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IXL Design Principles

Core Features Grounded in Learning Science Research

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IXL Design Principles

At IXL Learning, we are passionate about improving learning for all. We apply technology in thoughtful and innovative ways to unlock students' innate curiosity, creativity, and desire for knowledge. By creating these deeply engaging and fulfilling educational experiences, we help students all over the world learn more, and love learning.

To achieve this mission, we make sure everything we do is grounded in research and best practices. In this document, we provide an overview of our flagship product, IXL, and highlight the design principles used in its development with special emphasis on the strong connection between learning science research and core features of the IXL experience.

IXL Design Principles:
Core Features Grounded in Learning Science Research

IXL Overview

IXL is a personalized learning platform, built on four components that work together to provide an engaging, empowering, and effective personalized learning experience to all students:

COMPREHENSIVE CURRICULUM

First, IXL's *comprehensive curriculum* consists of more than 8,000 skills in the four core subject areas (i.e., English language arts, mathematics, science, social studies) as well as Spanish. Each skill is developed by a team of curriculum specialists, roughly half of whom are former teachers and half of whom are subject-matter experts with advanced degrees in the relevant subject areas.

These content experts also perform multiple rounds of review to ensure questions and tasks associated with each skill are aligned with Common Core or other state standards as well as popular textbooks for each grade level. In addition, our curriculum team performs sensitivity reviews to make sure questions and tasks throughout the curriculum are accessible, equitable, and fair to all special groups in the student population.

REAL-TIME DIAGNOSTIC

The second component of IXL is the *Real-Time Diagnostic*. The IXL Real-Time Diagnostic is an adaptive interim assessment designed to provide students and teachers with an accurate, up-to-the minute portrait of students' grade-level proficiency on key math and language arts (ELA) strands. Having this informative tool as part of the IXL product was critical, given the surmounting evidence in favor of interim assessments and their effectiveness in promoting learning (Carlson, Borman, & Robinson, 2011; Clune & White, 2008; Konstantopoulos, Li, Miller, & van der Ploeg, 2017; Konstantopoulos, Miller, & van der Ploeg, 2013; Shepard, Davidson, & Bowman, 2011; Slavin et al., 2013). As an adaptive assessment, the Real-Time Diagnostic is very efficient in pinpointing student proficiency levels without the burden of a long test. Moreover, using Item Response Theory (IRT; Lord, 1980), the IXL Real-Time Diagnostic draws on information about question difficulty and student response patterns in both skill practice and the diagnostic Arena to provide overall and strand-level scores in math and ELA. As such, it is an invaluable tool in communicating to both students and teachers what students know and what they are ready to work on next. This information is deemed a critical component of a quality interim assessment (Perie, Marion, & Gong, 2009).

> *The IXL Real-Time Diagnostic is able to pinpoint the precise areas where knowledge breakdowns occur.*

PERSONALIZED GUIDANCE

We named IXL's third component *personalized guidance* because it is truly personalized for each learner. Using information from both the IXL Real-Time Diagnostic and skill practice in the curriculum, IXL is able to provide tailored recommendations as to what a student should work on next. These next steps come in the form of highly granular "MicroSkills" that unpack concepts into their smallest components to target individual student needs. For instance, instead of simply assessing whether or not a student can add fractions, IXL looks at student proficiency within a range of sub-skills and difficulty levels. By digging into whether students can multiply two fractions with models, but not without, or whether they can multiply whole numbers by a unit fraction, but not by a non-unit fraction, the IXL Real-Time Diagnostic is able to pinpoint the precise areas where knowledge breakdowns occur. Identifying exactly where these gaps begin allows the diagnostic to

> *Instead of locking students into a path based on prior performance, personalized guidance gives students enough information that they can make informed decisions about their own learning.*

[1] *Strands are broad skill categories. For math, the strands include (a) Numbers & Operations; (b) Algebra & Algebraic Thinking; (c) Fractions; (d) Geometry; (e) Measurement; and (f) Data, Statistics, & Probability. For ELA, the strands include (a) Reading Strategies; (b) Vocabulary; (c) Writing Strategies; and (d) Grammar & Mechanics.*

recommend the skills students should study next in order to move forward and maximize learning gains. Furthermore, IXL's personalized guidance promotes students' ownership of learning by offering students choice. Instead of locking students into a path based on prior performance, personalized guidance gives students enough information that they can make informed decisions about their own learning moving forward. This feature was inspired by the literature on active learning which we revisit in more detail later.

IXL ANALYTICS

Last but not least, IXL's fourth component is *IXL Analytics*. This is where teachers come to examine student learning activity and progress. While of course everyone would agree that feedback for students is important, some argue that feedback for teachers on a regular basis about what students know and don't know is even more important (Hattie, 2009). Therefore, a key design principle for IXL was the ability to give educators all the information they would need to make sure each student is making sufficient progress against grade-level and state standard benchmarks. For example, IXL Analytics allows teachers to identify trouble spots for the entire class, groups of students, or individual students. Teachers can then use this information for targeted instruction, small-group instruction, or one-on-one work with students. What is more, IXL Analytics allows teachers to monitor students' work on a given skill in real time, thus making this formative component an ideal tool for both differentiated instruction (Siegler, 2007; van Geert & van Dijk, 2002) and blended learning (Watson, 2008). Finally, teachers can use the insights from IXL Analytics to provide the right amount of aid to students and only when needed. This goes along with Vygotsky's (1978) conceptualization of the *zone of proximal development,* which is the gap between what a student can do with help and what they can do on their own (Vygotsky, 1978, p. 86). The idea is that, given students' different zones of proximal development, providing appropriate, personalized, and differentiated assistance will give students the boost they need to achieve their learning goals.

"Teachers can use the insights from IXL Analytics to provide the right amount of aid to students and only when needed."

"IXL Analytics allows teachers to identify trouble spots for the entire class, groups of students, or individual students."

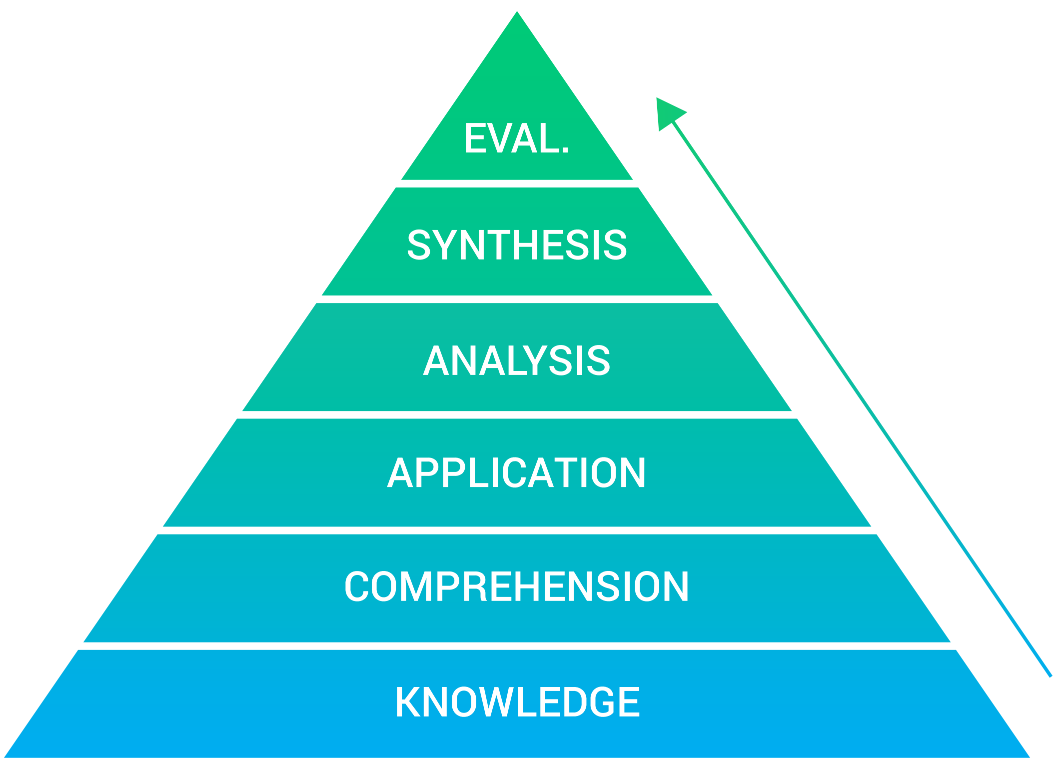
Now that we have a shared understanding of IXL's four components, for the remainder of this document we turn to the cognitive and learning science literature to illustrate how each design principle in the creation and integration of these four components was not simply guided by, but deeply grounded in learning science research and best practices. We begin with general organizational frameworks of cognitive tasks that primarily guided our curriculum development and conclude with more specific theoretical frameworks that affect the learning process itself.

Organization of Cognitive Tasks to Facilitate Learning Progressions

Several theories have been developed, tested, and refined to pave the roadmap to effective learning. One theory that has garnered a great deal of attention is focused on learning progressions (Duncan & Hmelo-Silver, 2009). It stipulates that academic material can be broken down and organized into segments of increasing rigor or complexity so that, through instruction and practice, students can gradually progress to higher achievement levels by building on the simpler ideas and bits of information they already know (Briggs et al., 2015; Corcoran, Mosher, & Rogat, 2009).

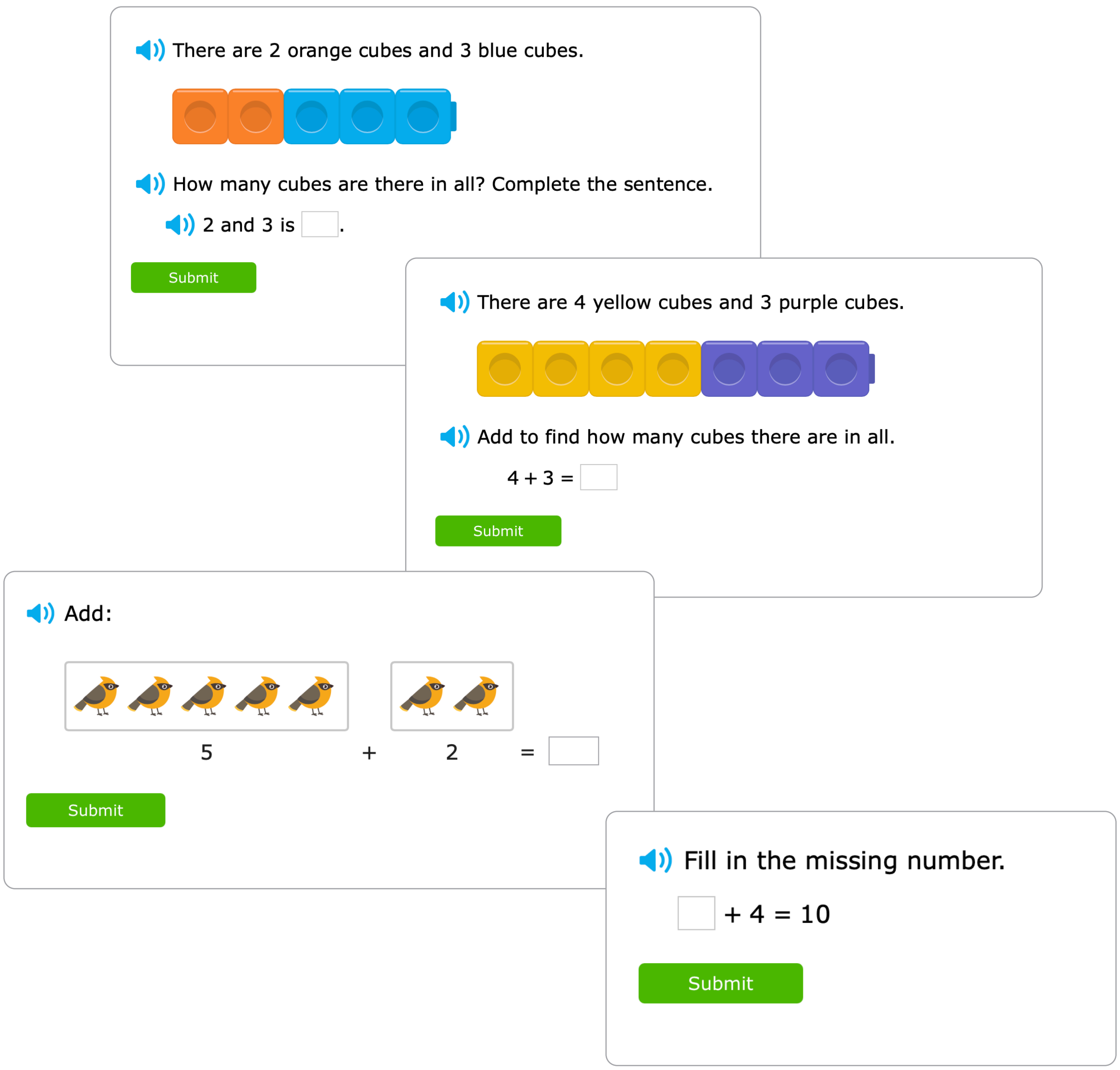
BLOOM'S TAXONOMY

Several other theories are helpful in this effort. For example, under Bloom's Taxonomy (Anderson, Krathwohl, & Bloom, 2001; Bloom & Krathwohl, 1956), educational goals are ordered from the lowest cognitive demand of recalling information to the most advanced—creating original content. The underpinnings of Bloom's taxonomy and its revised version are evident throughout IXL's comprehensive curriculum, as each skill category comprises several related skills ordered by complexity.



Bloom's Taxonomy (original framework)

For instance, within a single phonics topic—like the *short a* vowel sound—IXL offers multiple carefully scaffolded skills. Students who are still struggling to sound out words can practice the first skill in the sequence, where they are asked to simply listen to words and identify the *short a* sound. Students who are already sounding out individual words can practice the second skill, which involves reading simple words with the *short a* sound. The most advanced students, who have already mastered the other skills in the sequence, can practice spelling *short a* words or reading sentences with *short a* words to develop their fluency. Similarly, the “Adding up to 10” category begins with a skill using a familiar model of linked cubes to represent addition as “putting together.” Skills that appear later in this category extend the symbolic representation of addition using the plus (+) and equal (=) signs and have students demonstrate understanding of addition by relating the cube model to an addition sentence (e.g., 4 + 3 = 7). Finally, students who have mastered these skills can work on skills asking them to find missing terms in addition sentences with, and then without, pictures.



Similar to Bloom's Taxonomy (1956), under Webb's (1997) Depth of Knowledge theory, cognitive activities are organized in order of increasing complexity in thinking, from basic recall of information to extended thinking, where interpretation of data is a prerequisite to solving a problem. In addition, Webb's Depth of Knowledge theory places greater emphasis on the context or situation of the activity, not the activity itself.

This scaffolding was an integral part of IXL's design, as it is well-aligned with and supported by all leading theories we have discussed so far. To illustrate this design strategy, we dive a little deeper into how we approached curriculum development in math and ELA in the early grades next.

For example, our fourth-grade literary devices category has the following progression:

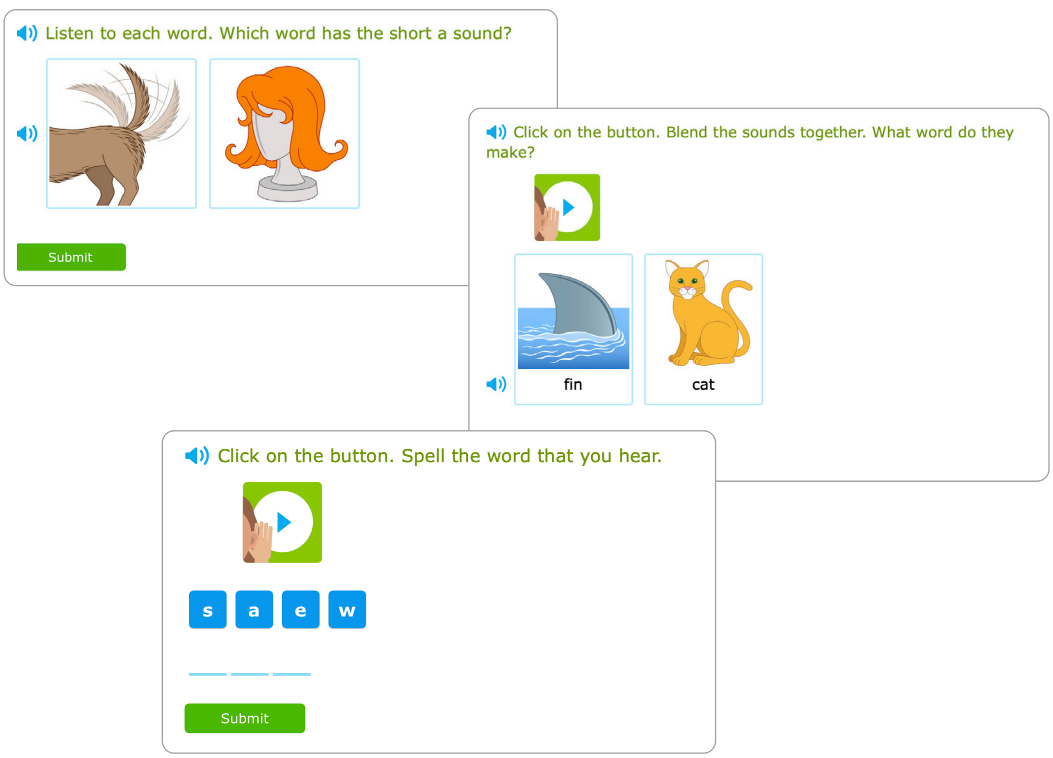
- It starts out with a basic skill, where students identify which sentences use similes and metaphors.
- Then, the skills get more complex—students not only identify similes and metaphors; they also have to show that they understand them.
- In later skills, students are asked to identify the picture that matches the meaning of a simile or metaphor, and then to determine the meaning of similes and metaphors in sentences.
- Finally, after completing these skills, students analyze how figures of speech affect meaning and tone.

Likewise, our fourth-grade math category on mixed operations is scaffolded as follows:

- It begins with skills that focus on rote procedural practice performing the four operations.
- Then, we have skills that require students to find patterns in input-output tables and use them to find missing values, working both forward from inputs and backwards from outputs.
- Skills that appear later in this category have students internalize the problem and determine which of the four operations is needed to solve the problem.
- Finally, students are presented with multi-step word problems, where they need not only apply knowledge to solve complex problems, but strategize how to go about evaluating the response someone else gave to the problem.

Early Literacy Development

Research on early literacy development has emphasized the importance of teaching phonemic awareness—the ability to identify and manipulate sounds in language—and phonics—the relationship between sounds and their spellings (Ball & Blachman, 1991; Castles, Rastle, & Nation, 2018). Furthermore, in order to be effective, phonics instruction must be explicit, systematic, and structured (Castles et al., 2018; National Reading Panel, 2000). Based on these principles, IXL's foundational reading skills were designed to teach students how to recognize, segment, and blend sounds in words, and cover all of the most important phonics concepts—from consonant sounds and short vowels to more advanced concepts like diphthongs, R-controlled vowels, and multisyllabic words. These skills follow a logical sequence from simple to more complex, allowing students to work through concepts in a structured, systematic, and cumulative way. Even within a single topic, IXL offers multiple carefully scaffolded skills that give students opportunities to listen to the sounds in words, to read them, or to spell them. Our immediate feedback and explanations provide students with explicit instruction on key concepts, and our professionally-recorded audio allows students to hear clear examples of the sounds and words they are learning.

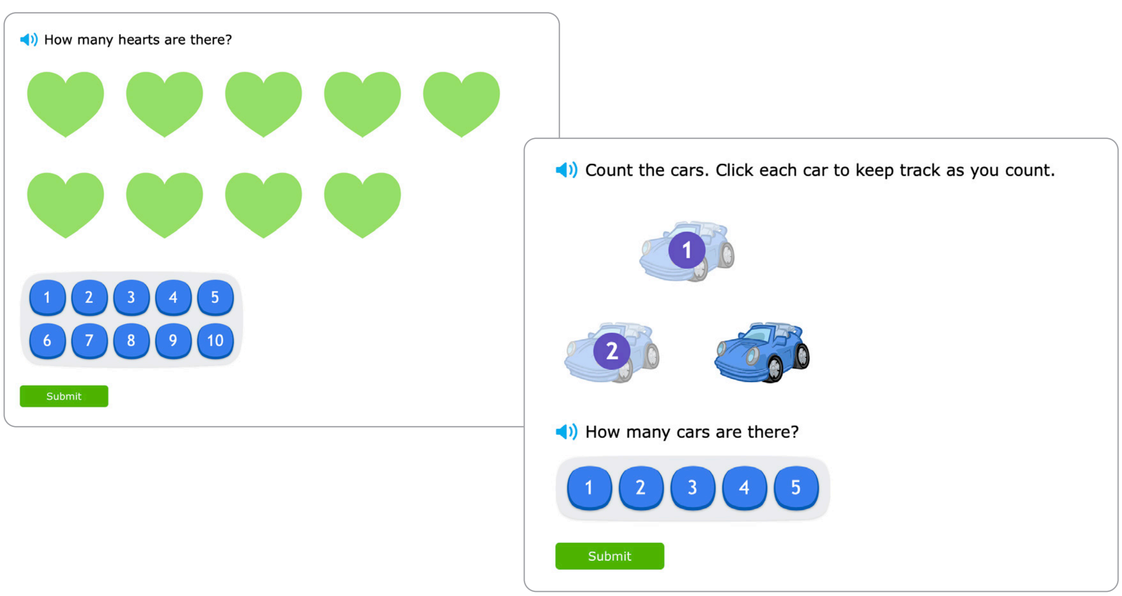


Beyond phonics instruction, in order to develop reading fluency, students need many opportunities to practice reading a wide variety of texts (Stanovich & West, 1989). IXL's read-alone literary and informational text skills in Kindergarten and First Grade provide students with opportunities to practice reading independently and to build fluency with varied texts. Our read-along literary and informational texts feature audio support that highlights each word as it is being read, allowing students to follow along with the text as a professional voice artist models fluent reading.

Finally, research has also shown that phonics instruction and fluency development are not enough—students must also work on reading comprehension (Castles et al., 2018). Explicit instruction in reading comprehension strategies can help young students extract meaning from texts (Willingham, 2006b). Conversely, a poor vocabulary or lack of background knowledge can inhibit reading comprehension (Castles et al., 2018; Recht & Leslie, 1988; Willingham, 2006a). In line with these principles, IXL's reading program includes targeted reading strategies skills for students. These skills break down key concepts like main idea, inference, and author's purpose and help students truly master these concepts. It also includes more traditional mixed reading comprehension skills where students read literary texts or informational texts and answer many different questions about them. These texts are rich in content—especially our informational text skills, which introduce students to a wide range of science and social studies topics and build their knowledge base. IXL's vocabulary skills also teach students key word-learning strategies, like using word parts or context clues to determine the meanings of unfamiliar words, that help them build grade-appropriate vocabulary.

Early Numeracy Development

Young children begin to develop early numeracy by learning how to count procedurally, from one to three or from one to five, and so on (Sarnecka, Goldman, & Slusser, 2015). Once they have memorized the count sequence to a given number, children begin to associate number words with collections of objects by counting. Eventually, children learn that they can determine the number of objects in a set by counting them, with the last number word in a counting sequence indicating the total number of objects in that collection. This is known as the *cardinality principle* and is one of the fundamental aspects of developing numeracy (Sarnecka & Wright, 2013). IXL teaches the cardinality principle through counting in both pre-kindergarten and kindergarten. Our "Learn to count" skills begin with having students associate a number name with an object (e.g., as students tap each object, its count number appears); these skills also teach students that the last number named indicates the total. Other skills young learners can practice at these stages include skip-counting, shapes, patterns, positions, comparisons, and others.



Beyond counting, children need to learn numerical symbols and varied representations of numbers in order to understand the concept of quantity (Leibovich & Ansari, 2016; Merkley & Ansari, 2016). Showing children different representations of the same number through Arabic numerals, number words, and sets of identical or related objects is often used to accomplish this goal. This ultimately allows children to *subitize,* or correctly identify the quantity of small sets (usually up to five) without counting. Number sense is further developed by moving from concrete to visual to abstract representations. Teachers are encouraged to make explicit connections throughout these gradual transitions by presenting the same quantity in different ways. For example, an educator may begin with concrete physical objects, then move to visual representations of the objects, and eventually move toward abstract representations (e.g., using number lines). This progression is called *concreteness fading* and is considered essential in early numeracy development (Brown, McNeil, & Glenberg, 2009). Within our counting skills, students count a variety of objects, from less to more abstract (e.g., illustrations of familiar concrete objects, abstract shapes, circular counters). Given the importance of visuals in the early stages of abstraction, IXL's virtually unlimited collection of interactive visual problems is especially well-suited for young learners as they begin to make sense of numbers and quantities.

"Teachers are encouraged to make explicit connections throughout these gradual transitions by presenting the same quantity in different ways."

Once familiar with the concept of quantity and how to differentiate between countable quantities and non-countable quantities (e.g., the amount of water in a cup), children can begin to learn simple arithmetic (e.g., adding and subtracting numbers up to ten). Memorizing these basic operations with small numbers frees up space in working memory to learn how to execute more complex operations such as multiplication and division (Deans for Impact, 2015). IXL makes use of these principles by scaffolding skills in terms of complexity and offering a wide variety of practice so young learners are well-positioned to tackle more complex problems later on in the curriculum. For example, IXL introduces number lines as well as the concept of *place value*—the value of a digit based on its position in a number—as early as first grade in order to solidify children's understanding of magnitude and facilitate the acquisition of more abstract algebraic thinking skills, such as those involving fractions and decimals, later on (Siegler & Braithwaite, 2017).

"IXL makes use of these principles by scaffolding skills in terms of complexity and offering a wide variety of practice so young learners are well-positioned to tackle more complex problems later on in the curriculum."

The sections on early literacy and numeracy development above serve to illustrate our research-based approach to content development at the elementary school level; however, the same strategy applies to content for all grades in K-12, as well as other subject areas IXL offers: science, social studies, and Spanish. In the following sections, we focus on learning science principles that cut across all subject areas and universally impact the learning process.

Active Learning

From early childhood, children start to develop a sense of curiosity and to experience joy with discovery, which can be a very powerful motivator for sustained learning far into adolescence and beyond. Research shows that allowing students to choose what to study can provide substantial learning benefits (Tullis, Fiechter, & Benjamin, 2018). So when designing IXL, we made sure not only to make room for choice, but to make choice a front-and-center piece of the IXL experience.

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From the moment a student clicks on a skill to tackle, they are given a choice: start answering questions and solving problems immediately (i.e., learn by doing) or "Learn with an example" where we present a step-by-step guide to solving a problem. Whichever path a student chooses, they are already on track to learn new material or reinforce familiar concepts, with the added benefit that *they* are in the driver's seat; *they* are taking ownership of their own learning. Although this choice may seem trivial, there is evidence suggesting that attempting to answer questions allows for a more efficient retention of knowledge (Brown, Roediger, & McDaniel, 2014; Roediger & Butler, 2011).

> *Providing students with the tools they need to monitor their progress is recognized as one of the key principles of effective learning.*

Moreover, the idea of giving students choice is prevalent throughout IXL. From selecting which skills or topics to practice, to occasionally choosing which question to answer next in the diagnostic Arena, to selecting which skill recommendations to work on next, students are encouraged to drive their own learning. Thus, students are not only actively engaged in learning by doing, but they also take ownership of their learning, which in itself promotes learning (Grabinger & Dunlap, 1995). Finally, providing students with the tools they need to monitor their progress is recognized as one of the key principles of effective learning (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010). IXL promotes this autonomy and enables students to monitor their progress on all individual skills via IXL Analytics and in key ELA and math strands via the IXL Real-Time Diagnostic.

Adaptive Learning

To assess student progress on each skill, IXL uses its proprietary SmartScore, which is a numeric representation of proficiency in a given skill based on students' responses to questions or items making up that skill. The SmartScore quickly adapts to each learner's trajectory, as it incorporates item difficulty, answer accuracy, response patterns, and relative progress on a skill. It ranges from 0 to 100, but is *not* a percent-correct score, so reaching 100 (mastery) is always possible. The SmartScore increases more rapidly at the beginning of a skill to allow students to build self-efficacy, which has been shown to boost performance by enhancing effort (Bandura, Adams, & Beyer, 1977; Schunk, 1982). As students make progress on a skill, gains for correct answers begin to taper off, challenging students to demonstrate that they have truly mastered the skill. As such, this feature promotes students' mastery goal orientation (Elliott & Dweck, 1988).

IXL's SmartScore is "smart" because it adapts to learners' response patterns. If a student answers a question correctly, they will get a similar or slightly more difficult question next; if they answer incorrectly, they will get an explanation and a chance to try again. The same adaptive principle applies to the IXL Real-Time Diagnostic as well, but at a higher level, using information from multiple skills. By adapting to each student's working level, IXL allows for efficient learning and assessment at the right level of rigor. This essentially eliminates frustration or anxiety with overly difficult items and boredom with overly easy items (Deville, 1993, as cited by Linacre, 2000). This alignment and adaptation to each learner's personal progress and trajectory is of course reflected in IXL's personalized guidance and IXL Analytics as well.

Immediate Feedback and Learning from Mistakes

Another feature of IXL worth highlighting is that it provides immediate feedback. This is a key element of a quality formative assessment (Perie et al., 2009), as learners are provided with timely and specific information about what they are getting wrong (Shute, 2008). Providing feedback following incorrect attempts is crucial, as it enhances subsequent learning (Kornell, Hays, & Bjork, 2009). Not only is each incorrect answer accompanied by an explanation, but the scoring algorithm behind the SmartScore is also forgiving of mistakes, so reaching 100 is always within reach.

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Both the forgiving nature of the SmartScore and its dynamic computation along the scale were designed with Dweck's (2006) growth mindset theory in mind. A growth mindset is the belief that intelligence is malleable (i.e., not a fixed entity that one is born with). As such, instilling a growth mindset in learners through the IXL design features described above sets learners on the path to success from the moment they begin using IXL.

Engagement and Motivation

Dweck's theory (2006) has also been largely studied and supported by the motivation literature. Sustaining motivation was another important factor in the design of IXL because students need to be motivated to persist in becoming proficient in and mastering more skills (Ambrose et al., 2010). Specifically, under Eccles' Expectancy-Value Theory (Eccles, 1987; Wigfield & Eccles, 2000), motivation is a function of one's expectancy to do well on a task and one's perceived value of achieving said task. While fostering value in students can be a long and arduous process, boosting students' expectancy to succeed on a given IXL skill is easily achieved via the SmartScore algorithm discussed above.

> *IXL acknowledges and rewards not only students' achievement, but also the effort they put forth to reach their learning goals.*

Another way to bolster student motivation, especially among our younger learners, was the addition of rewards in the form of virtual awards that students unlock when they reach proficiency or mastery on a given skill or achieve other milestones in their IXL learning journey (e.g., number of questions answered, time spent on IXL). In this way, IXL acknowledges and rewards not only students' achievement, but also the effort they put forth to reach their learning goals. Finally, our customizable leaderboards set up by the teacher add another fun motivator for students in the form of a friendly competition with their classmates. As evident from the examples above, engaging and motivating students was essential in IXL's design.

Conclusion

As a state-of-the-art K-12 learning platform, IXL was designed by drawing on decades' worth of learning science research, well-established cross-disciplinary theories of learning and teaching, and best practices by our curriculum specialists and product designers. All of this work has culminated in IXL's four components: a comprehensive curriculum to support any learning need, the IXL Real-Time Diagnostic to assess where each student is, personalized guidance to help students work on the most relevant skills for them, and actionable analytics to help teachers make the right choices for each student. Each component of IXL is powerful, and yet, personalized learning takes all four working together. The demands of personalized learning are complex, but by weaving all four components together in a single, integrated platform, IXL makes true personalized learning possible and simple for every student, every teacher, anywhere.

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