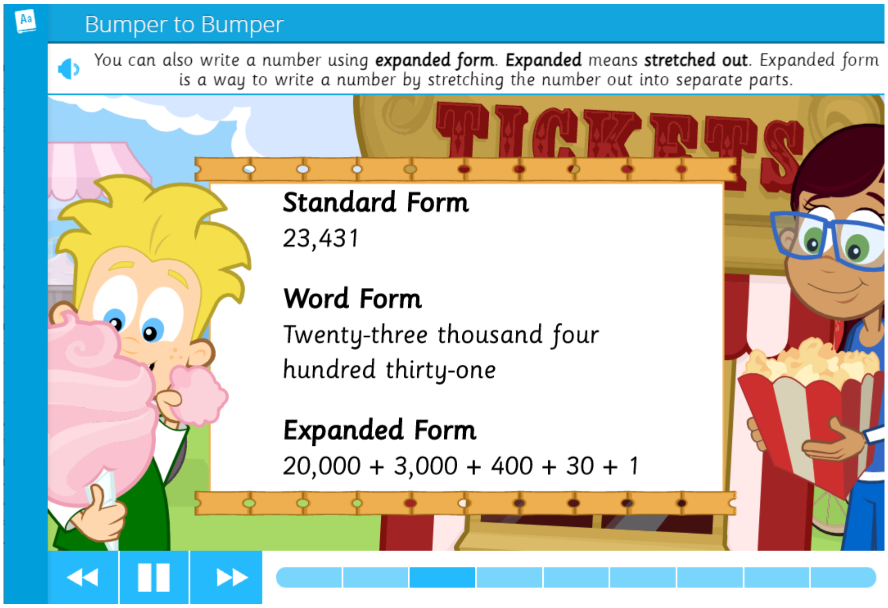



*Figure 44. This Grade 4 lesson, "Bumper to Bumper," shows multiple forms of the same whole number, including numerals, words, and expanded (decomposed) form.*

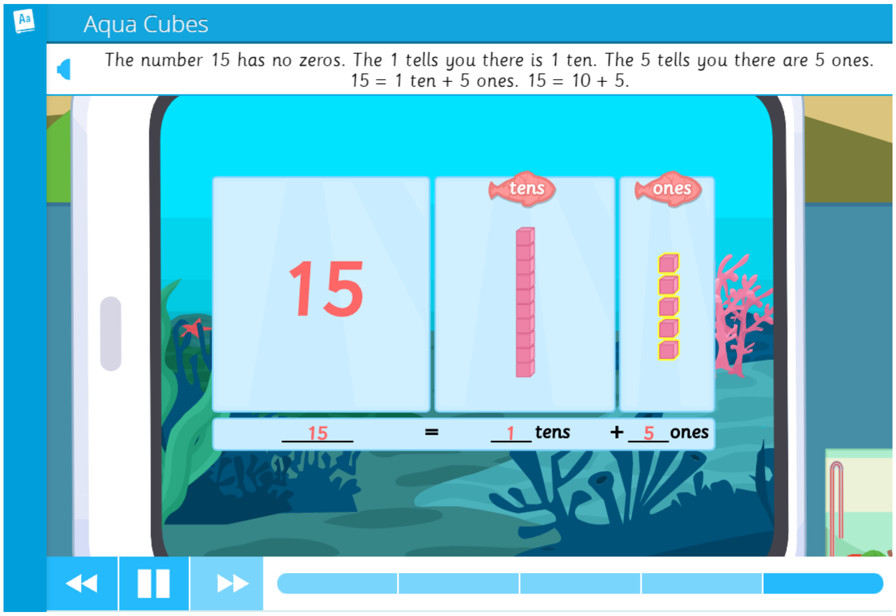



*Figure 45. This Grade 1 lesson, "Aqua Cubes," shows multiple forms of the same whole number, including numerals and a concrete representation using base-ten blocks.*

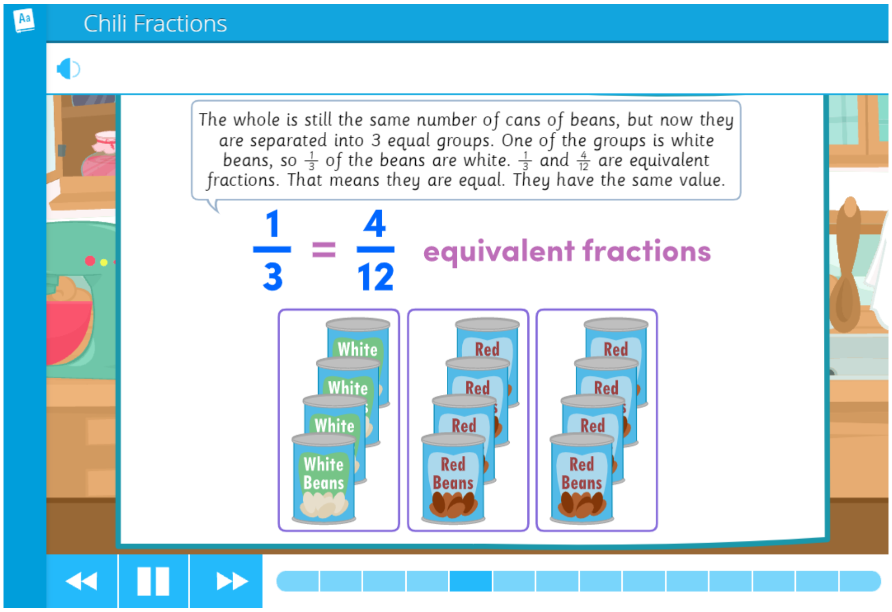



*Figure 46. In the Grade 4 lesson, "Chili Fractions," students use pictorial representations to find equivalent fractions before adding.*

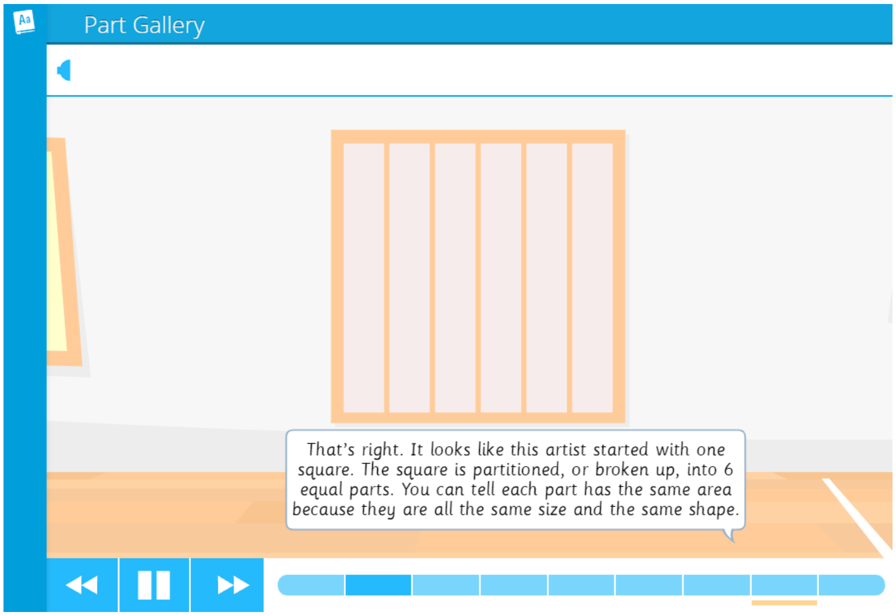



*Figure 47. In this Grade 3 lesson, "Part Gallery," students use partitioned shapes to build connections between fraction and area concepts.*

## Conclusion

Exact Path is aligned with valid research. This paper has documented the research findings that support the program and presented examples of that research in action by showcasing actual screens students engage with. Whether a second grader is working on new reading skills or a fifth-grader is revisiting key Building Blocks in mathematics, Exact Path offers the individualized instruction, practice, and assessment that each learner needs.

Equally important to the research base of Exact Path is its pedagogy. This is an important consideration that many other digital learning tools fail to embrace. At the heart of pedagogy is the teacher, and the educational technology world should never forget this. Exact Path is designed first and foremost to support educators and fit naturally into their daily routines. Exact Path learning-design principles and instructional pillars make that commitment clear, and the data and reports that are at teachers' and administrators' fingertips show an understanding of what is most helpful in managing today's wide variety of learning environments.

Serving today's tech-integrated students and supporting the role of modern educators are difficult tasks that technology has long promised to help accomplish. Doing so demands that digital educational tools are designed properly. What does this require? Research findings must be incorporated. Educators must be front and center in program conceptualization, development, and implementation. Meaningful data must be regularly provided to teachers to inform their decisions. Learners must feel empowered by success and know that their learning path is transparent to them at all times. These requirements and more are fulfilled by Exact Path.

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