



Learning, Design, & Curricular Framework

MAY 2019

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About this Guide

This guide provides an introduction to Kitkit School, a tablet-based literacy and numeracy application from Enuma, Inc. Designed to bring high-quality learning experiences to all students—regardless of access to school or education resources—Kitkit School uses best practices and research in game design and literacy and numeracy education to support children’s engagement and learning. This document describes the learning philosophy, design, and research used to create Kitkit School.

Overview

At Enuma, we believe *all* children deserve access to high-quality learning experiences.

Yet, today an estimated 262 million children lack access to school.¹ In developing countries, even children enrolled in school face barriers to a good education. From outdated curriculum to untrained teachers, limited access to education resources hobbles students’ best opportunities to reach their full potential.

Kitkit School is a tablet-based application with a comprehensive curriculum that spans early childhood through early elementary. It is designed to provide children with the fundamentals and practice needed to build foundational skills in literacy and numeracy—even without access to school or resources.

In Thai, the word *kít* means, “to think.”

Our Learning Philosophy

All children deserve access to high-quality learning experiences. A great education is the most powerful tool to eradicate extreme poverty. UNESCO estimates that “if all students left school with basic reading skills, 171 million people could be lifted out of poverty.”²

In education, one size does not fit all. Every child is unique. A single sequence of skills won’t reach all children, especially those with special learning needs. And a single pace won’t allow all learners to master the skills and knowledge they need to reach their fullest potential.

An engaged learner is a dedicated learner. Our brains are wired to learn. They respond to new patterns and information with feelings of joy, encouraging us to seek out new skills and knowledge. We can help children build foundational literacy and numeracy skills—and develop positive learning habits—by making the learning experience more engaging.



1 “New Education Data for SDG 4 and More.” UNESCO Institute for Statistics. September 27, 2018. Accessed May 10, 2019. <http://uis.unesco.org/en/news/new-education-data-sdg-4-and-more>.

2 EFA Global Monitoring Report, *Teaching and Learning: Achieving Quality for All*. UNESCO. 2014. Accessed May 10, 2019. <https://unesdoc.unesco.org/ark:/48223/pf0000225660>.

About Kitkit School

Kitkit School is a comprehensive early learning solution designed for all children.

Kitkit School is a child-directed, tablet-based, personalized learning system, ideal for self-directed early learning in low-resource communities in developing countries. Children learn foundational literacy and numeracy skills through access to high-quality learning games, books, videos, and creative tools. Our goal is to empower children around the world to identify themselves as self-confident, independent learners with a lifelong passion for learning.

There are three main components in the Kitkit School learning system:

- › **The Kitkit School Learning App** with a Pre-K through second-grade literacy and numeracy curriculum.
- › A built-in **Library** with access to hundreds of books and videos in multiple languages.
- › A suite of **Tools** to support creative self-expression through music and art using an intuitive, child-friendly interface.

KITKIT SCHOOL LEARNING APP

In the Kitkit School Learning App, children discover more than 2,400 activities, books, and videos to help them build foundational literacy and numeracy skills to a second-grade proficiency level.

Children control the pace, order, and amount of time they spend completing learning activities, and can choose to focus on new challenges, review and repeat activities for enjoyment and confidence-building, or play along with friends.

Literacy Coop

- 11 Egg Courses
- About 280 Sessions
- Over 1,200 Learning Activities

Math Coop

- 11 Egg Courses
- About 260 Sessions
- About 1,200 Learning Activities

Developmentally-Appropriate Content

The Kitkit School Learning App's games and activities are designed for children in developing countries, aged seven-to-ten years old.

Child-Directed Learning

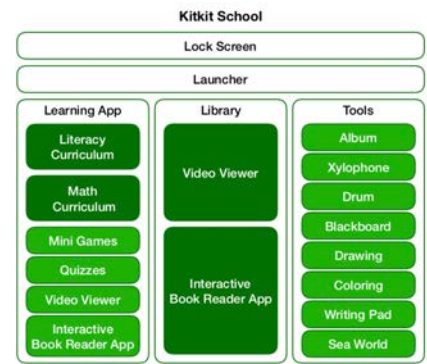
Children are encouraged to play and learn with minimal direct instruction. Interactive tutorials demonstrate rules and teach game mechanics. Children control the pace and order of the Kitkit School curriculum.

Progressive Curriculum

Children build foundational literacy and numeracy skills and knowledge as they explore more than 2,400 learning activities included in Kitkit's progressive early learning curriculum.

Real-Time Feedback

Children track their progress and celebrate success with exciting audio and visual cues that increase engagement and encourage them to continue learning.



Kitkit School Learning System Components

Kitkit School is a safe, enclosed system. Kitkit School's intuitive design supports self-directed learning, allowing children to easily launch and stay within Kitkit School.

Progress Monitoring

The Kitkit School Learning App helps children track and share their progress. As they advance through the curriculum, they watch 22 playful animal characters grow alongside their expanding skillsets, collect coins to access in-game tools, and create underwater ecosystems in their virtual Sea Worlds.

ASSESSMENT

Children complete a variety of assessments to demonstrate their learning and unlock more challenging games and activities.

Quizzes

Most Sessions include two quizzes to help children understand and track their learning progress.

Post-Course Test

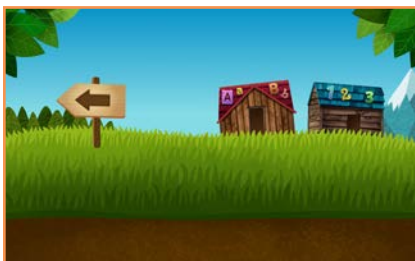
Each Egg Course includes a test after learners have completed all available Sessions. This assessment checks for understanding of the skills and knowledge covered in the Egg Course. Successfully completing the post-Course test unlocks a new Egg Course.

Special Course

The last Egg Courses in the Math and Literacy Coops help evaluate children's learning progress. Special Courses include games and videos that review previous skills and knowledge. By successfully completing Special Courses, children earn plants and marine life to add to their virtual Sea Worlds.



Launch the Kitkit School Learning App from the main page.



Learners select between the Literacy or Math Coop to determine the subject they will follow during each Session.



Learners select one of 11 Egg Courses in each subject. How it works:

- Players tap eggs to hatch the creatures within.
- As users progress through activities, the creatures will grow.
- After successfully passing the post-Course test, the creature gets a crown and the next egg becomes ready to hatch.



Within each Egg Course, learners select a Session.

- Each Egg Course includes approximately 30 Sessions.
- Most Courses have 3 quizzes within the series of Sessions.
- All Courses have one final post-Course test.
- Learners may choose to replay past Sessions or play the newest Session.



Within each Session, learners choose an Activity.

- Sessions include 4-to-6 Activities.
- Learners may choose to replay past Activities or play the newest Activity.

For example, Course 2, Session 4's curriculum is 'learning the letter D' and has 4 Activities:



• Video 'Letter D'



• Alphabetic Principle/Phonics



• Letter Writing



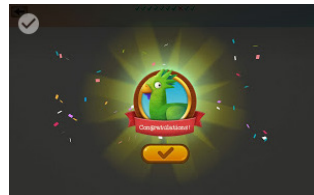
• Book 'Letter D'

Learner's completion of Activities, Sessions, and Courses are celebrated with visual and audio cues.



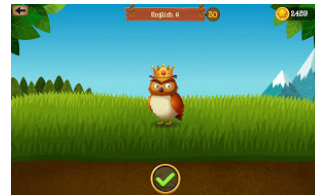
Activity Completion Celebration:

- Fanfare popup screen shows.
- Activity icon marked with a check.



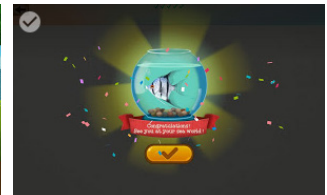
Session Completion Celebration:

- Coins are awarded.
- Creatures grow.
- Session icon marked with a check.



Egg Course Level Completion Celebration:

- Crown awarded to creature.
- Final Session shown with crowned creature.



Fish Quiz and Sea World

- A fish or tank decoration item awarded when passing Special Quiz.
- Child can check their growing Sea World collection.

THE KITKIT SCHOOL LIBRARY

The Kitkit School Library includes more than 250 high-quality educational books and videos, covering a variety of subjects—from science and numeracy concepts to fun stories of friendship and adventure—to support children’s learning progress.

Children build their literacy skills as they discover the joy of reading for pleasure, key to fostering a foundation of literacy and lifelong learning. Children also access hundreds of videos with engaging educational stories and songs, developed by Enuma or in collaboration with Ubongo, a Tanzania-based children’s media company.

Multi-Leveled Books

The Kitkit School Library features hundreds of culturally appropriate books at seven different reading levels to provide “just right” reading opportunities.

Read-Aloud Feature

By tapping a speaker icon, children can hear pages of books read aloud. Children can select individual words to hear them read aloud, increasing engagement and comprehension.

Variety of Genres

Kitkit School videos and books expose children to a variety of genres, including fiction, non-fiction, folk tales, and biographies. Books with predictable text and repetitive words and phrases help children develop early literacy skills.

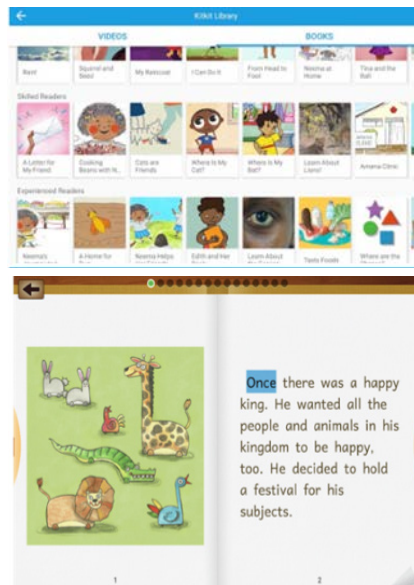
Engaging Topics

To appeal to children’s interests and build a joy of reading, books in the Kitkit School Library cover a variety of engaging topics, including animals, science, friendship, and role models.

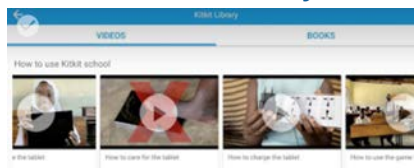
Culturally Appropriate Content

Books and videos in the Kitkit School Library were designed to be culturally appropriate for children in developing countries. They feature a balance of male and female characters to promote a diversity of positive gender role models.

The Kitkit School Library: Books

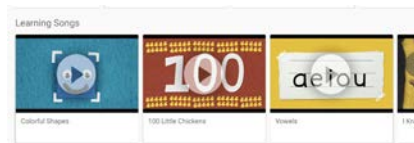


The Kitkit School Library: Videos

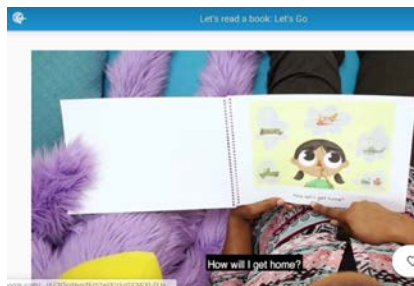


Digital Literacy Videos

“How to take care of your tablet”
“How to charge your tablet”



Learning Song Videos



Literacy Modeling Videos

These videos model positive literacy skills for children, including those often assumed in literate environments.

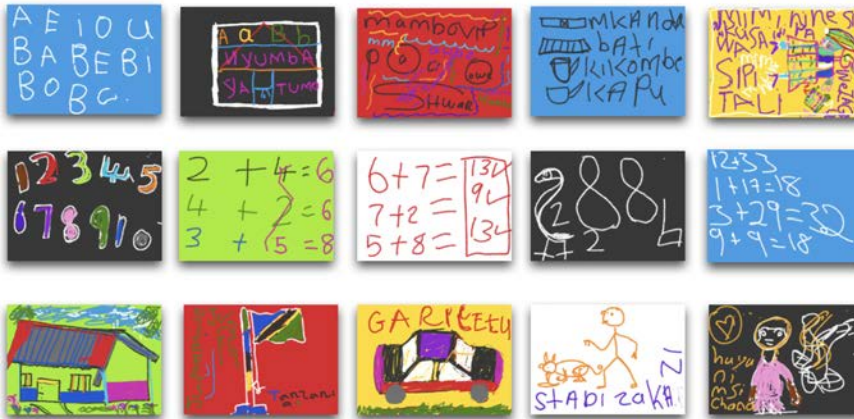
THE KITKIT SCHOOL TOOLS

Kitkit School Tools offer children important opportunities for self-expression through art and music. Through an intuitive, child-friendly interface, children select among eight learning tools that support self-confidence in their ideas and abilities. The Kitkit School Tools include virtual musical instruments, a blackboard to practice writing, and drawing and coloring tools to create unique artworks.



Kitkit School Tools

Drums, Xylophone, Blackboard, Drawing, Coloring, Album, Sea World, Writing Board



Tanzanian children's drawings from the Global Learning XPRIZE field test log data.

Kitkit School Curricular Framework

The Kitkit School curriculum was designed based on early childhood development research, best practices in literacy and numeracy education, and research and field test data related to our target users.

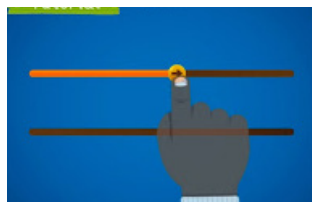
DIGITAL LITERACY

Many children in developing countries have not had exposure to, or experience with, interactive digital media. The Kitkit School curriculum incorporates tutorials on how to use and care for their tablets. Digital literacy videos in the library include "How to Charge the Tablet" and "How to Store the Tablet." Throughout our curriculum, children learn core mechanics necessary to complete learning activities, including dragging objects on the screen, swiping, and puzzle play.

Digital Literacy Examples



- Video: How to operate Kitkit School



- Tutorial animation demonstrating how to drag your finger to trace a line



- Video: How to use a number keypad



- Game that teaches typing on a keyboard

EARLY CHILDHOOD SKILLS FOR LITERACY AND NUMERACY

Due to a lack of access to high-quality learning experiences in many developing countries, millions of children do not have the foundational skills necessary for later literacy and numeracy learning.

Before learning the alphabet, it is important for children to understand images and icons. As children draw, they build fine motor skills that are important for writing. Songs and stories help build background knowledge to make learning letters or numbers easier and more effective in higher levels. Kitkit School focuses on exposing children to these early childhood skills.

In Kitkit School, children learn:

- › The Alphabet Song in the Library
- › Pattern-making in Pattern Train
- › Visual discrimination in Find the Pair
- › Working memory skills in Matching
- › Spatial experiences in Puzzles
- › Coloring, drawing, music-making in Tools

LITERACY CURRICULUM

The Enuma team's research into how different languages formed and developed across cultures informed the design of the Kitkit School literacy curriculum. We identified common elements in language development to build a literacy curriculum that could be customizable in multiple languages, giving children reading and writing instruction in their native languages.

Enuma used the foundational skills identified by the Early Grade Reading Assessment (EGRA) to guide the creation of the Kitkit School literacy curriculum. The EGRA orally assesses basic foundational literacy skills of children in developing countries and defines key skills used in literacy acquisition, including letter naming, word recognition, reading and listening comprehension, and dictation.³ The Enuma team also researched best practices for learning literacy (including whole language and phonics-based approaches), met with literacy expert Dr. Elfrieda H. Hiebert, and gathered information from the Regional Literacy Advisors of international NGOs.

DECODING AND READING COMPREHENSION

Kitkit School's literacy curriculum has two major components: decoding and reading comprehension.⁴ Through game-based activities—including linking letters to sounds, inventing words with phonemes, and remembering how to spell vocabulary words—children develop essential decoding skills. Children develop reading comprehension skills and habits through high-quality videos, books, and activities.

3 "Early Grade Reading Barometer." About EGRA. Accessed May 10, 2019. https://earlygradedereadingbarometer.org/pages/about_egra.

4 Gough, Philip B., and William E. Tunmer. "Decoding, Reading, and Reading Disability." *Remedial and Special Education* 7, no. 1 (1986): 6-10. doi:10.1177/074193258600700104.

Daily literacy learning Sessions provide a good balance between these two components by exposing children to a variety of activities and encouraging daily reading habits through Kitkit School's read-aloud feature.

KEY LEARNING AREAS

Kitkit School's literacy curriculum covers 11 key learning areas:

1. Oral language
2. Print awareness
3. Alphabetic principle (letter knowledge)
4. Phonemic awareness
5. Phonics
6. Spelling
7. Syntax
8. Vocabulary
9. Fluency
10. Written expression
11. Reading comprehension

A SEQUENCED PROGRESSION

The Kitkit School literacy curriculum provides children with a sequenced progression of core literacy skills, from letter recognition to phonics and print awareness. Sequential courses introduce new skills and reinforce previously covered concepts at more difficult levels.
























Children build a vocabulary of simple words and practice decoding and encoding fluently before advancing to simple sentences, more difficult vocabulary, and simple paragraph books. Oral language is woven throughout the curriculum, along with a focus on making meaning and developing comprehension.

To support children's fine motor skills, children begin with tracing lines and shapes and progress to tracing words and writing words on their own in the Blackboard Tool. Embedded videos increase exposure to oral language, positive reading habits, and concepts like punctuation and sentence writing rules.

The tables on the next two pages provide a snapshot of Kitkit School's literacy curriculum: the skills children are able to practice within each course and how games and videos are organized to support each course's learning goal.

LEARNING AREA/COURSE	PRE COURSE	COURSE 1	COURSE 2	COURSE 3	COURSE 4	COURSE 5	COURSE 6	COURSE 7	COURSE 8	COURSE 9
ECD and Digital Skills	LT AP LM	LT AP	AP	AP	AP			T	T	T AP
Oral Language		V	V	V	V	V	V	V	V	V
Print Awareness			T3	B	B	B	B	B	B	B
Letter Knowledge		AP LM LT	AP LM LT	LT						
Pronological Awareness				WM	BP WM	BP				
Systemic Phonics Instruction				ST WM WN	WM WN	WN	WM			
Vocabulary						L	L	L		
Spelling				S	S WN	S WN	WT			
Fluency						WK RB	WK RB	WK RB	WK RB	
Written Expression							WT SB	SB SM	SB SM	SB SM
Comprehension – Sentence					B CQ	B CQ	WIT	WIT WK	WIT WK	WIT WK
Comprehension – Stories						B CQ	B CQ	B LC CQ	B LC CQ	B LC CQ

Key

-  Line Tracing
-  Animal Puzzle
-  Literacy Matching
-  Typing
-  Video
-  Book
-  Trace 3 Times
-  Letter Tracing
-  Bird Phonics
-  Word Machine
-  Sound Train
-  Word Matrix
-  Word Note
-  Labeling
-  Spelling
-  Word Tracing
-  Word Kicker
-  Reading Bird
-  Sentence Bridge
-  Sentence Maker
-  Comprehension Question
-  What Is This
-  Listening Comprehension

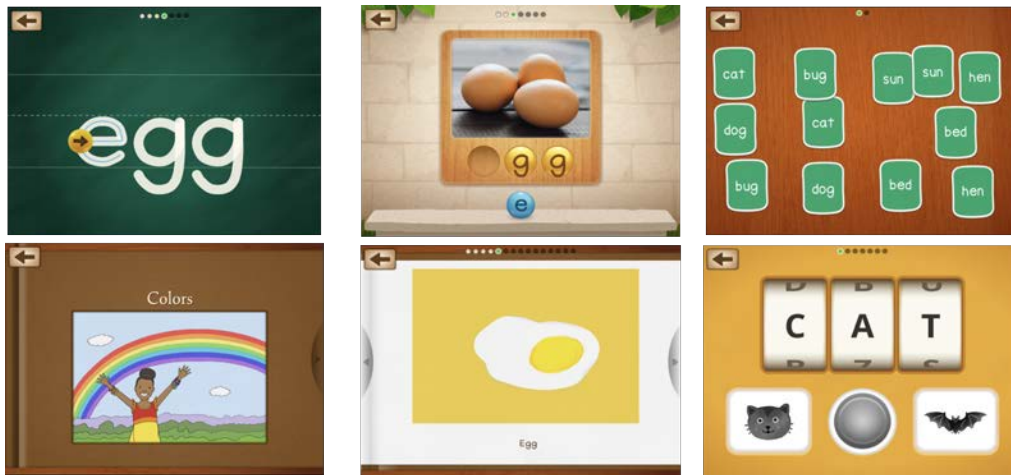
LITERACY COURSES	PRESCHOOL COURSE	COURSE 1	COURSE 2	COURSE 3	COURSE 4
Learning Goals	<ul style="list-style-type: none"> • Early digital literacy • Visual processing with images 	<ul style="list-style-type: none"> • Alphabetic principle • Print awareness • Exposure to writing 	<ul style="list-style-type: none"> • Alphabetic principle • Print awareness • Writing letters • Familiar words starting with each alphabet letter 	<ul style="list-style-type: none"> • Alphabetic principle • Phonics principle (phonological awareness, knowledge of graphemes) • Decoding for one-syllable words • Initial sound identification • Writing letters • Familiar words 	<ul style="list-style-type: none"> • Phonics principle • Decoding (including invented word reading) • Initial sound identification • Vocabulary • Fluency for word reading
Key Kitkit App Games	<ul style="list-style-type: none"> • Literacy Matching • Line Tracing 	<ul style="list-style-type: none"> • Letter Tracing • Literacy Matching • Alphabet Puzzle 	<ul style="list-style-type: none"> • Literacy Matching • Alphabet Puzzle • Letter Tracing • Trace 3 Times • Alphabet Word Books 	<ul style="list-style-type: none"> • Sound Train • Word Machine • Word Matrix • Word Note • Spelling • Level 1 Books with Comprehension Quiz 	<ul style="list-style-type: none"> • Sound Train • Word Matrix • Word Note • Word Machine • Bird Phonics • Spelling • Reading Bird • Level 2 Books with Comprehension Quiz
Supporting Games	<ul style="list-style-type: none"> • Animal Puzzle 	<ul style="list-style-type: none"> • Animal Puzzle 		<ul style="list-style-type: none"> • Animal Puzzle • Letter Tracing 	<ul style="list-style-type: none"> • Animal Puzzle
Videos		<ul style="list-style-type: none"> • Vowel • Alphabet • Sounds of letters 	<ul style="list-style-type: none"> • Alphabet 	<ul style="list-style-type: none"> • Alphabet • Vowels • Uppercase and lowercase • Book read aloud 	<ul style="list-style-type: none"> • Book read aloud • Initial sounds of words • Days of the week

LITERACY COURSES	COURSE 5	COURSE 6	COURSE 7	COURSE 8	COURSE 9
Learning Goals	<ul style="list-style-type: none"> • Initial sound identification • Decoding (including invented word reading) • Vocabulary • Fluency for word reading • Writing words 	<ul style="list-style-type: none"> • Decoding (including invented word reading) • Vocabulary in context • Fluency for phrase & sentence reading • Writing words & sentences • Syntax • Reading comprehension • Listening comprehension 	<ul style="list-style-type: none"> • Fluency by sentence reading • Syntax • Writing sentences • Reading comprehension • Listening comprehension 	<ul style="list-style-type: none"> • Fluency for sentence reading • Syntax • Writing and completing sentences • Reading comprehension • Listening comprehension 	<ul style="list-style-type: none"> • Syntax • Writing full sentences • Reading comprehension • Listening comprehension
Key Kitkit App Games	<ul style="list-style-type: none"> • Bird Phonics • Word Matrix • Word Note • Spelling • Labeling • Reading Bird • Word Kicker • Level 2 Books with Comprehension Quiz 	<ul style="list-style-type: none"> • Labeling • Word Tracing • Reading Bird • What Is This • Word Kicker • Sentence Bridge • Comprehension • Level 3 Books with Comprehension Quiz 	<ul style="list-style-type: none"> • Labeling • Reading Bird • What Is This • Word Kicker • Sentence Bridge • Sentence Maker • Comprehension • Level 3-4 Books with Comprehension Quiz 	<ul style="list-style-type: none"> • Reading Bird • Word Kicker • What Is This • Sentence Bridge • Sentence Maker • Comprehension • Level 4 Books with Comprehension Quiz 	<ul style="list-style-type: none"> • Sentence Maker • Sentence Bridge • Comprehension • Level 4-5 Books with Comprehension Quiz
Supporting Games		<ul style="list-style-type: none"> • Word Matrix 		<ul style="list-style-type: none"> • Typing 	<ul style="list-style-type: none"> • What Is This • Typing • Animal Puzzle
Videos	<ul style="list-style-type: none"> • Book read aloud • Familiar words 	<ul style="list-style-type: none"> • Daily life 	<ul style="list-style-type: none"> • Usage of uppercase • Punctuations • Opposites • How to write words 	<ul style="list-style-type: none"> • Book read aloud • Writing a complete sentence 	<ul style="list-style-type: none"> • Listening Comprehension • Reading Comprehension • Book read aloud

CURRICULUM REINFORCEMENT

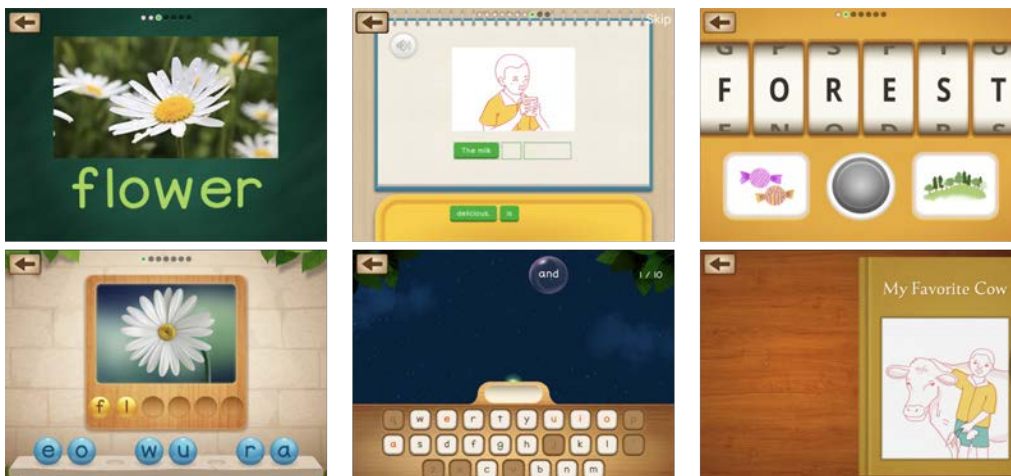
Kitkit School's learning activities are designed to help children meet a primary learning goal, while also reinforcing additional literacy skills. For example, in the screenshots below, children are tracing, spelling, matching, reading, and identifying simple words across different games. Their work in each activity reinforces and builds on the knowledge developed in others.

Middle Literacy Course Examples



After practicing letters in earlier courses, children become fluent in simple words. They use this knowledge to advance to more difficult words and begin reading simple sentences. Key literacy skills are continuously reinforced and practiced as students advance through the curriculum.

Later Literacy Course Examples



BOOKS

Kitkit School's reading curriculum includes reading one book a day with a focus on building comprehension. Books are organized into seven reading levels, and include video introductions to model good reading habits and strategies. Books cover a range of topics and genres, including folk tales, biographies featuring role models, and non-fiction nature books.

Comprehension Quiz

After children finish a book, they are given a comprehension quiz to help them think more deeply about what they have read, and track their progress.

Read-Aloud Feature

The Read-Aloud Feature exposes children to reading even as they are developing their decoding and comprehension skills.

Highlight Words

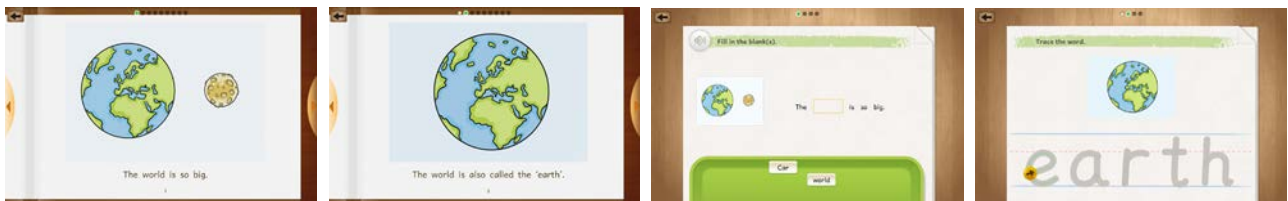
The ability to highlight words helps children connect words to their corresponding sounds, while helping them gain familiarity with reading left to right and top to bottom.

Book Levels

Our team used the following principles to develop books across seven reading levels:

- › **Word Difficulty:** Difficulty of vocabulary
- › **Length of Text:** Sentence length and number of sentences per page
- › **Context Familiarity:** Familiarity of context affecting comprehension
- › **Content Choices:** We aimed to broaden children's views with various subjects, while providing them with examples easy to understand across cultures.

Level 3 Examples



- Examples of a book

- Reading comprehension activities

Level 7 Examples

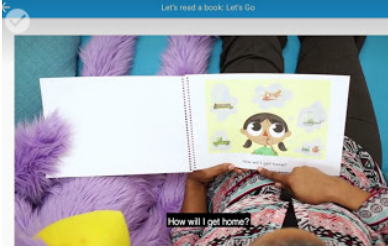


- Examples of a book

- Reading comprehension activities

LITERACY RICH EXPERIENCES

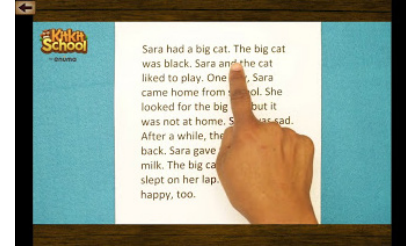
Research in early literacy development stresses the importance of surrounding children with “literacy rich” environments. Since many children in developing countries do not have the opportunity for this, Kitkit School includes a variety of topics, genres, styles, and difficulty levels. We also included modeled literary experiences in our videos (see examples below).



- An adult reading a story aloud



- Saying a name of body part while pointing with a finger



- Tracking book text with a finger

MATH CURRICULUM

Kitkit School's math curriculum draws on Enuma's experience creating *Todo Math*, an award-winning math learning app for children in Pre-K through second grade, aligned to the U.S. Common Core State Standards. The Kitkit School math curriculum follows children's natural developmental progression by focusing on the concepts children need to master to build a foundation for future math success.

Our math curriculum makes important links with literacy through books and videos about numbers, number operations, shapes, and word problems.

KEY LEARNING AREAS

The foundational math concepts covered in Kitkit School include:

- › Number identification
- › Quantity discrimination
- › Counting
- › Representation of numbers
- › Addition
- › Subtraction
- › Finding missing numbers
- › Shapes
- › Word problems
- › Multiplication

LEARNING TRAJECTORIES

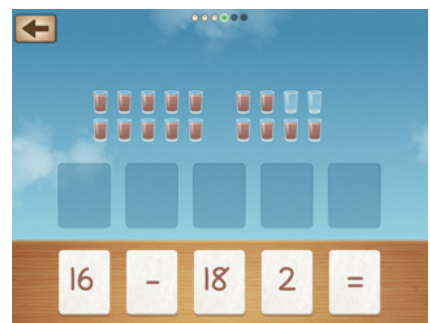
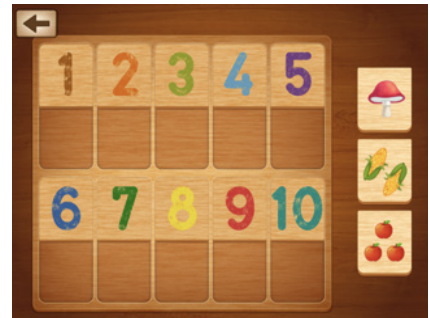
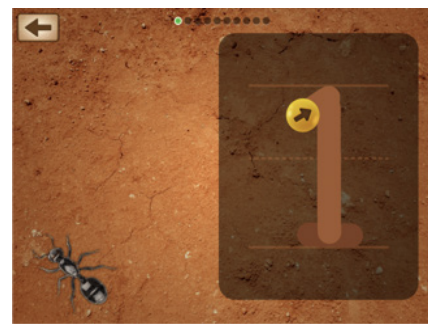
Kitkit School follows a developmentally appropriate approach to guide children through key math concepts using curriculum pathways called "learning trajectories."⁵ Learning trajectories have three parts, each of which is contained in each game and across Egg Courses:

1. A specific math goal
2. A path along which children develop to reach that goal
3. A set of activities that help children move along that path

In Kitkit School's Math Coop, each Egg Course has at least one specific math goal, introduced in a progressively challenging way. As children advance through the courses, they encounter similar games at more difficult levels, as well as new games to address complementary skills.

The tables on the next two pages provide a snapshot of Kitkit School's math curriculum: the skills children are able to practice within each course, and how games and videos are organized to support each course's learning goal.

5 Clements, Douglas H., and Julia Sarama. "Learning Trajectories in Early Mathematics – Sequences of Acquisition and Teaching." *Encyclopedia on Early Childhood Development*, July 2010. <http://www.child-encyclopedia.com/sites/default/files/textes-experts/en/784/learning-trajectories-in-early-mathematics-sequences-of-acquisition-and-teaching.pdf>.



Kitkit School's Math Curriculum

LEARNING AREA/COURSE	PRE COURSE	COURSE 1	COURSE 2	COURSE 3	COURSE 4	COURSE 5	COURSE 6	COURSE 7	COURSE 8	COURSE 9
ECD and Digital Skills	BP PT FP	PT FP	BP PT							
Number Identification		NB NT NM	NB NT NM	NT	NT	NT				
Quantity Discrimination		LM	FT	FT PV	FT PV	PV	PV	PV	FT PV	PV
Counting		C	C	C PV	PV	PV				
Representation of Numbers				EM	EM					EM
Addition				BM FT	EM FT	MS DM	MS FT DM QF	DM QF	DM QF	DM QF
Subtraction				BM FT	EM FT	MS DM	MS FT DM QF	DM QF MK	DM QF MK	DM QF MK
Missing Number			30 NT	30 NT MN	100 NT MN	100	30 MN	30 NT MN	NT MN	MN
Shape	NM					LM SM			SM	SM
Multiplication								ML	ML	ML QF EM
Word Problems								WW	WW	WW

Key

- Bubble Pop
- Pattern Train
- Find the Pair
- Number Blocks
- Number Tracing
- Number Matching
- Line Matching
- Feeding Time
- Place Value
- Counting
- Equation Maker
- Bug Math
- Fish Tank
- Mango Shop
- Double Digit Math
- Number Train
- Quick Facts
- Math Kicker
- 30 Puzzle
- 100 Puzzle
- Missing Number
- Shape Matching
- Multiplication Lamp
- Word Window

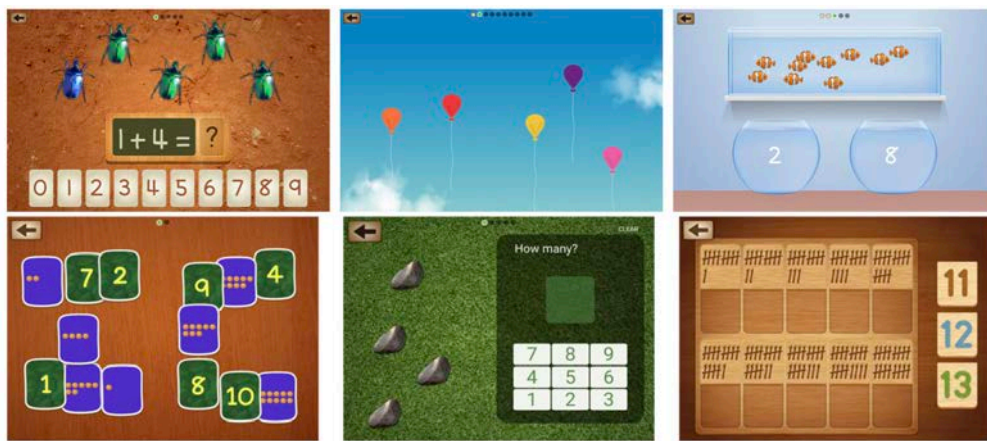
Math Courses	PreSchool Course	Course 1	Course 2	Course 3	Course 4
Learning Goals	<ul style="list-style-type: none"> • Number identification • Early digital literacy • Visual processing with shapes • Pattern recognition 	<ul style="list-style-type: none"> • Count, write & represent numbers up to 10 	<ul style="list-style-type: none"> • Count, write & represent numbers up to 20 • Compare the magnitude of numbers within 10 • Order numbers within 10 	<ul style="list-style-type: none"> • Count, write & represent numbers up to 50 • Compare numbers within 20 • Order numbers within 20 • Skip counting within 10 • Decompose numbers within 5 • Add, subtract numbers within 10 	<ul style="list-style-type: none"> • Count, write & represent 2-digit numbers • Compare, order numbers within 50 • Skip counting within 20 by 1s, 2s • Compose & decompose numbers within 10 • Add, subtract numbers when the sum/ minuend is within 20 without regrouping • Identifying shapes
Key Kitkit App Games	<ul style="list-style-type: none"> • Bubble Pop • Find the Pair • Number Matching • Pattern Train 	<ul style="list-style-type: none"> • Number Blocks • Number Tracing • Number Matching • Counting 	<ul style="list-style-type: none"> • Counting • 30 Puzzle • Feeding Time • Number Train • Number Blocks • Number Tracing • Number Matching 	<ul style="list-style-type: none"> • Bug Math • Number Train • Equation Maker • Number Tracing • Fish Tank • Feeding Time • Missing Number • Place Value 	<ul style="list-style-type: none"> • Number Tracing • Place Value • Feeding Time • Missing Number • Fish Tank • Equation Maker • Shape Matching
Supporting Games		<ul style="list-style-type: none"> • Find the Pair • Pattern Train • Line Matching 	<ul style="list-style-type: none"> • Bubble Pop • Pattern Train 	<ul style="list-style-type: none"> • Counting • 30 Puzzle 	<ul style="list-style-type: none"> • Number Train • 100 Puzzle
Videos		<ul style="list-style-type: none"> • Count up to 5 • Count up to 10 using both hands • Sorting 	<ul style="list-style-type: none"> • Count up to 20 • Add/subtract 1 by 1 • Concepts of big & small based on number magnitudes • Concepts of magnitude symbols • Basic concepts of addition & subtraction • More, less, same • Counting within 20 & number line 	<ul style="list-style-type: none"> • Add/subtract 1 by 1 • Concepts of big & small based on number magnitudes • Concepts of magnitude symbols (>, =, <) • How to use a keypad • Basic concept of operations • Concepts of addition & subtraction (within 10) • More, less, same • Counting within 20 & number line 	<ul style="list-style-type: none"> • Names & attributes of shape • Song of shape • How to use a keypad • Vertical addition • Vertical subtraction • Concepts of each place value
Math Courses	Course 5	Course 6	Course 7	Course 8	Course 9
Learning Goals	<ul style="list-style-type: none"> • Recognize two-digit numbers • Compare, order numbers up to 50 • Skip counting within 50 by 1s, 5s, 10s • Add, subtract numbers within 20 with regrouping • Shape 	<ul style="list-style-type: none"> • Recognize multi-digit numbers • Order, compare numbers within 100 • Skip counting within 100 by 1s, 2s, 5s, 10s • Compose & decompose teen numbers • Add, subtract numbers within 20 • Fast operations within 10 	<ul style="list-style-type: none"> • Recognize 3-digit numbers • Order, compare numbers up to 100 • Skip counting within 100 by 3s, 2s, 5s • Add, subtract numbers within 100 without regrouping • Word problems within 10 • Multiplication • Fast operations within 20 	<ul style="list-style-type: none"> • Recognize 3-digit numbers • Order numbers within 100 • Compare 3-digit numbers • Skip counting with 3-digit numbers • Add, subtract numbers within 100 • Word problems • Multiplication • Fast operations within 20 	<ul style="list-style-type: none"> • Recognize 3-digit numbers • Skip counting with 3-digit numbers • Addition, subtraction within 100 • 3-digit addition, subtraction • Word problems • Multiplication • Identify shapes • Fast operations within 20
Key Kitkit App Games	<ul style="list-style-type: none"> • Double-digit Math • Math Kicker • Equation Maker • Number Train • Mango Shop • Place Value • Missing Number • Feeding Time • Shape Matching 	<ul style="list-style-type: none"> • Place Value • Feeding Time • Missing Number • Fish Tank • Mango Shop • Double-digit Math • Math Kicker • Quick Facts 	<ul style="list-style-type: none"> • Place Value • Number Train • Missing Number • Double-digit Math • Math Kicker • Word Window • Multiplication Lamp • Quick Facts 	<ul style="list-style-type: none"> • Place Value • Number Train • Missing Number • Double-digit Math • Math Kicker • Word Window • Multiplication Lamp • Feeding Time • Quick Facts 	<ul style="list-style-type: none"> • Quick Facts • Multiplication Lamp • Shape Matching • Missing Number • Double-digit Math • Word Window • Place Value
Supporting Games	<ul style="list-style-type: none"> • 100 Puzzle • Line Matching 	<ul style="list-style-type: none"> • 30 Puzzle • Number Train 	<ul style="list-style-type: none"> • Mango Shop • 30 Puzzle 	<ul style="list-style-type: none"> • Shape Matching • Line Matching 	<ul style="list-style-type: none"> • Math Kicker
Videos	<ul style="list-style-type: none"> • Names & attributes of shape • How to use a keypad • Vertical addition • Vertical subtraction • Make objects with shapes 	<ul style="list-style-type: none"> • Vertical addition • Vertical subtraction • Concepts of each place value • Make objects with shapes • Basic concept of operations 	<ul style="list-style-type: none"> • Vertical addition • Vertical subtraction • Concepts of each place value • Basic concept of operations • Multiplication song • Word problems 	<ul style="list-style-type: none"> • Multiplication song • Word problems 	<ul style="list-style-type: none"> • Vertical addition • Word problems • Sharing

CONCRETE, SEMI-CONCRETE, AND ABSTRACT MODEL

The Kitkit School math curriculum uses the Concrete, Semi-Concrete, and Abstract (CSA) model. The CSA model recognizes that a child first needs to manipulate objects before they can understand more abstract representations of early math concepts.⁶ The CSA model offers a flexible approach to accommodate different learners' cognitive and skill levels, introducing new concepts or reinforcing previously learned concepts into new abstract forms.

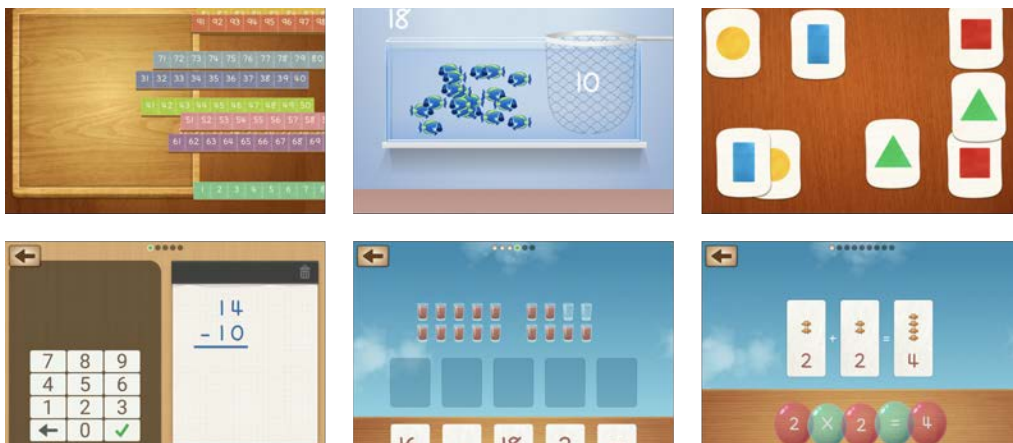
The screenshot below illustrates this concept across a variety of early games in Kitkit School. Children are not only shown $1+4$, but see one blue bug and four green bugs come together. When asked to decompose $10 = 2+8$, they have to assign two fish to one fish tank and eight fish to the other.

Early Math Course Examples



As children move on to later courses in Kitkit School, some quantity representations remain to help support children as they tackle larger quantities and more difficult concepts. For some cases, representations can be removed, helping children to focus on abstract numerals.

Later Math Course Examples



⁶ Works of Dr. John Van de Walle and others.

Where Does Fun Come From?

A GAME DESIGNER'S PERSPECTIVE ON ENGAGEMENT

Children often receive messages from adults that education is not meant to be fun—only endured. Just as game designers aim to create fun games that compel players to continue playing, successful educators know that engaged learners are dedicated learners. But where does fun come from? What can education game designers do to increase engagement and learning?

In developing Kitkit School, our team sought to better understand how to support children to develop a lifelong love of learning. We turned to leading research on early childhood development. We looked for best practices in literacy and numeracy education. And, because of our experience as game designers, we looked for insight there, too.

In his book *The Theory of Fun for Game Design*, renowned game designer Raph Koster described the fundamental relationship between games, learning, and fun. “Fun in games,” he wrote, “arises out of mastery. It arises out of comprehension. It is the act of solving puzzles that makes games fun.” We feel fun in response to learning new information, recognizing patterns, and mastering skills—an evolutionary adaptation that aided human survival by rewarding exploration, discovery, memory, acquisition, optimization, socialization, and competition.

Yet, even game designers like us know better than to assume that learning is always fun in the same way or fun at all. (We remember our college physics classes!) Many subjects — especially

academic subjects—are too complex for our brains to discover the patterns that normally trigger a neurochemical reward.

In Kitkit School, we sought to encourage children to persist through the curriculum by deepening engagement. Our literacy and numeracy curriculum translates challenging concepts into bite-sized skills, helping children discover the patterns that make language and math mastery possible. Our Learning App, Library, and Tools give children the autonomy to control their learning within Kitkit School. They choose which games and activities to play,

which videos to watch, and which books to read.

Our goals are not the traditional goals of game designers. We're not designing just for fun or player retention. We're trying to equip children in developing countries with high-quality learning resources. But providing those resources alone isn't enough to increase global literacy and numeracy. Children have to carry through the curriculum. By designing for fun and considering learners' experiences, educational game developers can lead children to deeper learning.



Engagement For Self-Directed Learning

The goal of Kitkit School is to help seven-to-ten-year-old children in developing countries develop Pre-K through second grade literacy and numeracy skills in 15 months. To sustain engagement for such a long period of time, Enuma prioritized children's short-, mid-, and long-term experiences rather than short bursts of explosive fun.

SHORT-TERM FUN: THE JOY OF SOLVING PROBLEMS

The invention and widespread adoption of touch screen devices created exciting opportunities to help young learners around the world. By removing the need for typing skills, touch screens enabled young learners to access educational software.

Because our goal is to bring high-quality learning materials to children with little to no experience with digital devices, we thought carefully about how to quickly engage learners by creating a highly intuitive interface through:

- › **Realistic Look and Feel.** We created digital objects that look and react in familiar ways to help young learners in developing countries build understanding.
- › **Digital Manipulatives.** We translated existing learning manipulatives into digital versions (e.g., realistic sounds of a pencil scratching the paper when tracing letters on the screen, the click of a wooden puzzle piece placed in its correct spot).
- › **Proportionate Responses.** We leveraged digital audio and visual cues to encourage and reward children's progress (e.g., a voice reading out the letter that is highlighted, an explosion of sparkles when a learners makes a correct response). But, we thought carefully about making responses proportionate to players' achievements.

In addition, to ensure the overall experience allows users to feel short-term fun, we applied the following elements:

- › **Speedy Progression.** Short, easy-to-understand actions minimize transition time and get learners to their desired destination quickly. Sequences are kept short, transitions quick, and music and effects concise. For nearly all interactions, users can quit the activity immediately.
- › **Clear Feedback.** Users receive clear feedback to indicate success. When a child succeeds, they receive delightful visual and auditory cues. A gentle screen vibration indicates a child has answered incorrectly.
- › **Ease to Success.** Learners who know the correct answer are able to complete the activity easily. Puzzle pieces brought close to their correct spot snap into the right place. Answering multiple-choice questions incorrectly removes the incorrect answer from the remaining list of choices.



MID-TERM FUN: SYSTEM DESIGN AND CONTENT

Crisp, responsive interactions can delight a user in the short-term and allow them to enjoy playing for several days. But as users become familiar with game patterns, they can become bored. How can we ensure the user, who is going through a repetitive system, is engaged every day?

› **Variable Rewards.** In his book *Hooked*, Nir Eyal describes how successful startups use four stages to develop habit-forming products that hook users:⁷

1. Trigger
2. Action
3. Variable Reward
4. Investment

By linking learning to conspicuous rewards, learners are encouraged to continue pursuing their learning goals. Kitkit School builds engagement by displaying assets they earn throughout gameplay. As a user progresses through the curriculum, they earn creatures, coins to access art and music tools, and plant and marine life decorations for their virtual Sea World.

- › **Fresh Content.** New games featuring new patterns can help deepen user engagement. Enuma is committed to continuing to develop fresh, high-quality learning content. Kitkit School content has increased three-fold since the first version developed in 2017. As we move forward, we plan to expand our offering further based on user data as well.
- › **Clarity of UI.** A clear user interface helps users quickly understand where they are and how much they have progressed through the curriculum. Menus clearly show users their locations in the system.
- › **Diversity.** Once users become familiar with patterns, they quickly lose interest. Kitkit School games provide a wide array of game play patterns, graphic styles, and learning challenges. We worked with illustrators, actors, and animators with a wide variety of styles to develop educational books and videos.
- › **Removal of Barriers.** When users encounter problems that they cannot solve or become frustrated by repetitive games, they lose interest. By analyzing user data, we update games to create a more engaging experience and support users to advance through the curriculum.

⁷ Eyal, Nir. 2014. *Hooked: how to build habit-forming products*.

LONG-TERM FUN: SUPPORTING THE USER'S GOALS

Each Kitkit School user's ability, interests, and goals will be different. By reflecting on the diversity of our users, we can design long-term fun. We asked ourselves, "What is the user's goal of learning?" and "Is there a way to understand and better support their goals?"

To answer these questions, our team borrowed from a practice commonly used in video game design: identifying player categories. In his 1996 article, "Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDs," Richard Bartle identified four player types based on their playing style (action vs. interaction and world-oriented vs. player-oriented).⁸ Drawing from our experience designing learning apps for children and by analyzing user-generated data, we identified four player profiles reflecting children's different approaches to learning.



HIGH ACHIEVERS

High Achievers are eager to make progress, as defined by the rules of the game. They enjoy learning and completing activities. They feel confident and motivated because of their quick success and rapidly expanding skills. High Achievers are motivated to keep practicing and learning when they can show their progress to peers, receive in-game rewards, and meet time challenges.



This graph shows all children's speed to reach the end of the content in the Kitkit School math curriculum during the Global Learning XPRIZE field test period. The top 20% of users, who completed the curriculum in 2-4 weeks, were labeled High Achievers. (The two vertical lines indicate software updates made during the 15-month field test.)

⁸ Bartle, Richard. (1996). "Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDs." www.researchgate.net/publication/247190693_Hearts_clubs_diamonds_spades_Players_who_suit_MUDs

SELF MOTIVATORS

Self Motivators have just as strong motivation as High Achievers, but their goals aren't focused solely on completing in-game goals, like finishing all Egg Courses. They set and pursue their own goals, such as reading all the books in the library or completing all the tracing activities in the writing pads.

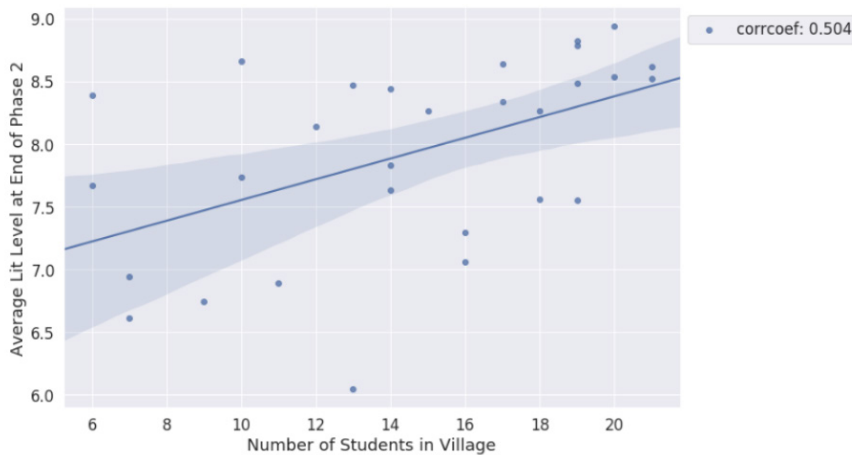
The game industry refers to this type of player type as a “collector” because they enjoy collecting proof of their progress. If the system offers various activities, we expect Self Motivators to identify what they want to collect and pursue that goal.

SOCIALIZERS

The majority of gamers in Bartle's research belong to the category 'socializers'. Socializers play games to be a part of the community and their progress often aligns with that of their peers.

During field research conducted in East Africa in 2016 and 2017, we observed many children engaging in group play, especially at less-structured, out-of-school research sites. We believe peers can be powerful motivators for this player type.

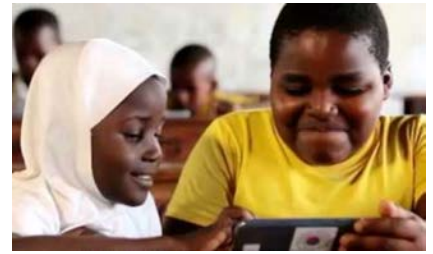
To encourage group play, we sought to provide clear, easy-to-understand rules and the freedom to choose games and activities. The first screen of the Math and Literacy Coops are designed as a visual dashboard so kids can easily compare their progress.



During 15 months, 30 villages—with various sample sizes ranging from 6 to 20 children—participated in Global Learning XPRIZE field tests. We observed that the higher the number of children in the village, the higher the average achievement levels found in that village. This aligns to the view in game design that the more high-level players who participate in a game, the higher the average level.



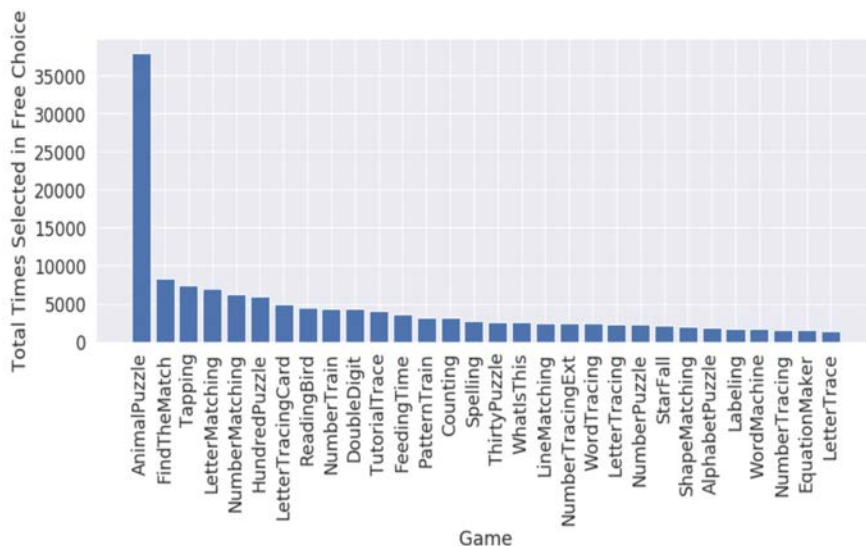
This child, a Self Motivator, repeated the drill and practice test more than 40 times within one week to collect Sea World decorations.



COMFORT SEEKERS

Comfort Seekers enjoy Kitkit School because they find they can build their confidence by succeeding at early-level activities.

While working on *Todo Math*, our team found that some children have low confidence in their learning ability due to fear of failure. Kitkit School's child-directed approach helps Comfort Seekers build confidence by replaying what they know until they are ready for a challenge at a more advanced level. We designed Kitkit School to sequence fun, easy puzzle games at the beginning. While helping children develop spatial skills,⁹ the puzzles offer young learners an accessible entry point.



In the Global Learning XPRIZE field test, we saw a few players who played the easy level of 'Animal Puzzle' more than 1000 times.

⁹ Susan Levine et al. Early Puzzle Play: A Predictor of Preschoolers' Spatial Transformation Skill. *Developmental Science*, Feb 2012 (in press)

Our Design Methods

DESIGN METHOD 1: DISCOVERY LEARNING & AUTO-EDUCATION

Kitkit School design has been inspired by two learning theories focusing on children engaging in self-directed learning in a carefully prepared experience.

1. **Maria Montessori's Auto-Education** approach explains that children learn best when they construct knowledge on their own—without external guidance or help. They do this through interaction with sensorial materials and figuring things out on their own. Additionally, careful attention to the environment and materials is critical for learners' success.
2. **Jerome Bruner's Discovery Learning** concept also highlights the importance of students constructing knowledge for themselves. Bruner emphasizes the importance of a carefully designed spiraling curriculum, with gradual levels of difficulty, building on previous knowledge to allow children to learn independently.

The Kitkit School system is carefully designed to support children creating knowledge independently in a spiraling curriculum with the tactile experiences delivered via a touch screen.

Children's experiences in Kitkit School are made in a series of game activities. In the beginning of each game, they learn how to play the game. As they advance, children repeat gameplay and discover learning patterns. When children play different games that explain the same concept, they reinforce their understanding of the concept. Some games help form muscle memory (e.g. Tracing), while others help children master a specific concept (e.g. Sound Train). Some games lead children to manipulate a concept and introduce its representations (e.g. Mango Shop), while others allow them to practice an accumulated concept (e.g. Word Machine) or repeat practices quickly (e.g. Quick Fact).

We tried to minimize learners' cognitive load through thoughtful game design. We focused each game around a single learning goal and designed a sequenced curriculum to help students build and retain knowledge. In early levels, users learn game mechanics by repeating gameplay seen in tutorial videos. Later levels introduce learning concepts built on the previous game rules, scaffolding new information and gradually increasing difficulty and complexity of games.

DESIGN METHOD 2: UNIVERSAL DESIGN FOR LEARNING

To ensure that Kitkit School supports and encourages children's independence, motivation, and success, we applied a research-based framework called the Universal Design for Learning (UDL), originally developed by the Center for Applied Special Technology. Their 2017 UDL guidelines inform our work and design.¹⁰




10 "The UDL Guidelines." UDL. August 31, 2018. Accessed May 10, 2019. <http://udlguidelines.cast.org/>.



UDL is an important part of Kitkit School's learning design because it optimizes instruction and learning for *all* people. Central to the UDL framework is a flexible and accessible design whose target is not limited to the group of average children. Rather, it accommodates all learners, including those with special needs.

We tested and observed our learning design with a population with a high variability of learning abilities, including children with learning difficulties, intellectual disabilities, or stimulation sensitivity. We designed Kitkit School's learning goals, content, methods, and assessments to meet each child's specific needs and to promote learner independence in accordance with the UDL framework.

With UDL, we are able to separate the learning process into three related components:

Engagement	Perception	Expression
How children engage in the learning process and what motivates them to stay engaged.	How children are presented with information and what motivates them to stay engaged.	How children express what they know and understand.
		
Kitkit School uses a variety of games and a <i>gamified</i> achievement system to maintain children's learning engagement.	Kitkit School supports multiple means of learning fundamental concepts with a variety of games. Information is presented in both auditory and visual ways.	Kitkit School helps students express their answers in a variety of ways.

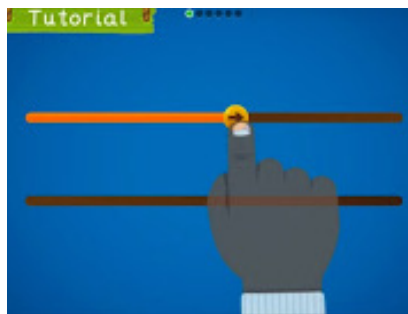
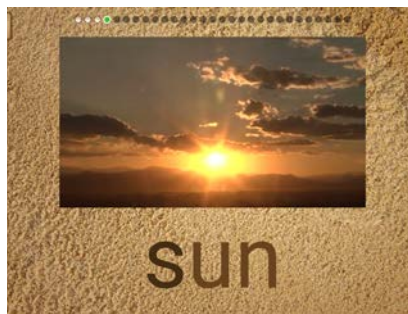
We discussed two of the components above by looking at how Kitkit School encourages children's learning engagement and creative self-expression. In addition, we try to bolster the aspect of 'perception' by providing both auditory and visual stimulation together or explaining a concept through different modalities. Given that some factors, such as children's hearing abilities, the device volume, and ambient noise levels, are unpredictable, we tried to minimize conveying information exclusively through audio (e.g., game tutorials are animated, highlighted words appear as they are read aloud, and subtitles are available in all videos).

By incorporating design features like this, Kitkit School aims to make learning a positive experience for children by reducing barriers that can cause frustration—or worse, lack of learning—and by providing diverse options to access learning.

DESIGN METHOD 3: UNIVERSAL NATURE THEME AND FAMILIAR CONTEXT

Children easily understand the world that they experience firsthand, but have more difficulty with unfamiliar contexts. For example, many children have trouble manipulating a digital steering wheel that they must turn left or right.

In Kitkit School, we deliberately chose a universal nature theme. Games and activities use this universal visual imagery, which all Tanzanian children recognize. We made visual decisions to prioritize learning for children and to focus their thinking. By using a visual design language that children immediately recognize, Kitkit School helps children focus on the curriculum and reduces their cognitive load.



Kitkit School uses a universal nature theme.

Backgrounds were chosen to be simple and nice to look at, and emphasize the key learning goal.

Datasets were chosen to include objects that children are familiar with or that they are most interested in.

DESIGN METHOD 4: CHILD-DIRECTED LEARNING

We define child-directed learning as learning that empowers children to choose their learning path, pace, and duration of engagement. Each child's experience with Kitkit School is unique. Some children only focus on literacy, while others alternate between literacy and math. Children can progress through the Kitkit School Learning App, use the Library to read books, and then return to the Learning App. Some children complete all the courses very fast and restart an easy level again to review what they learned. By emphasizing children's independence, we are helping build self-confidence and develop a foundation of literacy and numeracy skills.

Kitkit School gives children the freedom of choice in their education. At the same time, it encourages them to make progress with its reward system. Children can move back to any game that they previously played whenever they want.

Kitkit School prevents children from getting lost, if they try to advance to activities they are not ready to learn. We arrange a post-Course test at the end of nine courses in each subject. Children must score at least 80% correctly to continue to the next course.

Kitkit School uses child-directed learning because:

- › **Child-directed learning reaches the broadest range of learners.** When children drive their own pace and path, they are set up to succeed. All learning paths meet children at their own level and lead to mastery. Keeping children in lock step with others means some children are ready for a new challenge, while others are not. Kitkit School meets children where they are, which we believe is critical for learning.¹¹



Everyone chooses their own learning path.

¹¹ L.S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes* (Boston: President and Fellows of Harvard College, 1978), Chapter 6.

- › **Child-directed learning keeps children engaged and motivated.** Children remain engaged because they are choosing what they play, their learning path, and their activity (Learning App, School Tools, Library). Even if adaptive learning is not available for children in certain areas, it is still possible for those children to have customized learning by choosing what they want.
- › **Child-directed learning fosters self-confidence and identity as independent learners.** Independent, self-directed, successful learning shows children their inherent learning power. It fosters self-confidence among children as learners. They are not being compared to peers but rather following the best learning path to mastery for their unique needs and interests. They are able to pursue mastery without worrying about whether their pace is too slow, their peers' accomplishments, or bad grades. Children think, "I can learn. I can do it. I can figure things out on my own." And, we see this confidence helping children realize their power as learners, giving them self-confidence, and helping prepare them for life in the ever-changing world of the future.
- › **Child-directed learning sparks joy that evolves into a life of curiosity and learning.** By choosing their own learning paths, which books to read, and what games to play and replay, children will develop preferences, areas of interest, and curiosity. We see that allowing children choice in their learning paths helps spark the curiosity that will evolve into lifelong learning.

DESIGN METHOD 5: OBSERVATION AND DATA-DRIVEN ITERATION

Understanding and empathizing with our users is core to our product's success. As game designers, we naturally approach every project with an orientation of constant learning.

We are committed to helping unconventional learners, regardless of their access to schools or education resources. We are continuously evolving Kitkit School based on data and feedback to better support struggling learners. As a nimble, data-driven team, we can try something new, test its effectiveness, and roll out improvements with the opportunity to help millions of children.

FIELD RESEARCH

As most of Enuma's team members work in Berkeley and Seoul, we collaborated with multiple NGOs to understand local contexts and collect data through field research in East Africa. Funded by KOICA, our team began field research in 2016, and had three field studies in Tanzania and Kenya between 2017 and 2018. During this field research, we observed learning progress at school sites in Tanzania. We compared the learning progress of in-school children to that of out-of-school children. Most recently, we conducted research with an English-version of Kitkit School at a refugee camp. These three-month studies used EGRA and EGMA to define students' learning progression using Kitkit School in various environments.

During that period, tasks were not limited to measuring learning progress and collecting digital logs. We also collected daily observations of children's behaviors, interviewed parents and teachers, and reported

challenges or usage problems. In order to do so, we hired dedicated local staff, and our team members also visited research sites and participated in a direct observation.

OBSERVATION

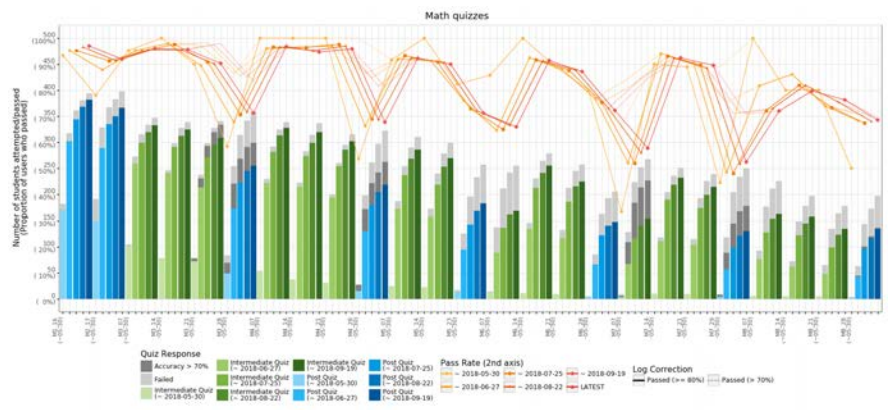
Our team has set up an ongoing field test site at one out-of-school center in Mtwara, Tanzania to understand user behavior in an out-of-school environment. Game designers conducted a week of observation in Tanzania after every major update since 2017. By observing the children’s reaction to new functionality and tracking the same children throughout the year, our team gains valuable insight about how children’s behavior changes over time. In addition, our team has requested to maximize the number of children with special needs in samples of the field research, and we found some cases that children with special needs successfully learned along with others in one classroom.

ANALYZING DATA

In Kitkit School, all the details of children’s behaviors are documented in a digital log. Using data from a digital log helps us identify learning trends and measure children’s progress. From 2017 to early 2019—the full period of field-testing for the Global Learning XPRIZE—our team has collected and continues to collect interaction information, including children’s touch data and digital drawings. By analyzing this data, the team gains valuable information on children’s learning and direction on how to improve the app.

We are committed to continual learning and improvement. Our team analyzes children’s quiz scores, speed of progress, and patterns of play to decide how to iterate Kitkit School. By adjusting the difficulty level of a learning activity or a passing score of a quiz if necessary, we try to improve children’s experiences.

Additionally, a research team at the Cognitive Computing Lab of Seoul National University, led by Professor Gahgene Gweon, participated in Kitkit School user data analysis and wrote a number of papers. These papers covered topics including users’ touch behavior to analyze children’s mastery of games, the relationship between level of mastery and selecting the next activity, and the use of the Drawing Board in double digit math to support cognitive load.



Bi-weekly trend of the math quiz passing rate, May–September 2018, at the Global Learning XPRIZE field test. We modified the question type and difficulty level of math quizzes in the October update.

Moving Forward

Kitkit School is a special project of Enuma, Inc, a mission-driven team that designs exceptional learning apps to empower *all* children, especially those who are struggling in learning, to be independent learners. This mission reflects our desire to make a better world for children.

Kitkit School evolved from our earlier works, especially *Injini Child Development Game Suite* (2011, NCsoft) and *Todo Math* (2014). Those applications were initially designed to help children with special needs enjoy everyday education practice. In all of our products, we adhere to three principles, always keeping the experience of struggling learners top of mind.

- › **Motivation.** Keep children engaged and excited throughout play.
- › **Success.** Let children win, regardless of their ability and cognitive level.
- › **Independence.** Let children explore and enable them to play without support.

The mainstream success of *Todo Math* around the world strengthens our belief that we can serve all children best by supporting each child's unique needs and differences.

In 2014, we heard about the Global Learning XPRIZE competition and its mission to help 250 million children who cannot read or write. We thought that our unique approach could contribute to solve this problem. So began the Kitkit School project.

We set out to design a highly inclusive tool that helps any child learn at their own pace and reach their full potential. We brought our experiences as game developers, Internet service designers, educators, immigrants, and parents to the field of digital education software.

Despite years of collective experience in designing learning tools for young learners, and a complete math curriculum, building Kitkit School was a very different challenge from our previous efforts. There was so much to learn—a new language (Swahili), culture, and environment. It frequently felt like 'building a car while driving it'. While building Kitkit School mostly in Seoul and Berkeley, we conducted multiple field studies¹² in East Africa to observe, assess, collect the data, and iterate the product. We are deeply grateful for our sponsor KOICA and field partners Good Neighbors Tanzania and Xavier Project, who helped to run valuable field studies and gave precious advice about East African culture and education.

As the culmination of the Global Learning XPRIZE competition, Kitkit School will be open-sourced.¹³ Because Kitkit School was designed for the unique environment of the competition, it is important to note how Kitkit School is different from common learning apps in the online app store.

¹² For additional information of our field studies, visit the impact page of our website (www.kitkitschool.com)

¹³ Kitkit School's code and asset follows Apache 2.0 license and Creative Commons 4.0. CC-BY license terms. The game part is built on an open-source game engine Cocos 2DX, and open-source libraries despite quality limitation.



- › **First, Kitkit School was designed to be installed physically on a dedicated tablet device.** Kitkit School is not an app but a comprehensive learning system, which includes a lock screen, launcher, learning apps, library and other learning tools.
- › **Second, Kitkit School works without Internet connectivity.** All videos and tools are installed to the hardware as part of the app, nearly 4GB of total content.
- › **Third, Kitkit School's goal is to teach basic reading, writing, and math skills to children in remote villages in Sub-Saharan Africa and under-resourced communities globally.** Kitkit School's real-world style (skeuomorphism) design and animated tutorials are designed to be accessible and relevant to all learners regardless of initial capacity or access to school or resources.
- › **Fourth, Kitkit School's users do not have many learning materials at home.** Kitkit School includes a total package of virtual learning tools, including a blackboard, paper, crayons, musical instruments, a library of books, puzzles, and toys.

The Global Learning XPRIZE's 15-month field study in 170 villages with 3,000 children in Tanga, Tanzania began in the winter of 2017 for the five finalists' solutions. About 30 villages were assigned to play Kitkit School. At each village, 6-22 children between the ages of seven- and eleven-years old received their own tablet device, which they charged on village-managed solar-powered charging stations. Participating children were not given any direction or instruction other than how to charge the tablets. Whether to use the tablet or not was each child's individual decision.

Because of competition rules, our team couldn't visit the field. Our only connection to the field test was the digital log data we received every two weeks. Updating the app without knowing what was going on was not easy work.

We set up a field test at a center for out-of-school children in a different region in Tanzania and compared the Global Learning XPRIZE field data with what we observed. We updated the application twice during the field test based on educated guesses.

How close is Kitkit School to our goal to support all children to learn basic literacy or math by themselves? We think it is not very far—but not close enough. In the data from the Global Learning XPRIZE field test, we could see high achievers who need more content and struggling learners stuck in the middle of the curriculum. Kitkit School will be improved with each iteration cycle. The improvement of infrastructure and iterations will lead to better content that promises better engagement and achievement from learners.

Our team will keep going, and Kitkit School will evolve with us. The Global Learning XPRIZE was never a goal, but a milestone for us toward our dream of a public digital learning system that diverse learners could use successfully. I hope that Kitkit School's source code, contents, design documents, and field data inspire developers all over the world to localize and improve it.



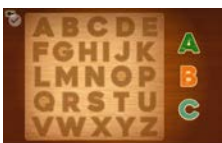




Please feel free to contact us, or visit us at kitkitschool.com, and follow our social media pages.









Team Kitkit School


Appendix





LITERACY GAMES

Below is a sampling of literacy games within Kitkit School. These are presented with tutorials at the earliest levels and progress in terms of complexity and curricular level as children play through the learning system.

NO.	GAME TITLE	DESCRIPTION	LEARNING GOAL
1	Line Tracing 	Trace different lines across the screen to expose the colors and patterns.	Pre-writing
2	Animal Puzzle 	Drag the animal puzzle pieces to their correct position.	Shape and object recognition Visual/spatial processing
3	Alphabet Puzzle 	Drag the letters to their correct location on the alphabet puzzle.	Letter identification Letter names Visual/spatial processing
4	Letter Tracing 	Trace letters	Letter identification Letter naming Writing
5	Trace 3 Times 	Trace a letter 3 times and then learn words that begin with that letter.	Letter identification Letter naming Letter sounds Writing Vocabulary
6	Sound Train 	Listen and see a letter or word. Drag letters or syllables to the correct space to match.	Phonics Letter sounds Decoding Spelling
7	Word Tracing 	Trace words and see a video showing that word.	Letter identification Letter naming Writing Decoding

8	<p>Literacy Matching</p> 	<p>See a pile of cards with symbols, pictures, letter or words, and match the cards to their appropriate pair.</p>	<p>Shape and object recognition Working memory Letter identification Letter sounds</p>
9	<p>Spelling</p> 	<p>See a word and image, then watch some or all letters disappear or shuffle. Move letters pieces to correctly spell the word.</p>	<p>Phonics Spelling Decoding Vocabulary</p>
10	<p>Word Machine</p> 	<p>Watch letters rotate into the correct position, sounding out each letter sound before hearing the full word. Select the correct image to accompany the word.</p>	<p>Phonics Decoding Vocabulary</p>
11	<p>Bird Phonics</p> 	<p>Listen to the sound each bird makes and feed them words that begin with the same letter sound.</p>	<p>Phonics Letter sounds</p>
12	<p>Word Note</p> 	<p>See a word or image and spell out the word using a selection of letters or syllables.</p>	<p>Phonics Spelling Decoding Vocabulary</p>
13	<p>Reading Bird</p> 	<p>Read aloud the word displayed on the card, and hear a bird repeat your response. Another bird will always provide the correct reading.</p>	<p>Decoding Speaking Listening comprehension</p>
14	<p>Sentence Maker</p> 	<p>See an image and move the available words to create an appropriate sentence.</p>	<p>Grammar Reading comprehension Listening comprehension Vocabulary</p>
15	<p>What is this?</p> 	<p>See a picture and choose a sentence or phrase that best describes it.</p>	<p>Listening comprehension Grammar Reading comprehension Vocabulary</p>

16	<p>Typing</p> 	Practice typing letters for common sight words.	<p>Word recognition (high frequency words)</p> <p>Spelling</p> <p>Letter identification</p> <p>Vocabulary</p> <p>Typing</p>
17	<p>Books</p> 	Practice reading and hearing leveled fiction and non-fiction books.	<p>Listening comprehension</p> <p>Reading comprehension</p> <p>Vocabulary</p> <p>Decoding</p> <p>Word recognition (high frequency words)</p> <p>Fluency</p>
18	<p>Comprehension Questions (Book)</p> 	Answer questions about what you read, with multiple choice, matching, fill in the blank, and tracing activities.	<p>Decoding</p> <p>Word recognition (high frequency words)</p> <p>Reading comprehension</p> <p>Vocabulary</p> <p>Grammar</p>
19	<p>Music Videos & Video Lessons</p> 	Videos covering various topics from the alphabet to punctuation are included throughout to reinforce learning topics.	<p>Alphabet</p> <p>Phonics</p> <p>Phonemic awareness</p> <p>Grammar</p> <p>Written language conventions</p> <p>Writing skills</p> <p>Reading comprehension</p> <p>Listening comprehension</p> <p>Oral language</p> <p>Vocabulary</p>
20	<p>Word Matrix</p> 	Practice decoding words and hearing phonemes in words. Drag words into the correct spot that matches with its phonemes. Practice making a graph.	<p>Phonics</p> <p>Decoding</p> <p>Making charts</p>

21	<p>Labeling</p> 	<p>Read or listen to words and drag them to match the objects in the picture.</p>	<p>Vocabulary Reading/listening comprehension Word recognition (high frequency words)</p>
22	<p>Sentence Bridge</p> 	<p>Drag parts of words or sentences into place to make complete sentences, including letters, punctuation, and spaces.</p>	<p>Grammar Vocabulary Phonics Word recognition (high frequency words)</p>
23	<p>Word Kicker</p> 	<p>Drag the correct word into place to create a complete sentence.</p>	<p>Vocabulary Grammar Decoding Word recognition (high frequency words)</p>
24	<p>Comprehension</p> 	<p>Read and listen to texts and answer comprehension questions.</p>	<p>Listening comprehension Reading comprehension Decoding Word recognition (high frequency words)</p>




MATH GAMES

Below is a sampling of math games within Kitkit School. These are presented as tutorials at the earliest levels and progress in complexity and curricular levels as children become familiar with the learning system.

NO.	GAME TITLE	DESCRIPTION	LEARNING GOAL
1	Bubble Pop 	Tap on each bubble/balloons until they all disappear.	Counting up to 100 Digital competency
2	Find the Pair 	Tap on the card that matches the one in the frame.	Visual processing
3	Number Matching 	Match the correct number/quantity cards.	Number awareness Quantity awareness Subitization
4	Number Blocks 	Drag the number/quantity to its correct position in the puzzle.	Number awareness Quantity awareness Subitization
5	Pattern Train 	Arrange the shapes in the correct pattern to complete the train.	Pattern recognition
6	Shape Matching 	Match the cards with the same shape.	Shape recognition Shape naming
7	Line Matching 	Draw lines to connect matching pairs of objects, animals and shapes.	Shape recognition with real objects Pattern recognition Number and quantity awareness

8	<p>Learn to 10</p> 	Trace the number and tap the bugs.	Number and quantity awareness up to 10
9	<p>Counting</p> 	Tap the objects to count and select the number that corresponds with the total number of objects.	Number and quantity awareness Subitization
10	<p>Number Tracing</p> 	Trace numbers and see them represented by tiles and in a number line.	Number writing up to 110
11	<p>30 Puzzle</p> 	Drag correct number piece(s) into the board to complete the numeric order	Number sequence up to 1,000
12	<p>Number Train</p> 	Arrange the numbers from smallest to largest or largest to smallest to complete the train.	Ascending/descending order of numbers up to three-digits
13	<p>100 Puzzle</p> 	Drag the group of numbers to their correct position in the 100 board.	Number sequence up to 100
14	<p>Bug Math</p> 	Select the correct number card to complete the simple addition or subtraction equation	Addition/subtraction with objects when the numbers are up to 10
15	<p>Fish Tank</p> 	Decompose by dragging the correct number of fish to the bowls; correctly re-order the numbers in the equation	Composition/decomposition of a number Operational strategies

16	<p>Double-digit Math</p> 	Tap the correct answer to the double-digit addition or subtraction problem	Addition/subtraction with vertical number alignment up to three-digits Operational strategies
17	<p>Equation Maker (addition to multiplication)</p> 	Move the cards to their correct location in the addition equation, and see the corresponding multiplication problem	Complete the (addition/subtraction/multiplication) equation sentence with three whole numbers Operational strategies
18	<p>Feeding Time</p> 	Select the greater than, less than or equal sign to correctly compare the numbers and objects on each side of the alligator.	Magnitude comparison of two numbers up to three-digit numbers
19	<p>Missing Number</p> 	See a row of numbers and drag the correct number to the empty spot to complete the sequence.	Skip counting up to 1,000
20	<p>Mango Shop</p> 	Complete the simple or double-digit equation. Use mangoes in groups of 10 to support addition.	Addition and subtraction with regrouping
21	<p>Music Videos & Video Lessons</p>	Videos covering various topics from simple counting to counting to 100, shapes, big and small quantity comparisons, place value, and addition and subtraction strategies.	Shape recognition and naming Counting up to 100 Addition Subtraction Place value understanding
22	<p>Multiplication Lamp</p> 	Place strings of lamps to the board and understand the concept of multiplication in relation with addition.	Understanding the concept of multiplication
23	<p>Place Value</p> 	Place the right number of water drops in the water tank.	Understanding the place value of a number up to three-digits

24	<p>Quick Facts</p> 	Find the answer block in limited time.	Fluent addition and subtraction when the numbers are up to 20
25	<p>Word Window</p> 	Read the word problem and find the answer. A user can flip the board for a visual representation.	Addition and subtraction word problems with various unknowns when the numbers are up to 20
26	<p>Math Kicker</p> 	Find the answer within a limited time.	Addition and subtraction up to three-digits when the numbers are presented horizontally

Kitkit School is a special project of Enuma, Inc., a company founded in Berkeley, California with offices in Seoul and Beijing. Our 40-person team, plus many contractors, partners, funders, and advisors supported this project in different ways. Below we list those who contributed more directly to the final version of the Kitkit School Application that is being released as open-source by the Global Learning XPRIZE in May 2019.

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ADDITIONAL

Book and video credits are included at the end of each work.
Juan-Jose Marcos is the author of DN KidLetters font.

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