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10/21
Introduction

Despite decades of attention, students in the United States continue to experience a wide achievement gap in mathematics and English language arts (ELA) due to a lack of equal access to high-quality resources, support, and opportunities to learn (Lacour & Tissington, 2011). Indeed, in an analysis of National Assessment of Educational Progress (NAEP) test results, Wiliam (2020) found that typical fourth-grade classrooms may have an 8-year span of achievement levels. Some students may perform as low as a typical first grader or as high as a typical ninth grader, with most students falling somewhere in between. Notably, Black, Hispanic, and American Indian/Alaska Native students tend to score 20–30 points below White and Asian/Pacific Islander students on NAEP math and ELA tests (National Center for Education Statistics, 2019). Such a wide achievement gap is attributed to extreme inequity in access to academic resources, and education scholars offer an alternative to the name “achievement gap,” instead naming it the “opportunity gap” (Flores, 2018).

The COVID-19 pandemic offered no solace to any students, but disproportionally affected Black and Brown students. Renaissance’s How Kids Are Performing (Spring 2021) report revealed students fell an average of 4 Percentile Rank (PR) points on Star Reading and 11 PR points on Star Math from where they were expected to end the year. Strikingly, for Black and African American students, results revealed an average 11-point discrepancy in reading and 19 points in math from where they would typically fall (Renaissance, 2021).

Access to high-quality resources is a key barrier to closing this opportunity gap. Extensive research suggests that explicit, systematic instruction is critical in developing foundational skills in both math and ELA (Hughes et al., 2017; Juel et al., 1986). Adaptive learning and differentiated instruction are key to providing explicit systematic instruction to meet the needs of each student (Subban, 2006); however, both can be difficult to implement with traditional instruction methods. Technology is key to making adaptive and differentiated instruction effective and efficient in the classroom, and this is where Freckle comes in.

What Is Freckle?

Freckle is a freemium educational practice tool (with both free and paid versions) offering unique tools for math, ELA, science, and social studies. Freckle maintains three key pillars: an engaging user experience; individualized, high-quality content; and formative feedback fed to both the teacher and student. With Freckle, students enter an engaging farmland where they develop and personalize an avatar to follow them through their journey in the program. Students earn coins as they complete activities, master skills, and reach goals. Only after earning 50 coins in a session a student can enter the Piggy Store to personalize their avatar and interface.

When students begin each activity domain, they take a pretest that places them on a scope and sequence at their skill level (or students are placed in the program based on compatible

To support student learning and teacher instruction, Freckle offers formative feedback through constructive support on each question when needed as well as extensive reports for both the teacher and students. Teachers can access student-level reports for almost every activity domain, and students can see their growth in skills and progress towards goals. Freckle supports teachers in lesson planning by grouping students based on standards and Freckle skill level, which facilitates small group rotations. Teachers can further use various reports to hone daily instruction and ensure all students are getting the support they need.

What Makes Freckle Effective?

Differentiation
Differentiated instruction stems from the idea that not all students learn at the same pace or in the same way. Historically, some instructional methods focused on teaching the “typical student” to ensure the class was on track with state learning standards. In reality, each student is unique with different learning styles and abilities, and teaching to the needs of individual students can allow for standard alignment. This instructional philosophy builds off influential philosopher and psychologist Lev Vygotsky’s famous theories: Sociocultural Theory of Learning and Zone of Proximal Development (ZPD).

Vygotsky’s sociocultural theory suggests educators must consider each learner’s social and cultural context, which is a critical component for high-order functions (Vygotsky, 1978).

For ZPD, Vygotsky noted that students learn best when faced with productive struggle that demands some level of support. An example of productive struggle is a student faced with a problem that is too difficult to answer alone, but who, with the assistance of prior knowledge, context, and peer support, can find a solution (Vygotsky, 1978).

Vygotsky’s theories work together to support differentiated instruction. Subban (2006) found that by acknowledging each student’s strengths and creating a learning environment that appeals to such strengths, students and teachers can work to support each other, while making each student feel valued. Subscribing to a differentiated classroom has shown to increase student engagement (Johnsen, 2003), which is critical, as increased engagement is linked to higher achievement outcomes (McClenney et al., 2012). Additionally, multiple studies have found significant increases in outcomes in classes that implement differentiation compared to classrooms that do not (Shepherd & Alpert, 2015; Subban, 2006).

Freckle uses differentiating instructional practices in two ways. First, the program evaluates the student’s reading level and adapts all future reading material to that level. For example, if students are working on a social studies lesson, the teacher can assign it with an adaptive reading level function so that each student receives the same core content but with the difficulty
of the material adjusted to their needs. Providing reading material at the level that allows students to best read and learn within their ZPDs increases the likelihood of comprehension.

Second, Freckle offers differentiation in the various learning activities. This feature is most robust in math where students can pick from various topics within each subject. Tomlinson and Doubet (2005) use numerous examples to explain the benefit of teaching to students’ interests. Rather than teaching students to pass a test and checking off boxes on a list of standards, teachers benefit greatly from getting to know their students and understanding their interests. The varied topics in Freckle appeal to students’ interests and support teachers in holding sociocultural relatedness as a pillar of instructional practice. Students learn to apply skills they are learning to their own experiences and inquire about ideas beyond the curriculum, while teachers can ensure student work is meeting standards requirements. In Freckle ELA, students can choose books to read from an array of topics, allowing them to pique their interests while learning to read with comprehension.

Robinson et al. (2014) found that a leading barrier to implementation of differentiated classrooms is the time required by teachers to lesson plan for such individualized experiences. Freckle provides an accessible way to implement differentiation while greatly reducing lesson planning time and supporting teachers’ planning beyond Freckle. For example, teachers can use detailed reports from Freckle to hone lesson plans and support students’ needs more directly.

Furthermore, Tomlinson (2000) argues that the key to successful differentiation is high-quality curriculum and instruction. Freckle directly supports curriculum and instruction by providing students with high-quality, differentiated assignments to help them practice and master core standards.

Computer-Assisted Instruction and Adaptive Learning

Extensive research supports the efficacy and efficiency of computer-assisted instruction (CAI) in the classroom. Fletcher-Flinn and Gravatt (1995) conducted an influential meta-analysis of the efficacy of CAI and discovered that from 1987–1992, studies reported a mean effect size of CAI to be \( d = 0.24 \), which is moderate, but not insignificant. They also discovered later studies found a mean effect size of \( d = 0.33 \). While this is still a moderate effect, technology then was very different than it is today. For example, more recently, a meta-analysis by Blok et al. (2002) found that CAI used in English speaking countries resulted in an effect size of about \( d = 0.50 \). As the education community learns more about how students learn and what makes learning more efficient, CAI tools are constantly improving and increasing in efficacy—as seen clearly in Freckle’s efficacy.

Even more effective than standard CAI, is adaptive CAI, which best describes Freckle. Adaptive CAI differs from typical CAI by adapting the content and skill level to meet each student’s needs. In Freckle, students take a pretest, which places them along a linear sequence that adjusts based on how the student performs on each item. Adaptive CAI is so effective because it helps to fill content gaps in areas where a student may be struggling. This is especially helpful for two reasons: (1) such struggle might not be apparent to the teacher, and/or (2) the teacher may not have time to individually support each student. Johnson et al. (2010) speaks to the efficacy of
adaptive CAI by looking at the variability in achievement related to different CAI methods (learner-controlled, linear sequencer, mastery sequencer, and control). Results showed that pre-K and kindergarten students who used adaptive CAI (linear or mastery sequencers) showed significantly greater growth on the Dynamic Indicator for Basic Early Literacy Skills (DIBELS) benchmark test than students who were in the control group. Cassady and Smith (2003) similarly found that kindergarten students who used the integrated learning system (a broader term for CAI) showed significantly greater growth in emergent literacy skills compared to students in the control group.

Adaptive learning is a great tool to further the efforts of differentiated learning, as differentiated instruction does not always mean individualized instruction (Peng et al., 2019). For example, a teacher could group students by learning styles and differentiate instruction for each group. Adaptive differentiated instruction, however, continuously re-evaluates an individual student’s skill level, and then adapts the differentiation accordingly. Freckle helps to facilitate adaptive differentiated instruction to make practice and instruction much more efficient for teachers and students.

Freckle uses adaptive CAI in two ways in: (1) the Adaptive Math Practice feature, and (2) the pretests for math and ELA. Using a mastery sequencer, Freckle’s adaptive learning algorithm allows students to work within their ZPD to grow their depth of knowledge without getting frustrated by impossibly tough questions for their current skill level.

The adaptive algorithm uses the total number of correct and incorrect questions for a specific skill to move the mastery score moves up or down—the threshold for mastery being 80%—for both the adaptive practice and pretests. Once a student reaches either the floor or ceiling threshold, they are moved to the next or previous skill, respectively. A student must fully master a skill before moving on to the next skill (see figure 1).

Figure 1. Math Adaptive Practice pathway
If a student answers more questions wrong than right, they are placed on a remediation track. The remediation track gives the student easier questions on a prerequisite skill of the target skill. When three questions are answered correctly on that prerequisite skill, the student can move forward in the skill progression. If students fail the first remediation path, they will be put on the remediation path of the previous skill. If they master that subskill, they will be moved back onto the skill progression of that skill, rather than the original skill.

**High-Quality Content and Implementation**

A practice or instruction program is only as high-quality as its content. An application could have an engaging and visually appealing interface, but if the content quality is lacking, it will not help a student learn. Conversely, a program’s pedagogy could be highly effective, but if it does not easily incorporate into a teacher’s instruction to meet the needs of students, it will serve little purpose. In 2006, Ferdig coined the term *technological pedagogical content knowledge* (TPCK), a concept that outlines the components needed to teach effectively with technology. Technological education programs need high-quality content that is compatible with technology. Content creators and technology developers need to know the content and how to teach it but also need a strong understanding of how technology can uniquely support pedagogy. In the case of Freckle for Math, ELA, Science, and Social Studies, the team prioritizes TPCK in product development by building a content and product team of both educators and experts with diverse pedagogical, educational, and technological expertise.

Each piece of content (e.g., questions, articles, activities) goes through several checks and balances to ensure it is both aligned to state-specific standards and truly accessible to all students. All members of the content team have extensive experience with standard-specific instruction. For each state, content is created in alignment with end-of-year tests and state-specific instruction to ensure it not only meets the state standards but also is culturally sensitive. The Freckle team do their best to create content that elicits critical thinking and builds inferential skills within the context of a computer-automated practice program.

**Professional development**

Ease of implementation of classroom technology is just as important as pedagogy. A major barrier to successful implementation can be teacher adoption. Many educators may not have time to learn a new product or may not be comfortable enough with it to work it into their lesson plans (Blackwell et al., 2013). Teachers are often also under pressure to teach in alignment with specific standards and may not feel inclined to use a new technology if they are not certain that it supports them (Purcell, 2005).

In Freckle, teachers have great flexibility in how they direct students work in the program. Teachers who use Freckle passively can allow students to sign in independently when they have completed other classwork. Teachers who use the program actively may dedicate specific time for Freckle throughout the day as well as frequently utilize its reporting, assignment, and assessment features.
In 2016, KnowProgress analyzed the effect of implementation on Northwest Evaluation Association (NWEA) Measure of Academic Progress (MAP) achievement and found that overall, students who used Freckle experienced greater growth than those who did not. Specifically, students who used Freckle longer saw greater growth than those who used it below the suggested use or not at all.

Freckle for Math and Freckle ELA are aligned to state standards and College and Career Readiness Standards, which allows teachers to feel confident that students using Freckle are building skills through activities that will support their long-term achievement. Freckle’s standards alignment and adaptive learning algorithm help teachers ensure that students are working on activities and skills specific to them, which frees up time for teachers to work one-on-one with students.

To support teachers in integrating Freckle into their classroom, the program prioritizes professional development by providing online asynchronous training videos, virtual and in-person training sessions, and an abundance of resources to help with lesson planning within and beyond Freckle. Additionally, the Freckle curriculum team stays up to date with state standard updates and makes sure all content maintains alignment to state and educator expectations.

**Spanish support**
Freckle translates to Spanish for almost all the user experience for students to navigate around the application, except for a few domains. Almost all the Math components (Math Adaptive, Targeted, and Benchmark question text, Fact Practice, Number Basics, and Focus skills) except Algebra 1 translates to Spanish. However, ELA, Science, and Social Studies articles and practice questions are not currently translated.

**Free versus Premium**
Whether educators have adopted the Free or Premium versions of Freckle, the student experience is identical. The main difference between the two versions is that the data accessible to teachers is more robust in the Premium version. From the teacher portal, teachers with Premium can compare an unlimited number of students on each Math and ELA report. Likewise, administrators using the Premium version can access a portal where they can view schoolwide and class trends and assign select benchmark assessments. The Free version also allows teachers to assign only one assignment per week, while the Premium version allows for unlimited assignments.

Note, one difference in the Free version is that there are no Social Studies articles/activities available and only a few Science articles/activities; however, the student experience is almost identical between the two versions for the content that is accessible.
Content Area Characteristics

Math
Freckle for Math comprises four main activity types with high-quality content for students: Adaptive Math Practice, Targeted Practice, Fact Practice, and Critical-Thinking Activities (Inquiry-Based Lessons [IBL], Depth of Knowledge [DOK] Challenges, and Constructed Response).

**Adaptive Math Practice** is broken up by domain, then standard, then skill. Students select a domain to practice in (e.g., Measurement and Data, Fractions) and then take a pretest that places them at a skill within that domain (see figure 2). If the teacher uses the Premium version, they can import students’ Star or NWEA MAP test scores or manually enter skill levels. The student then works through each level, driven by the program’s adaptive learning algorithm. Students will move to the next standard only after they have mastered the current one. (Kindergarten students start work at the first level.)

**Figure 2. Adaptive Math Practice: Measurement and Data Domain**

**Targeted Practice** can be selected by students or teacher assigned. If a student wants to work on prior skills, they can choose a previous level in the Adaptive Math Practice progression. Teachers can assign Targeted Practice by selecting a domain, standard, and skill, and then choosing how many questions the practice will contain.

Students do not earn coins for student-selected Targeted Practice; instead, the sole reward is skill development.
**Fact Practice** is a grid of basic math problems that students should be able to solve in their heads (see figure 3). If a student accurately answers all of them, they receive 65 coins. (Note, coins are randomly distributed to each question, so some problems may be worth more than others). Because it only focuses on a single skill and allows students to earn so many coins, Fact Practice is a favorite Freckle activity among students and is limited to two sessions per day.

As deficits in foundational math skills are becoming increasingly apparent in elementary students, and teachers are turning to math fact practice to fill these gaps (Musti-Rao et al., 2015), Freckle's Fact Practice is especially important. Stickney et al. (2012) looked at the effects of fact practice on low- and high-achieving students and found that low-achieving students were less likely to exhibit strong math fact fluency; however, those who did demonstrated a significant growth in achievement.

![Figure 3. Fact Practice](image)

**Critical-Thinking Activities** (Inquiry-Based Lessons [IBL], Depth of Knowledge [DOK] Challenges, and Constructed Response) in Freckle encourage students to think creatively and understand how skills they are learning in class can be applied to everyday life.

Cross-curricular activities, such as Inquiry-Based Lessons, build conceptual understanding of math topics while students explore real-world scenarios and work together to create their own questions and find solutions. Such activities encourage collaborative and critical thinking. A key component of these lessons is that students are encouraged to use their creativity and personal experience. With teacher support as needed, it is up to the students to find a solution from start
to finish. Such autonomy leaves room for creative and critical thinking that can result in a variety of solutions from different students.

**Inquiry-Based Lessons**

John Dewey, an early 20th century philosopher and researcher, is often credited with promoting student-centered, hands-on learning and specifically advocating for IBL. Dewey believed that inquiry was not just application but expansion (Tanner, 1988). He proposed that for true inquiry, students must solve a problem from start to finish, they must understand the consequences of their solutions, and they must explain exactly what prompted the issue in the first place.

In a 2017 study of almost 500 teachers from 10 different countries, Silm et al. began to understand the role that teachers’ attitudes play in implementation and efficacy of IBL. They found IBL increased student engagement and teachers believed it would also increase motivation. However, while teachers wanted to implement IBL and saw the value, the strongest effect on teachers’ attitudes was available resources.

The design of the current US education system limits resources and complicates logistics, preventing teachers from implementing IBL, but Freckle removes those barriers. Freckle provides unique resources for teachers by furnishing fully developed lesson plans and all the resources necessary to implement such lessons in the classroom. Additionally, each Freckle activity takes only about 30 minutes to complete. Teachers can feel confident that they have everything needed use IBL in the classroom and that each lesson is high quality and aimed at developing skills related to specific standards.

Inquiry-Based Lessons are available for grades 1–8. For elementary grades (1–5), students are provided with open-ended questions to scaffold discussion and question development, while middle school students (6–8) have no scaffolding, allowing for more agency. Each lesson starts with a “Number Talk” (or “Dot Talk” for first grade). During this time, students are asked to solve a math problem in their head as many ways as they can and then share their thought process. This helps students think about diverse ways to solve problems. Next, students watch a 1–3-minute video explaining the real-world situation that relates to the problem. Students then get into groups to produce a few critical questions, engage in active problem solving, and develop conceptual understanding to solve the inquiry. Finally, students present their solutions with in-depth explanations of their thought processes and then are asked to reflect on their processes.

Looking beyond its philosophy, IBLs are effective at improving academic outcomes. Ješková et al. (2016) found that IBLs significantly increased first- and second-grade students’ inquiry skills in both math and science classes, and Barron et al. (1998) found IBL to show improved achievement for students on standardized tests.

**Depth of Knowledge Challenges**

Freckle also offers Depth of Knowledge Challenges and Constructed Response worksheets. DOK challenges can be assigned by the teacher but are also presented to students after they master a level or standard in Adaptive Math Practice. DOKs are three or four question sets that increase in
mathematical rigor while connected to a real-life application. DOKs are accompanied by visual representations of real-life scenarios (e.g., For kindergarten students, the number of dogs in a dog park as a few dogs come and go).

**Constructed Response**

Teachers can print Constructed Response worksheets for students. For middle school (6–8) and Algebra 1 standards, teachers can provide these worksheets to help students practice concepts, apply their practice to situations, or visualize a concept. Each Constructed Response worksheet has 4 or 5 questions and gives students ample room to show their work.

A core philosophy within Freckle is that learning does not happen in a bubble. It is important for students to apply skills to other areas to build conceptual understanding and cross-curricular context. Critical-Thinking Activities like IBL, DOK Challenges, and Constructed Response encourage students to think creatively and understand how the skills they are learning in class can be applied to everyday life. Freckle teaches students the foundational problem-solving skills they will need for not only academic but also lifetime achievement.

In several studies, Freckle for Math has shown greater growth for students in benchmark tests as compared to the control group (Freckle Education & WestEd, 2016; Freckle Education, 2018; KnowProgress, 2016; Renaissance, 2020).

**ELA**

Freckle ELA has three main components: Word Study, Skills Practice, and Library, and two additional domains for K–2 students: Decodables and Sight Words. As in Freckle for Math, students take a pretest when they begin any practice activities. Depending on their grade, students can pick from up to five different activity types (an example dashboard for fifth grade is shown in figure 4):

**Word Study** gives K–12 students opportunities to work on spelling and learn different word families. Depending on the student’s reading level, they answer multiple choice, matching, or short-answer questions (e.g., the program will say a word and ask the student to spell it).

**Skills Practice** starts with a pretest for first grade and up to place students in the program. Students then work through various reading and grammar skills that continuously adapt to their individual levels. (Kindergarten students start work at the first level.)

**Library** articles cover fiction and nonfiction topics and are differentiated to adapt to the reading level of each student. This way, all students have equal opportunity to read and learn about any topic and are less likely to become bored or frustrated due to text difficulty. After completing an article, the student answers a few comprehension questions using inference and context to arrive at the correct answer.
Decodables are available only to K–2 students and focus on foundational reading skills. Students read short stories and then answer two comprehension questions. They must answer both questions correctly to move on to the next Decodable activity.

Sight Words activities spell out a word, sound out a word, and use a word in a sentence, and then ask the student repeat the word. Freckle’s extensive library of sight words is based on sight word lists from both Dolch and Fry.

Figure 4. ELA Practice Dashboard for a fifth-grade student

The Freckle ELA scope and sequence strongly adheres to Scarborough’s (2001) rope model for literacy development, which expands on the Simple View of Reading to suggest that reading comprehension is a product of strong skill development in language comprehension and decoding (Hoover & Gough, 1990). As shown in figure 5, Scarborough’s model posits that language comprehension and word recognition skills wind together to develop skilled reading comprehension. Each strand within both skills areas starts at the same point, which suggests that each skill is equally important and can be learned independently. The rope visual implies a deficit model in that a student could technically read without completely mastering each skill, but it may be hard to spot exactly where students are struggling.

Freckle’s systematic, adaptive approach allows the student to learn the same content as their peers in subjects such as social studies and science, while revisiting critical foundational reading skills to help boost their reading level to that of their peers. Students in grades 3 and up continue Word Study along with reading comprehension. Consistent practice of key foundational skills is critical to development and maintenance of strong, automatic reading skills.
To practice reading comprehension in Freckle, students can read fiction and nonfiction articles on a wide array of topics. Guszak (1967) conducted a study to understand the questions teachers were asking students about reading comprehension questions and how beneficial these questions were. The study found that about 70% of questions were practical in testing students on their understanding of text, but that the other 30% tended to be about minute details a student could not reasonably remember from reading. Another study found that story-structure questioning aided students in recall and comprehension (Bowman & Gambrell, 1981).

Freckle ELA exposes students to fiction and nonfiction text while showing them questions about the article (see figure 6). Students can answer the questions only after they have finished reading the article. Question content is aligned to the state and other ELA standards when applicable, including requiring students to make inferences about the text and to unravel the story structure and meaning. Allowing students to view the questions while reading (but not answer them) helps students scaffold their reading and retain the main ideas of the story.
Science and Social Studies
Because science and social studies curriculum can vary between states and districts, Freckle offers a variety of topics that cover the basics and beyond. For both Freckle Science and Freckle Social Studies, teachers assign articles to students that cover subject-area content and include comprehension questions to gauge how well students understand the material. To ensure students of all reading levels can access the material, teachers can either assign articles with adaptive lessons, so that the reading level matches students’ individual achievement levels, or offer text at the same level to the entire class. At the end of each section, teachers can use an assessment that will cover all the material discussed in that unit.

In many of the social studies units, teachers can assign an end-of-unit project that asks the student to apply what they have just learned to real-world experiences. For example, the Basic Economics unit project asks students to interview a trusted adult and then develop an economic portfolio based on what they learned in the unit. The teacher has access to a day-by-day timeline, instruction, and a rubric to aid in planning.

Freckle’s science and social studies articles and activities are great tools for students, especially if they find textbook material difficult to read. These activities can also serve as additional reading comprehension practice. In comprehensive literacy instruction it is important to apply the skills learned in ELA to other subjects (Gambrell et al., 2011). Cross-discipline practice helps to generalize the skills learned and increases students’ self-efficacy, both which are important in increasing academic achievement. See figure 7 for a student’s typical use of Freckle.
Figure 7. Typical use case of a student on Freckle
The Four-Phase Model of Interest Development

To understand the ways teachers can support academically unmotivated students, Hidi and Renninger (2006) developed a four-phase model of interest development. The model suggests students need situational interest, a “foot in the door,” until they progressively find value in a topic or subject, and their motivation crosses over to be more self-generated (or intrinsic). Freckle employs all four phases of this model:

**Phase 1: Triggered Situational Interest:** First, students need a hook—some feature to pique their interest and initiate attention to the lesson, instruction, or practice. In a typical classroom, this could be a puzzle or game to introduce a topic, and after students are drawn in, the teacher may ease into traditional instruction. This stage usually is externally supported—or builds on extrinsic motivation (Bloom, 1985; Sloboda 1990; Sosniak, 1990). In Freckle, students are drawn in by the interface and avatar personalization. Freckle has a farm theme, where students can select and personalize their own avatar. The seamless and colorful user experience and personalization provides a source of situational interest to get students “in the door” and more open to participating in the educational components of the product.

**Phase 2: Maintained Situational Interest:** Then, situational interest is prolonged to maintain engagement until the student develops intrinsic motivation. Like phase 1, the stimuli tend to provide extrinsic motivation; however, Freckle offers both externally and internally supported features to maintain interest. For example, for students still struggling with motivation, the coin system provides a performance-focused motivation that allows students to build and sustain the triggered situational interest (i.e., personalizing their avatar and interface). As students earn coins for accurately completing activities, they can visit the Piggy Store for 90 seconds to exchange coins for clothes and hairstyles for their avatar or new backgrounds (see figure 8).

**Figure 8. Students exchange coins for avatar accessories in the Piggy Store**
To maintain situational interest, students can also set achievement-oriented goals. Black and Wiliam (1998) explain the importance of goal setting in garnering intrinsic motivation. Setting their own goals allows students to feel in control of their education and learning journey. When students can monitor their goal progress self-efficacy increases, which in turn improves performance. Mastery is about how a student learns and whether they feel comfortable with the material, and research supports that goal progress monitoring increases self-efficacy and allows students to understand their ability (Schunk & Swartz, 1993).

Hidi and Renninger (2006) stress that, in this phase of interest development, “instructional conditions or learning environments provide meaningful and personally involving activities.” The core goal of Freckle is to provide an individualized practice experience. When students first login and begin either an Adaptive Math Practice or ELA Skills Practice, they take an adaptive pretest to place them along the scope and sequence at their skill level. Beginning all students at a universal skill level would not account for differences in learners, or address that when students practice skills that are too easy or too hard, it is likely their interest could wane. Providing activities that fit each student’s skill level (and areas of interest in the Freckle Library) helps academically unmotivated students maintain situational interest, and then progressively become internally motivated so that the effects of extrinsic rewards, such as coins, would begin to decrease.

Phase 3: Emerging Individual Interest: Next, the student’s implicit motivation begins to emerge. The student has experience with the program, feels comfortable navigating it, and has found which activities and topics are most helpful and interesting. The student is excited to choose Freckle to learn skills, rather than just win coins. Freckle best supports this stage by providing formative feedback: Freckle offers immediate feedback after each question. If a student answers the question incorrectly, a few tries and hints are provided to help the student find the correct answer independently. Students can also see their own progress on different skills and activities. Extensive research supports formative feedback as a tool to increase students’ academic success (Black & Wiliam, 1998; Elawar & Corno, 1985). In a meta-analysis studying “enhanced instruction,” Tenenbaum and Goldring (1989) suggest that reinforcement, feedback, and correctives increased student outcomes with an effect size of $d = 0.66$. Consistent feedback allows students to understand where they are in their learning process and develop skills to improve.

Research also suggests that formative feedback increases student interest when incorporated into instruction (Pinger et al. 2018). Having interest stem from achievement (rather than situational triggers) is crucial because it allows students to monitor and visualize their progress on academic skills. In turn, their motivation to complete activities in the program will become more consistently intrinsic. For each skill in Freckle, students can see their growth from where they started and how they are performing in relation to other students.

Phase 4: Well-Developed Individual Interest: Inquisition and application are critical in the final stage of this model. At this point, students have successfully learned and feel confident about the skills developed through the Freckle program because they see the benefit on their
achievement. For example, in this phase, students read because they enjoy reading. Freckle supports students by showing them the benefits of and successes from learning these important foundational skills. While interest can be triggered by fun themes and avatars, the ways teachers can feel confident their students are maintaining interest and engagement in lessons are through personal involvement and the meaningfulness of the task (Mitchell, 1993).

To further support students’ curiosity, Freckle offers IBLs, DOK Challenges, and Constructed Response activities, which require students to think creatively and apply lessons they have learned to real-world experiences. Students are encouraged to develop their own questions and understand problems at their core. In turn, students develop a greater appreciation of the skills learned and are excited to use them in new and more extensive ways.

Freckle supports the development of initial interest and intrinsic motivation in students by offering differentiated activities that ensure students are learning at their level (ZPD). With the right amount of support from teachers, peers, and the program, students tackle challenges and activities that reinforce their abilities, which makes learning fun, interesting, and exciting.

**Teacher Portal**

**Assignments**
Teachers can assign math and ELA activities, skills practice, and assessments to the entire class or individual students by activity type (see figure 9). Within those activity types, teachers select the domain and standard they want students to practice and decide whether the activity includes 3, 5, or 10 questions. To account for students that may not be at the level of the assignment, the teacher can select to have those students receive a supported version that allows hints before attempting each question.

**Figure 9. For math and ELA, teachers choose assignments by activity type**
For Science and Social Studies, teachers can search through each Freckle unit and assign articles that will adapt to each student’s reading level. See figure 10 for a teacher’s typical use of the program.

**Figure 10. Typical use case of a teacher on Freckle**
Pretests
Before students begin most math and ELA activities, they are required to take a pretest (pretests are not required for targeted practice assignments). The pretest works through a logic tree by starting at a grade or standard level below the student’s rostered level. Using item response theory (IRT), the pretest then adapts to below, on, or above grade level based on the student’s responses. Each student will end the pretest above or below their rostered grade level by no more than three grades.

Pretests are not always required. If a teacher manually inputs the student’s grade level, the practice will proceed based on that data. Additionally, if students have taken Star or NWEA MAP benchmark assessments, the teacher can connect those scores to Freckle to take the place of the pretests. Lastly, kindergarten students do not take the pretest but are instead placed at the beginning of each learning progression.

Assessments
Ample evidence suggests that formative feedback increases long-term academic outcomes. In a meta-analysis, Bangert-Drowns et al. (1991) concluded that more frequent, short tests were more effective at increasing skill development and knowledge than long, spaced-out tests. However, an important aspect of such testing is feedback. It is crucial that students understand where they need to improve.

To help monitor students’ progress throughout the year, teachers may assign students Freckle Benchmark Assessments for Math and ELA. The ELA assessment is multiple choice and tests students in grades 3–8 on ELA state learning standards for informational and literary texts, writing, speaking, listening, and language. Similarly, the math assessment is based on state standards, but teachers can select which standards to include on the assessments, as standard alignment may vary by state. All questions on the math assessment are multiple choice and available for K–9 (Algebra 1). Test topics include everything from counting and cardinality to financial literacy, geometry, and quadratic expressions and equations.

For math, teachers can also preview questions to make sure they are suited for their students. Assessment length is a function of the content coverage selected by the teacher. Reports from these tests are a great tool to help teachers understand where each student is struggling and develop student-focused lesson plans.

Reports
Freckle offers extensive reporting to support instructional decisions, including identifying struggling students and determining the skills students may be ready to tackle next. Student Reports help teachers understand the nuances of each students’ learning journey and allow them to adjust lesson plans accordingly. In fact, in a study of a computerized instructional-management system, students whose teachers used this system to hone lesson plans and daily instruction showed significantly greater growth over 6 weeks than students whose teachers did not use the system (Ysseldyke & Tardrew, 2007).
Freckle provides teachers with detailed reports on student- and class-level data to support not only Freckle use, but also in-person instruction. When teachers first login to Freckle, they see the Activity Feed (see figure 11), which provides a general idea of how students are performing and how active they are.

**Figure 11. Activity Feed**

<table>
<thead>
<tr>
<th>FILTER BY SUBJECT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Math (9 selected)</td>
<td>ELA (9 selected)</td>
</tr>
</tbody>
</table>

- **Most correct questions**
  - Iny-Rose: 2974 correct / 3517 total
  - Hogan: 2963 correct / 3517 total

- **Least correct questions**
  - Yunus: 24 correct / 24 total
  - Noble: 24 correct / 24 total

- **Most time practiced**
  - Iny-Rose: 449 minutes
  - Hogan: 449 minutes

- **Least time practiced**
  - Yunus: 3 minutes
  - Noble: 3 minutes

- **Highest accuracy**
  - Demi: Great accuracy
  - Lee Merritt: Great accuracy

- **Lowest accuracy**
  - Aaron: Okay accuracy
  - Farrell: Okay accuracy

One of the most useful reports is the Student Grouping Report, which allows teachers to group students by Freckle level or standard (see figure 12). During classroom activities, teachers can then focus on specific skills with certain groups or have students who are at different levels within a standard support each other to solve problems.

**Figure 12. ELA Student Grouping Report by standard**

- **Domain**: RI.2 - Summarizing & Main Ideas
- **Current grade level (a...)**: 1.8
- **Grade level growth (a...)**: 0.0
- **Questions answered (...)**: 25.8

- **Carry Payne**
- **Henri Campbell**
- **Assign

- **Abraham Allman**
- **Rafferty Dixon**
- **Assign

- **Tony Moran**
- **Assign
In math and ELA, teachers can view data by student, class, standard, and domain (see figure 13) and track student growth across assessments. For math, teachers will also see a Fact Practice report showing how students are progressing on math fact problems such as multiplication tables.

**Figure 13. Standards Report with student progress breakdown**

<table>
<thead>
<tr>
<th>K.C.C.6</th>
<th>30</th>
<th>0</th>
<th>0</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compare Groups of Objects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K.C.C.7</th>
<th>101</th>
<th>4</th>
<th>4</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compare numbers &lt; 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For ELA, teachers can see both Article Reading and Article Writing reports, which show color-coded breakdowns of how students are performing on reading comprehension and writing performance, respectively. Like the Fact Practice reports, the Word Study Matrix color codes student performance on each skill within Word Study (e.g., phonological awareness, alphabet knowledge, and consonant sounds).

Social studies and science reports show how the student performed on each article read, the questions that were answered incorrectly, and the level at which the article was read (see figure 14).

**Figure 14. Example of a Freckle Science Report**

**Jun 10, 2021**

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Article Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>5A</td>
</tr>
</tbody>
</table>

**Newton’s First Law of Motion**

**What is Inertia?**

Have you ever seen someone pull a tablecloth from underneath a set of dishes without knocking over a single...
Freckle Efficacy Research

A study drawn from Renaissance databases, comprising more than 10,000 students in grades 1–12, who used both the Star Math assessment and Freckle for Math practice during the 2019–2020 school year aimed to evaluate growth on different variables (Renaissance, 2020).

First, the study found that students who had more successful math practice in Freckle had greater growth in general math achievement on Star Math. Second, students who used Freckle for Math for the recommended minutes per day show higher growth than those who used it for fewer minutes or not at all. Likewise, students who spent more weeks on Freckle for Math for the recommended use per day achieved higher growth than those who used Freckle for the recommended use but for fewer weeks. These results remained significant between grades. Finally, both struggling and non-struggling students exhibited more growth than non-Freckle users (see figure 15).

Figure 15. Effects of Freckle use on Student Growth Percentiles for struggling and non-struggling students

In another study, WestEd, a nonpartisan, nonprofit research, development, and service agency, partnered with Freckle to conduct a study of the effect of Freckle for Math on K–2 student achievement (Freckle Education & WestEd, 2016). During the 2014–2015 school year, 14 teachers (263 students) volunteered to participate in the Freckle group while 11 teachers (203 students) volunteered to participate in the control group. Students who used Freckle scored about 4.6 points higher on their end-of-year NWEA MAP assessment compared to students who did not use Freckle ($p < .001$; see figure 16). Such results remained significant when controlling for beginning-of-year scores and grade level.
Lastly, retrieving data from the program’s database, Freckle conducted analyses to examine the effect of Freckle use on Math and ELA test scores (Freckle Education, 2018). In math, a multiple regression analysis suggested that each day of Freckle usage increased student scores by .1217 points ($p = .1$). For ELA, each day of Freckle use increased student scores by .1312 ($p = .05$).

**Conclusion**

Freckle is a multidiscipline, adaptive practice platform with ample supporting evidence. Two key features make Freckle impactful. First, Freckle provides teachers with an easily implementable differentiated resource. While extensive evidence supports the utilization of differentiated instruction, it is often not used due to lack of time and resources. Freckle removes many of the largest barriers to differentiation by building it into the product itself. Second, Freckle adapts to each student. Every student learns at their own pace, in their own way. The program uses adaptive technology to adjust each progression and question to meet the needs of each student and forces them to work within their ZPD. When used in tandem or individually, Freckle provides a comprehensive practice and instructional tool that helps students learn the foundational skills needed to succeed and supports teachers in tracking the progress of those skills.
References


Bloom, B. (1985). The nature of the study and why it was done. In Developing talent in young people (pp. 3–18). Ballantine.


McClennen, K., Marti, C. N., & Adkins, C. (2012). *Student engagement and student outcomes: Key findings from CCSSE Validation Research.* Community College Survey of Student Engagement.


