GUIDE TO DEVELOPING DIGITAL GAMES
FOR EARLY GRADE LITERACY
FOR DEVELOPING COUNTRIES

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with

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ALL CHILDREN READING:
A GRAND CHALLENGE
FOR DEVELOPMENT

DL4D
DIGITAL LEARNING
FOR DEVELOPMENT

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PREFACE

This guide was commissioned jointly by All Children Reading: A Grand Challenge for Development (ACR GCD) and Digital Learning for Development (DL4D).

ACR GCD, a partnership of the United States Agency for International Development (USAID), World Vision, and the Australian Government, is an ongoing series of competitions that leverages science and technology to source, test, and disseminate scalable solutions to improve literacy skills of early grade learners in developing countries.

As part of its mission, ACR GCD has supported the development, adaptation, and testing of digital games that teach reading skills. Specifically, this has focused on the adaptation of a literacy learning tablet app from MoToLi[1] to help Cambodian children improve their reading skills; the pilot testing of GraphoGame[2] in rural Zambia; and a collaboration with the Norwegian Agency for International Development (Norad) and other partners on the EduApp4Syria competition,[3] which involved developing smartphone applications to help refugee children from Syria build foundational literacy skills in Arabic.

DL4D is part of the Information Networks in Asia and Sub-Saharan Africa (INASSA) program, which is funded jointly by the International Development Research Centre (IDRC) of Canada and the Department for International Development (DFID) of the United Kingdom, and administered by the Foundation for Information Technology Education and Development (FIT-ED) of the Philippines.

DL4D aims to improve educational systems in developing countries in Asia through testing digital learning innovations and scaling proven ones. Specifically, it seeks to:

- Better understand how digital learning innovations contribute to improved educational equity, quality, and efficiency in developing countries in Asia;

- Foster international collaboration and partnerships on digital learning innovation research in developing country contexts in Asia and the rest of the world, to expand the reach, scope, and impact of the DL4D network; and

- Scale proven digital learning innovations through contributing to educational policy-making and action at national and sub-national levels in developing countries in Asia.
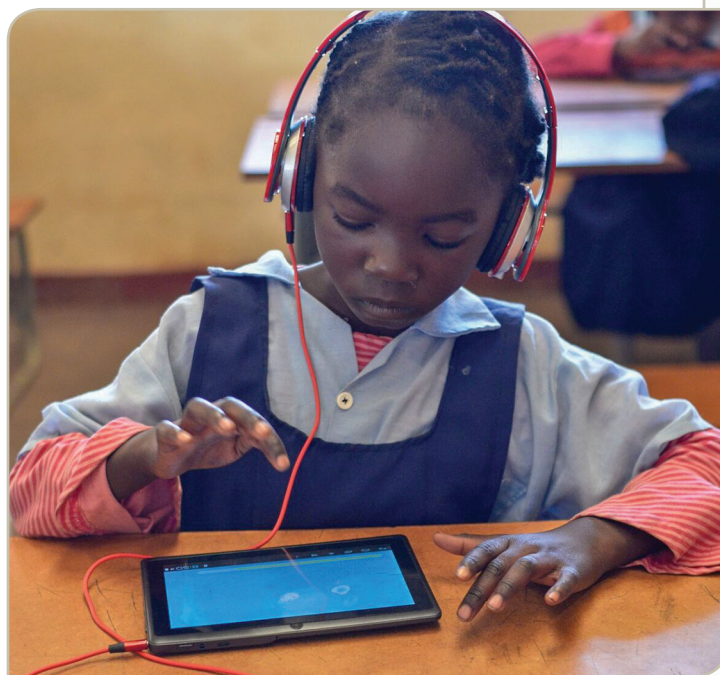
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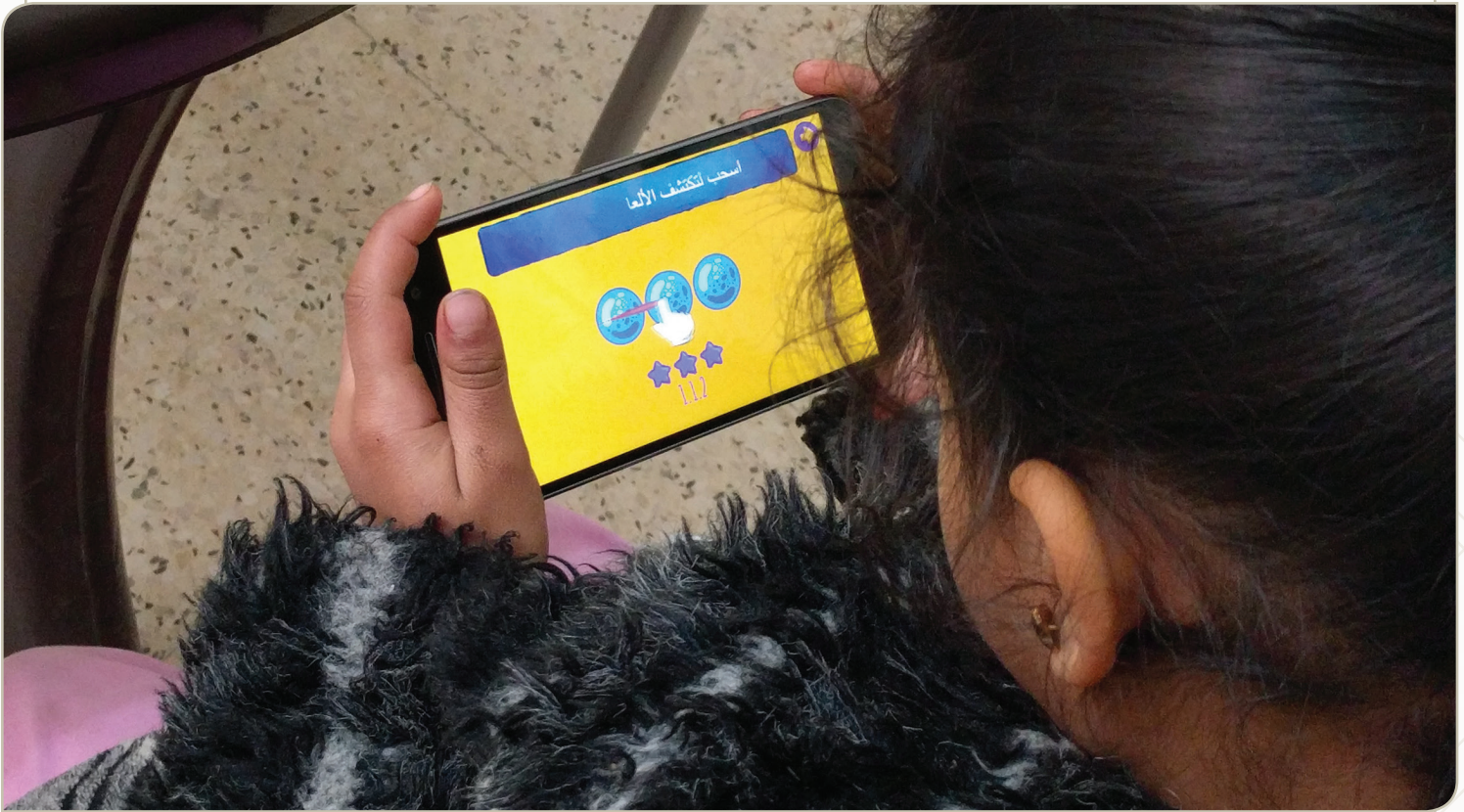
This guide is intended to assist game developers, literacy experts, and the staff of agencies interested in funding the development of digital games for early grade literacy learning. It is not a manual that provides step-by-step instructions. Neither is it an academic document; statements of fact are not footnoted, although Section 8 lists sources that provide evidence or describe theories that support the authors' recommendations. Rather, this guide presents information to be considered when designing games for literacy learning. It uses game examples that demonstrate how game developers and literacy educators have worked together. These examples were selected following a review of approximately 70 literacy learning games, including 50 games designed specifically for early grade students in developing countries submitted to the EduApp4Syria and the Global Learning XPRIZE competitions.

This guide was authored by Kenneth Y. T. Lim (research scientist at Singapore's National Institute of Education (NIE)) and John Comings (ACR GCD's lead early grade reading senior consultant), with Richard Lee, Ming De Yuen, Ahmed Hazyl Hilmy, Derek Chua, and Bing Heng Song (research assistants at the NIE).

Cher Ping Lim (chair professor of curriculum and instruction at the Education University of Hong Kong and DL4D principal investigator), Anthony Bloome (senior education technology specialist at USAID), Rebecca Leege (project director of ACR GCD at World Vision), and Victoria L. Tinio (executive director of FIT-ED and DL4D network manager) provided guidance and input throughout the writing of the guide. Edward Metz (research scientist at the U.S. Department of Education's Institute of Education Sciences), Robert Hone (acting director of the Game Lab/Studio at American University), and Scot Osterweil (research director for Comparative Media Studies at the Massachusetts Institute of Technology) also provided valuable advice that greatly improved this guide.

CHAPTER 1.
INTRODUCTION

In 1990, leaders and experts from governments, international agencies, and non-governmental organizations came together at the World Conference on Education for All and committed to providing every child an opportunity to gain a primary education. This led to the building of new schools and training of new teachers. While this work is not complete, the past four decades have seen massive expansions of primary school systems in many less-developed countries. About ten years ago, researchers began to investigate whether expanding access to primary school led to higher literacy levels. The findings were disappointing; in many countries most students in their second or third years of primary school either could not read at all or, if they could read, it was without comprehension.

The United Nations called on the world community to address this problem under Sustainable Development Goal (SDG) 4: "Ensure inclusive and quality education for all and promote lifelong learning." An indicator for the SDG 4 is the proportion of Grade 2 and 3 school students who achieve a minimum proficiency level in reading. While all the SDGs and their targets are important, achieving this reading target will provide a foundation that supports the achievement of all other targets under SDG 4. Without strong reading skills, children will be unsuccessful in the later primary grades and will, in turn, be unlikely to enter or complete a lower secondary education program. Reading skills are also important for life outside of school. Literacy has shown a strong positive correlation with almost every development sector. In fact, a mother's literacy skill level is a strong predictor of the survival of their infant to age five as well as of most other indicators of child health.

Governments, international agencies, and non-governmental organizations have thus intensified their focus on improving early grade literacy instruction. Achieving these improvements, however, is proving to be a slow and difficult process.

Literacy and digital games

Digital games can support young children with direct instruction that is engaging, targeted at their individual learning needs, and adaptive to their learning progress. Digital games can also provide practice in basic literacy skills that hold children's attention and lead to a key reading instruction goal—automaticity (the ability to read automatically). Once children can look at text and read without having to slow to sound out words, they will enjoy reading and read more, thereby improving their reading skills. Once children are reading, fiction and non-fiction can become more engaging when text is linked to games that help build comprehension skills.

Digital forms of instruction, including games, offer ways to provide high quality reading instruction to children in situations where schooling is not available or where it is available but teachers are not trained to teach reading. Providing schooling and improving reading instruction will take time, and the SDG goals will not be met unless a way around these two problems is developed within the SDG's 15-year timeframe. The literacy games that result from collaborations between game developers and educators who use this guide could help solve these problems more quickly and help achieve SDG 4.

Structure of this guide

The guide has eight sections, including this introduction. Chapter 2 addresses early grade reading design considerations; Chapter 3 discusses learning design considerations; Chapter 4 focuses on design considerations for games and learning; Chapter 5 highlights design considerations for game development; and Chapter 6 identifies areas for research and development. Following those are case studies of digital games for literacy learning and lists of supplemental resources on literacy learning and game development.

CHAPTER 2.
DESIGN CONSIDERATIONS FOR EARLY GRADE LITERACY

Designing digital games for early grade literacy learning requires an understanding of two complex concepts: developmental appropriateness for young children and the complexity of the literacy learning elements.

Developmental appropriateness

The primary challenge for developers of early grade literacy games is designing for the level of physical and cognitive development of learners in the first three grades of primary school (usually between 5 to 8 years of age). Where a game developer would normally create a game that challenges the average teenager's or adult's hand-eye coordination and cognitive ability, the average child may lack most of these skills and may therefore find such games too difficult. For instance, while teenagers may complete a connect-the-dots puzzle with relative ease, younger children may not be able to complete it without guidance since they may not have experience with either numbers or the object being formed. The learner's developmental levels determine both the pedagogical approaches that can be used and the learning tasks that can be incorporated into a game. Thus, the approach to designing games for young children must differ from the approach to designing games for teenagers or adults.

Jean Piaget described a theory that suggests four stages of children's cognitive development. Piaget's second stage of development is called preoperational. Children learning to read in primary school fall into the last substage of the preoperational stage called intuitive thought, which among children in industrialized countries spans ages 4 to 7 years. In this substage children become more curious, ask more questions, and begin to develop reasoning skills. However, children at this substage are likely to focus on just one characteristic of a situation and disregard other characteristics. Thus, children may be unaware that changing an object's appearance does not change its basic properties. For instance, children at this substage may see two equal glasses of water as different when water from one glass is poured into a taller, narrower glass. They may be unable to think through the reverse of this situation, which requires them to visualize a return of the water to two glasses of equal height and width. In addition, children at this substage may have difficulty using previous knowledge in a form of basic logic. For instance, if told that A is larger than B and B is larger than C, a child at this substage may not be able to make the leap of understanding that A is larger

than C. Similarly, if children at this substage are shown a picture of ten elephants and two monkeys, they will know that they are all animals but when asked if there are more elephants or animals, they are likely to say elephants.

These errors of logic are typical of children in the early grades of primary school but not in older learners. While literacy learning game designers need not become child development experts, they must be aware that young children may have trouble with games that require logical reasoning abilities greater than their own level. Game elements involving complicated tricks, which are intended to confuse players and thus make the tasks more difficult to accomplish, may be a good challenge for teenagers but can be frustrating for young children. Instead, elements of games designed for young children should enable the players to progress through the various levels after having demonstrated the skills taught at each respective level. Early in the game development process, the common elements of a game should be tested with children whose age and cultural background are like those of the target population.

A game's psychomotor demands should also be developmentally appropriate. Since young children have less developed psychomotor skills, simple physical interactions with the game interface (e.g. single taps or drawing gestures) may reduce frustration, as compared to interfaces which require more precise controls. For instance, intuitive drag-and-drop functions with multiple options may be more appropriate for young children than keyboard-based controls.

One way of introducing greater complexity into the gameplay is by exploiting the social aspect of children's learning. Young children first encounter language as speech, through their earliest interactions with their parents, siblings, and other relatives. Vygotsky described three stages of speech development.[4] Social speech (external speech) is the most primitive stage of language development, in which the child expresses simple thoughts and emotions out loud. The function of social speech is to control the behavior of others or to express simple, often poorly understood, concepts. As the child makes the transition from social speech to silent self-talk (or inner speech), the child goes through the stage of egocentric speech. Egocentric speech is characterized by the child appearing to talk to itself, in an apparent effort to regulate its own behavior. Inner speech permits higher mental functioning, self-awareness and metacognition. Such communications can be mediated through games which progress in difficulty to more developmentally complicated tasks.

Drawnimal is a good example. To play the game, players are asked to place their device on a piece of paper and draw an animal's shape around the device to complete a partial drawing of the animal shown on the screen (see Figure 1). If the player taps the screen, a narrator will identify the animal (e. g. "C is for cat.") An adult or older child can assist a younger child in drawing the connection between the animal drawn and its name. Such conversations—explicitly of social speech, with nascent egocentric speech—augment the embodied cognition the child experiences as the animal's form takes shape by the child's own hand. As the child attempts sketching more animal forms, metacognition and inner speech would gradually develop. Over time, learning is reinforced through the interplay of mind, body and language.
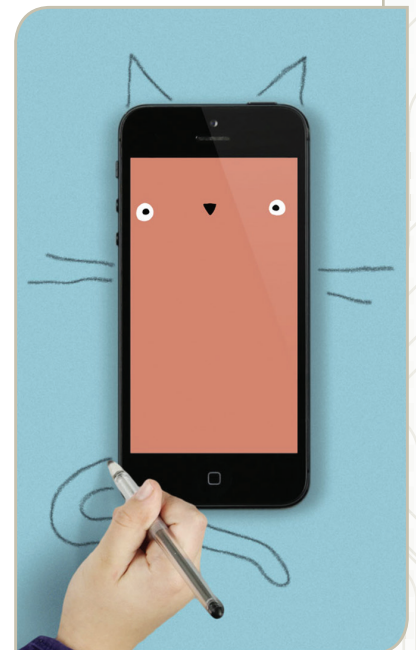

Figure 1. *Drawnimal. Used with permission from Yatatoy.*

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4   Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Elements of literacy learning

In a well-designed game, a player's advancement through game levels involves demonstrating learning. Developers of early grade literacy games must therefore have a basic understanding of how children acquire and improve their literacy skills.

Reading is not a single skill but rather a set of six component skills, namely phonological awareness, decoding, word recognition, vocabulary knowledge, oral reading fluency, and comprehension. Each of these component skills can and should be learned separately. The learner must then integrate all the separately learned component skills to perform tasks involving print or digital text (the *activity* of reading), such as reading for entertainment, answering a question, engaging in a discussion with others, and completing a work activity.

An analogy may be useful at this point. When a football (or soccer, for Americans) team is in training, the players spend time practicing basic skills (e.g. controlling the ball, passing or shooting) and time playing practice matches. To play matches well they must rely on all of their basic skills combined. Many amateur players have learned to play without formally practicing the basic skills, and a few of those players may be quite good. However, most players who learn without focusing on basic skills do not become accomplished players. Good players do not have to think about basic skills during a match since these skills have become second nature to them through practice. Instead they can focus on strategy, assessing the other team's strengths and weaknesses, and predicting where the ball will go next.

The same is true for reading. Children learn best through instruction and practice in the component skills of reading along with practicing reading by accomplishing tasks with text. Tasks and texts should be interesting, enjoyable, and challenging without being too difficult for new readers. Games should teach the component skills by starting with easy, simple skills and then slowly incorporating more difficult, complex skills. As with all skills acquisition, learning to read requires practice. Teaching that focuses solely on component skills, without reading practice, provides insufficient support for children to develop into good readers. More time reading leads to stronger reading skills.

A digital game may focus on just one component skill or it may include several or all of them. Game developers should understand that component skills are not learned by progressing from one to the other. Rather, children should start by spending time on each of the skills so they acquire the ability to read simple texts successfully early in their learning. Children will be more successful at building these skills if they are motivated to learn, and if they are learning in a language they speak and understand.

Component skills

Phonological awareness is the ability to recognize the different sounds of spoken words, parts of words (syllables), or phonemes (the smallest unit of sound in a language). An example of phonemes in English is the three sounds, each represented by a letter, that make up the word *cat*. In English, a letter such as c represents more than one phoneme and can be pronounced differently depending on the word. In many languages (e.g. Spanish, Hindi, and Swahili), each letter or letter combination has only one sound. In some languages, consonants are always attached to a vowel, and this vowel may be another letter, a small mark that symbolizes the letter, or have no marking at all and be perceived only in the context of the text. In Hindi, a consonant always has a vowel connected to it but a vowel at the beginning of a word stands alone. All the other vowel positions are represented by a vowel symbol except for the first vowel in the alphabet (a form of *a*), which is assumed unless one of the other vowel symbols are present. Arabic and Hebrew also employ vowel symbols but in most texts these symbols are dropped. Game designers must understand a language's phonemes,

and the representation of phonemes as letters or letter combinations, before they can design a game.

Games could build phonemic awareness by teaching phonics directly and by providing opportunities for practice so students learn to recognize these sounds automatically. Instruction that builds phonemic awareness is most effective when: 1) children are taught to manipulate sounds with letters, 2) lessons are short and frequent, and 3) children are taught in small groups. Although children are learning a personal skill, it has an oral component that is strengthened by group work. This is true for all the component skills.

Decoding refers to the ability to connect phonemes to letters and to sound out unknown words. Because some languages, such as English, preserve the historical origins of words at the expense of clear sound-to-letter relationships, decoding requires knowledge not only of these relationships, but also of unusual clusters of letters (such as -*ight* in *night* in English or combination letters *tra* in Hindi).

Games could build decoding skills through phonics instruction or the systematic teaching of the relationships between sounds and letters. Phonics instruction begins by focusing on a few phonemes at a time using simple words. Rhyming games with words that have the same beginning or ending sound are particularly effective.

Word recognition refers to the rapid and effortless ability to read words, or word parts, after patterns have been encountered in print enough times to allow for automatic retrieval from memory. This automatic reading of individual words out of context is critical for effective reading and is highly correlated with reading comprehension.

Games could teach word recognition directly and provide practice so children can read words without consciously sounding them out. To do this, games should provide multiple encounters with words, enabling readers to retrieve words as whole units and freeing them from the need to slowly sound out these words, even words that are spelled phonetically. Sight word instruction or introducing

words as whole units, rather than analyzing their letter-to-sound correspondences, is another critical part of early reading instruction, particularly in languages such as English where many of the highest frequency words are not decodable using a set of rules (e.g. *one*).

Vocabulary knowledge is the understanding of the meanings of words and their uses in varying contexts. Children with larger oral vocabularies will understand more of what they read. However, different kinds of vocabulary instruction lead to varying degrees of reading comprehension.

While games could teach definitions of words directly, this is less effective in supporting comprehension than instruction that explores word meaning and usages in different stories and descriptive texts. Thus, games focused on building vocabulary should have written stories made up of words learners already know as well as new words whose meaning can be derived from context.

Oral reading fluency is reading with speed, accuracy, and correct stress, intonation, emphasis, and pauses (referred to as *prosody*). The development of oral reading fluency is critical. Learners who

read with high accuracy may still have trouble understanding what they read if they are reading too slowly or with poor prosody.

Games could provide instruction that involves oral reading of text at a difficulty level that is comfortable for a learner or just slightly above this level. A learner should be encouraged to read the same passage several times, each time trying to come closer to the oral reading demonstrated by the game's narrator.

Reading comprehension occurs when readers actively make sense of what they are reading by continuously connecting what they are learning in the text with what they know from their real life experiences and accumulated knowledge. Learners improve their comprehension by engaging in activities that require comprehension, such as answering questions, searching a text for a specific piece of information, discussing a text with others, and using a text to solve a problem.

Games could provide tasks that require players to use the information in a text to overcome an obstacle in the game, open a door to a new part of a game, obtain valuable in-game artifacts that boost their avatar's inventory, increase their avatar's experience points, or move up to a higher level of play.

Motivation

Motivation is key to learning to read with comprehension. For learners to be able to automate the decoding process, acquire a sufficient fluency level, expand their vocabulary and background knowledge, and build their comprehension skills, they must spend enough time and effort both acquiring component skills and practicing reading. Effective digital games for early grade literacy are therefore those that motivate and engage the player in a sustained way; in other words, long enough that players spend sufficient time learning. Games can support motivation by adding stories, interesting characters, and functions that let

children interact with the game in personal ways (e.g. by adding their name or picture) as well as with other players.

Practice

As with any skill, becoming a good reader requires practice. Initially, new readers need texts that use only the letters and letter combinations they already know (referred to as *decodable readers*). Once they have mastered all the phonemes of their language, students need texts that are written at their reading level or at a slightly more challenging one (referred to as *levelled readers*). Games can provide reading materials that are related to the games' themes and can require reading to make progress, acquire points, or open a door to the next level.

Language

While the approach to reading instruction described here is based on research with children learning to read English, it may be adapted to any language that uses letters or letter combinations to represent a language's sounds. The way in which a language's words are spelled is its orthography.

English has a defective orthography, in which one letter can have multiple sounds; one letter can change sound when followed by other specific letters or letter combinations; and some words cannot be sounded out by pronouncing the letters. Other languages, such as Spanish, may have shallow orthographies; that is, each letter or letter combination can only be pronounced in one way and each phoneme is only represented by one letter or letter combination. The Spanish *a* is the only letter that represents the sound that in English is the *a* in *palm*, and this is its only sound. In contrast, the English *a* can be pronounced like the *a* in *palm*, the *a* in *apple* or, if it is followed by an *e* after a consonant, the *a* in *gate*. There are other English letter combinations that are complicated, such as *augh* in *laugh* or *ough* in *brought*. Some

words, such as *one*, cannot be sounded out. Both Arabic and Hebrew drop vowels, which must be inferred from the context of their use. Other languages, such as Hindi, have vowel symbols or use parts of consonants that combine with other letters to make complex sounds.

Generally speaking, languages written in a shallow orthography that employ the Roman alphabet (e.g. Spanish, Bahasa Indonesia, and many African languages) are easier to learn to read than languages that never reformed their spelling (e.g. English, French, and Arabic). Game developers should seek the assistance of linguists to understand the complexities of the orthography of their target language. These orthographic features would affect when and how letters and letter combinations are introduced in a game since literacy learning should start with words that are easy to decode.

Since languages also differ in syntax and grammar, a game cannot just replace one language's vocabulary for another. Even when the populations of two countries—or two regions in one country—speak the same language, the two local dialects could be different enough to have an impact on literacy learning. For instance, while Kiswahili is spoken in both Tanzania and Kenya, the two forms of the language have many vocabulary differences.

Apart from understanding the unique challenges posed by the game's target language, game developers must also understand the language policies that guide instruction. An increasing number of developing countries have adopted mother tongue–based instruction. This means teaching children to first read and write in the language they speak at home or know well because it is spoken widely in their community. This is because children can only learn to read and write in a language they already know. Foundational literacy skills in the mother tongue can then scaffold the learning of a second language. This is particularly significant in countries where children are expected to learn a national language different from their mother tongue that serves as the official medium of instruction.

Game designers could develop games that help learners transition from learning to read and write in the mother tongue to learning to speak and understand the national language and later, when their oral skills are strong enough, learning to read and write in that second language.

GAME DESIGN
CHECKLIST

For early grade literacy

- A game's difficulty level should not exceed a child's psychomotor and cognitive skills.

- A game should be informed by research on how children acquire and improve their literacy skills. It could focus on one component skill of reading, a few skills, or build all the component skills.

- A game should be informed by a linguistic understanding of the target language.

- A game should motivate children to learn and practice their literacy skills.

- A game should provide or encourage reading practice.

- A game should help children learn to read in a language they speak and understand. If a national language is used for instruction, a game can help children whose mother tongue is not the national language to transition from reading and writing in the mother tongue to reading and writing in the national language.

CHAPTER 3.
DESIGN CONSIDERATIONS FOR LEARNING

The specific activities that support learning to read should be informed by an understanding of learning. Two sources of insight can inform literacy learning game development: learning theories and the hierarchy of learning domains.

Learning theories

Educators, psychologists, and neuroscientists study learning and have contributed theories of how people learn. These theories fall on a continuum from support for direct, organized instruction that helps students build knowledge, skills, and attitudes, to support for designing environments and activities that allow students to construct knowledge, skills, and attitudes. Although many individual theories sit on this continuum, this guide focuses on two in particular: cognitive theory and constructivist theory.

Cognitive theory sees learning as a process of building on existing knowledge, skills, and attitudes in discrete steps that employ teaching, demonstration, practice, and feedback. While the learner is an active participant, the process is organized by a teacher. An example is training for specific jobs where trainers study a job and identify its individual tasks. These tasks are explained to trainees and are demonstrated to them; they are then helped to perform the tasks, and improve their performance by learning from their trainers' feedback.

Constructivist theory sees learning as a process of constructing an environment in which learners manage their own learning: a teacher designs an environment; learners direct their efforts within that environment. An example is a Montessori classroom where teachers build a learning environment filled with objects that are interesting to children. The children play with these objects, learning through their direct experience and interactions with other children.

Both approaches to instruction have strengths and weaknesses; some content may be better learned with one theory rather than the other. For instance, the simple view of reading comprehension is a combination of fluency and vocabulary knowledge. In other words, if you learn to read faster and more accurately and build a larger vocabulary, you will score higher on a comprehension test. A cognitive approach may increase fluency more effectively while a constructivist approach may build vocabulary more effectively.

Game developers should be aware of these learning theories and apply them in ways that make sense for helping children learn to read.

Domains

One offshoot of cognitive science is a description of learning domains and a hierarchy of skills within each domain. Bloom's Taxonomy describes three hierarchical domains of learning: 1) cognitive

(knowledge), 2) affective (attitudes), and 3) psychomotor (skills). Table 1 presents the learning objectives for the three domains.

Table 1. Bloom's Taxonomy[5]

COGNITIVE DOMAIN	AFFECTIVE DOMAIN	PSYCHOMOTOR DOMAIN
1. **Remembering:** Recognizing or recalling knowledge from memory.	1. **Receiving:** Being aware of or sensitive to the existence of certain ideas, material, or phenomena.	1. **Imitation:** Observing and patterning behavior after someone else's.
2. **Understanding:** Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.	2. **Responding:** Actively engaging with the ideas, materials, or phenomena involved.	2. **Manipulation:** Performing certain actions from memory or by following instructions.
3. **Applying:** Using learned material to carry out a procedure.	3. **Valuing:** Being willing to be perceived by others as valuing certain ideas, materials, or phenomena.	3. **Precision:** Refining, becoming more exact, and performing a skill with greater precision.
4. **Analyzing:** Breaking materials or concepts into parts; determining how the parts relate to one another, how they interrelate, or how they relate to an overall structure or purpose.	4. **Organizing:** Integrating different values with values already held and forming a new internally consistent philosophy. The learner organizes values into priorities by contrasting different values and resolving conflicts between them.	4. **Articulation:** Coordinating and adapting a series of actions to achieve harmony and internal consistency.
5. **Evaluating:** Making judgments based on criteria and standards through checking and critiquing.	5. **Characterizing:** Building abstract knowledge consistent with the values the learner has internalized.	5. **Naturalization:** Mastering a skill or body of knowledge until it becomes second nature or without much thought.
6. **Creating:** Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.		

5   Adapted from: Engelhart, M.D., Furst, E.J., Hill, W.H. & Krathwohl, D.R. (1956). In Bloom, B.S. (Ed.). *Taxonomy of educational objectives. Handbook I: The cognitive domain.* New York: David McKay Co Inc., and Krathwohl, D.R., Bloom, B.S. & Masia, B.B. (1973). *Taxonomy of educational objectives: The classification of educational goals. Handbook II: Affective domain.* New York: David McKay Co., Inc.

For each of the three domains, observable activities are sequenced on a hierarchy from simple to complex. Within each level, a specific activity could be easy or difficult.

Game developers should design their games to their target users' skill level while also offering players gameplay that helps them develop an ability to engage in more complex and difficult activities within all three domains. Game developers can use Bloom's Taxonomy to include learning goals that build cognitive and reading skills at the same time. Cognitive skills can be learned and improved upon while learning and practicing reading skills. Once cognitive skills are acquired in the learning of a specific skill or body of knowledge such as reading, they will free up attention for the learning of other sets of skills.

GAME DESIGN
CHECKLIST

For Learning

- A game should help learners build on what they already know and develop, in small increments, all the knowledge, attitudes, and skills they need to improve their ability to read and write.

- A game should provide an environment in which children can become active participants in learning to read and write.

- A game should help children build their knowledge, attitudes, and skills as they learn the content of literacy.

CHAPTER 4.
DESIGN CONSIDERATIONS FOR GAMES AND LEARNING

Learning is a part of all digital games. A digital game requires players to interact with it to overcome challenges. To do that, players must know the game's rules, learn how to navigate the game's environment, and master the game's elements that lead to success. Higher success levels come with deeper knowledge of the game. The game does not directly teach this content; it provides an environment and activities that allow the player to discover how to be successful.

In a simple game like Pac-Man, players can quickly learn the game's core mechanics even without a tutorial. Pac-Man is a progression-style game in which players must accomplish tasks before they can move on to the next game level. As players move their character, Pac-Man, through a maze, they learn how to earn points by eating the dots in the maze. Players also learn that touching the ghost characters chasing Pac-Man will kill him and end the game. From these basic elements players devise strategies to eat all the dots at one level without getting killed and move on to the next level. As the game increases in difficulty with each new level, players need to improve their skills to stay in play for as long as possible and achieve a higher score.

Like many well-designed games, Pac-Man is easy to understand but hard to master. The core mechanics are easy to understand because the game gives players clear feedback, both when they are succeeding and when they fail. The level of challenge rises smoothly as players improve their skills, motivating them to continue playing.

In contrast to Pac-Man, Minecraft is a more complex "sandbox game" in which players explore a large and complicated world. This type of game has an open-ended rather than linear playing world. Players are free to explore in any direction and take on many different tasks. In Minecraft, the world is like a digital Lego set where players can choose items from a toolbox, such as glass, bricks, flowers, and chests, to construct a virtual landscape. At the start of the game, players are given simple tools (wooden and stone pickaxes). As players explore the world, more materials are unlocked, including a form of circuitry that can be used to control mechanical devices. Players can also use items they have collected from their adventures to form new tools. These options broaden what the players can do in the environment. The game's appeal lies in its endless construction possibilities and, if a player has Internet access, the opportunity to collaborate with other players.

While playing Pac-Man or Minecraft is fundamentally a learning experience, the skills and knowledge that players learn are internal to the game and are not explicitly related to life outside the game.

For designers of educational games, the challenge is in conceptualizing and enacting game designs, whether simple or complex, such that players are afforded opportunities to acquire the real-world knowledge and skills they are meant to learn in ways that are authentic to them.

For instance, designers of early grade literacy games could develop sandbox games that require players to find letters to build words, sentences, and stories. A sandbox game's system and hierarchy of tools and objects are well suited to learning names of objects (nouns), actions (verbs), and relationships between objects and actions. If the game also has a multiplayer component, it can encourage children to communicate with each other using an in-game text chat, provided their devices can connect to each other via the Internet, a local area network, or Bluetooth.

An effective approach to educational game design

When educational game developers first began to design computer-based games in the 1970s and 1980s, they typically took an existing game design (say, a progression-style game) and embedded non-interactive educational content, such as animations and slideshows, at the end of each game level. This approach, in which the game serves as a fun incentive for players to sit through the educational content delivered between levels, proved ineffective because players would skip through the content or simply tune it out until the game returned control to the player.

Educational game developers also took to "reskinning" an existing game design; that is, leaving the game essentially the same and merely changing its graphics, sounds, and other display characteristics (e.g. by giving game characters, locations, and items names related to educational concepts). This approach also proved ineffective as players, especially those strongly focused on winning the game, simply ignored the game's surface aspects.

A more effective approach to educational game design is one that leads to meaningful learning. Game activities, rules, and mechanics must be closely related to the knowledge and skills players are meant to learn as they play the game and interact with the game's systems.

Hey Monster! English for Kids is a storytelling exercise with several different storylines. This enables learners to explore new words and, at the same time, to customize various scenes. The game is a series of narrated scenes that form a story. During each scene, the player is given the option to interact with and customize the scene and the character. For instance, when there is supposed to be an animal in the scene, the player can choose an animal by tapping the word *dog, cat,* or *bird.* The player can decide the animal's color and other features. Hey Monster! makes it clear which words are the keywords the player is meant to pick up, and reinforces these words by allowing players to customize the on-screen choices associated with each. When a word is selected at a juncture, the story is animated in relation to the word chosen. This allows learners to better associate a word with its meaning, engage with the story, and expand their vocabulary.

In summary, developers should not think of a game as simply a means to deliver educational content.

Figure 2. Hey Monster! English for Kids. *Used with permission from TechSpaghetti.*

Rather, developers should design games that allow players to learn and practice as they play. This means keeping the learning goals and tasks at the front of the designer's mind and ensuring that game activities, rules, and mechanics all help the players achieve those goals and complete those tasks. In this way, players can have meaningful learning experiences with the game even with very simple game activities and mechanics.

To achieve a good fit between the learning goals and game design, an iterative workflow is highly recommended. Developers should create a rough working prototype as early as possible for testing with educators, parents, and children. Getting feedback from target users early in the development process will enable developers to refine their game design and create a final product that both meets the desired learning goals and is fun and engaging for children.

Open-endedness in game design

Game designs can be placed on a spectrum of open-endedness. Open-endedness is the extent to which a game gives players freedom to express themselves creatively (e.g. by drawing or making music in the game, or modifying the game environment). Most games, including educational games, have traditionally been designed in a closed manner; that is, the game simply presents a player with a series of challenges to overcome.

A closed design may be a good approach for games intended for children to play on their own. But developers who are making games for groups of children may want to consider a more open-ended design approach. Open-ended designs that allow children to learn socially by sharing and discussing in-game creations with peers and teachers, on the one hand, and give teachers room to customize game activities for their own lesson needs, on the other hand, have been found to result in powerful learning experiences in school settings.

Creating an open-ended game can be a daunting task. Designing a game that offers players a finite set of options while moving linearly from level to level is far easier than creating a game environment and gameplay that enables exploration and customization. Research into designing open-ended learning activities for games and virtual worlds suggests several learning design approaches that developers may use to inform their design and development process (Lim, 2009).

Learning by exploring refers to learning that results from exploring the game-world, which can be supported by in-game activity tasks that encourage learners to observe and analyze the game-world. Developers can plan for this learning approach by designing the game-world in such a way that it encourages and rewards exploration (e.g. by including hidden areas or secrets that players are encouraged to find but must use newly-acquired literacy skills to locate).

Learning by being refers to learning that results from explorations of self and identity. Players take on roles in the game-world (e.g. fantasy roles, as is typical in games for entertainment, or roles they might observe around them such as cooks, teachers, or parents) and learn as they engage in activities that make sense in the context of that role. Developers can plan for this learning approach by choosing roles players can take on in the game, and then ensuring in-game activities and tasks make sense for that role. For instance, a cook character can be tasked with putting together a list of ingredients for a dish while a parent character is tasked with helping the cook learn the words needed for the list.

Learning by building refers to learning that results from activities in which players build or modify objects in the game-world. This could include games in which players build structures such as houses or bridges as well as games with crafting systems that allow players to build tools such as axes or saws. The popularity of Minecraft has led to both mechanics becoming common in games.

Developers can plan for this learning approach by designing building or crafting systems that align with a game's larger learning goals. For instance, a game in which players are asked to design and build a house could require them to learn to write the names of shapes, colors, building materials, or parts of a house.

Learning by collaborating refers to learning that results from players working together to solve problems or accomplish larger goals in the game-world. This can be seen in most multiplayer games in which players almost naturally band together to accomplish goals faster and more efficiently than they could on their own. Developers who design multiplayer games can incentivize players to work together in a game by allowing them to share resources or by giving them in-game objectives that can be achieved more easily in groups (e.g. writing a story together).

Learning by expressing refers to learning that results from players presenting an in-game activity or creation to an out-of-game audience. Developers can facilitate such learning by creating features that allow players to save screenshots or videos of their gameplay to show peers, parents, or teachers. For instance, players can print out a summary of what they learned, which parents can then use to assess learning progress.

GAME DESIGN
CHECKLIST

For games and learning

■ Keep the game's learning goals and tasks in mind when designing game activities, rules, and mechanics.

■ Design activities that will require players to learn as they interact with the game.

■ Create rough working prototypes as early as possible during the development phase and test these with children, parents, and teachers from the target environment.

■ When designing open-ended games, consider using one or more of the following learning design approaches:

- Learning by exploring: learning that results from exploring the game-world.

- Learning by being: learning that results from explorations of identity and self, such as taking on roles in the game-world.

- Learning by building: learning that results from building objects, structures, or tools in the game environment, or by modifying the environment.

- Learning by collaborating: learning that results from working with peers to solve problems or accomplish goals.

- Learning by expressing: learning that results from presenting in-game activities or creations to an out-of-game audience.

CHAPTER 5.
DESIGNING GAMES FOR DEVELOPING COUNTRIES

Game developers designing games intended for use in developing countries must be mindful of the sociocultural, linguistic, educational, technological, and economic contexts of their target populations.

Sociocultural and linguistic diversity

Sensitivity to sociocultural and linguistic contexts is essential when intending to design or adapt games for use in developing countries, particularly given that game development indigenous to those countries is, by and large, still emerging.

Developers of early grade literacy games, especially those from developed countries who are designing games for developing countries, should observe and learn from the communities they are targeting to ensure a game suits the needs of children from those communities. If possible, developers should visit those communities to learn more about how the children learn and play. Conversations with children and adults will aid in understanding how to design a game that builds on children's local knowledge. However, some aspects of local culture may not be suitable for a game, and designers should discuss design elements with members of the target community before incorporating them into the game.

Sociocultural contexts can differ fundamentally across societies, which is why it is important for game design teams to study the different ways

parents teach and nurture their children. In some societies, parents may prefer a more hierarchical approach to their children's learning; in other words, their children learn primarily from teachers, who are deemed experts, rather than from them. In other societies parents or older siblings may play active roles in children's learning—by teaching them at home or by participating in school activities. The teaching and learning cultures of people in different societies, along with their exposure to various education media, is a key element to consider in the design process. If game designers are designing for a country or community that is foreign to them, they must test their game with members of that community to see how it is received and to eliminate incorrect translations or game elements that may be culturally insensitive. If the designers live in a country with immigrants from the target culture, the latter may be able to play the key role of critical reviewer.

At the design stage, games can draw on the characteristics of traditional village games familiar to the children who will use the games, rather than the design elements of contemporary Western digital games. Common childhood games often involve one child chasing another, or one hiding while the other seeks out their hiding place. Childhood games often involve competition, but

games in some cultures may require cooperation. A child's local culture may have stories with animals, mythical figures, or historical figures. These are elements that could be incorporated into a game. Designers should also consider incorporating local plants and animals and other objects and activities that are part of a child's everyday experience.

Multilingualism

More than half of the world's population speaks at least two languages, and many children grow up in multilingual environments. However, languages in most multilingual societies do not have equal status. An international language or a national language may be prescribed as the language of instruction and not the local languages that children first learn to speak and understand (i.e. their mother tongues or local lingua franca that they speak as a second language).

If a game's target learners do not speak the language of instruction used in their schools, they will be unable to learn to read in that language. Children should learn to read first in a language they speak and understand. This language could be a language spoken at home, or another local language children have learned because it is spoken widely in their community. Thus, a literacy learning game should start by teaching children how to read a home or community language they speak and understand. The same game could also teach children how to speak and understand the national language of instruction, and then transition gameplay to teaching reading in that national language after children are reading well in one of their own languages. These children will learn to read quickly in the national language once they can read well in one of their own languages. Helping children learn to read in their own languages and transitioning them to a language of instruction may be ambitious at this time, but new approaches may make this possible.

Technology and platform considerations

When designing games for developing countries, developers must have an understanding of local technology and device usage patterns before making decisions about target platforms, both in terms of hardware (such as computers, tablets, or phones) and software (such as iOS, Android, Windows, OS X, or Linux). This research should also consider a game's exact target market; that is, whether it is meant for individual parents who would allow their children to play on devices at home, or whether it is meant to be used in schools. For instance, in many developing countries, Android phones are much more widely used as personal devices than computers or tablets, and developers who want to market their games to parents may want to choose Android as their target platform. However, developers who want to market their games to schools may want to choose Windows, OS X, or Linux as their target platform, depending on which is most widely used in schools in their target country or community. Developers can also consider a multiplatform release, if they have the resources to do so, to reach both individual parents and schools.

A game's platform will also determine its distribution medium. For mobile games, distribution is straightforward: Google Play Store (for Android devices) or Apple App Store (for iOS devices). For computer games, there are various means of distribution—from online platforms such as Steam, to direct download from the game developer or publisher's website, to thumb drives, or even antiquated disc-based distribution methods. The decision as to which distribution platforms to use should be made after researching the devices used by parents and schools as well as the quality and cost of Internet service available to them.

If it is important for individual students to be tracked (in terms of their activity and preferences, for example), then the developer of the app should design for the creation of multiple user profiles,

with one profile being assigned to each learner. Whether these individual user profiles are stored locally on the phone or tablet or stored in a cloud-based service is a decision the developer has to make, taking into account potential scalability and anticipation of access to data networks (thus, for example, if the app is anticipated to be used in infrastructure-poor areas, then the data should be stored locally on the phone or tablet).

Developers should also consider device screen size when deciding what game activity types to design. For instance, games that are more exploratory, and which require a player to interact with multiple elements on a single screen, may be more suited for larger-screen devices such as tablets or computers. Games that are designed for phones should incorporate fewer visual elements, such as menus, so that the screen is not cramped or cluttered. This is particularly important when designing for younger children, who may have problems tapping on small icons or buttons.

Finally, if a game is meant to provide an income for the person or company that designs it, developers should not over-emphasize in-game monetization options. The game should not overwhelm children with popups that remind them that they are using the free trial version or corner them whenever they attempt to access a locked feature. These can be frustrating for children, parents, and teachers, who must continually reset the game to get the player back to the main activity. The in-game purchase options should likewise not be readily accessible to children, who may unwittingly purchase a game. One way to circumvent these issues is to place the option to purchase the full version inside the game's settings menu, which can be locked with a security question that checks whether or not the user who is trying to access the menu is an adult.

Many learning games in developing countries are free to the user because they are subsidized by development agencies. However, this presents a problem for users who cannot pay for upgrades or technical support. Developers should plan for free upgrades and technical support that are sufficient

to ensure a game can function after its initial release or design games such that these services will not be needed.

GAME DESIGN CHECKLIST

For developing countries

- As early as possible, visit communities within the target demographic to observe, ask questions, and engage in conversations, to ground the game in a context that is familiar to the children who will play it.

- Design the game to teach children how to read in a language they speak and understand; if possible, build their oral capacity in the national language of instruction as well.

- Consider the local technology environment to understand which platforms would be most suitable for game development, including any current and future changes in that environment.

- Tailor the game design to the target device's screen size.

- Hide in-game purchase screens so they are not easily accessible to children but can be accessed by parents or teachers who make purchasing decisions.

- Consider ways to ensure upgrades and technical support are either unnecessary or available at no additional cost.

CHAPTER 6.
AREAS FOR RESEARCH AND DEVELOPMENT

While developing this guide, authors identified critical areas that would benefit from research and development (R&D).

Adapting digital games for different languages

Separating the language and game mechanics into different files makes it easier to produce multiple language versions of a game. However, the game would still have to change to adapt to the differences in the way languages are written. R&D activities may well make this adaptation easier and quicker.

Universal design for learning

Children with disabilities who are learning to read may not benefit from the games commonly available. In some cases, games could be adapted to serve students who have blind, deaf, or have learning-disabilities. A better approach would be to use the principles of universal design for learning to build games that can be used by all children. R&D activities could develop easy ways to apply these principles in the game design process.

Appropriate hardware

Games require a device. While smartphones are becoming more affordable in developing countries, the more expensive tablets with their larger screens are more appropriate for sustained use as literacy learning tools, especially by young children with limited psycho-motor skills. R&D could focus on combining the affordability of smartphones and the ease of use of tablets. Devices must also be sturdy enough to withstand the conditions found in rural areas of developing countries. In places that are off-grid, or where power supply is limited or too expensive, low-power and alternative power solutions would be ideal. In addition, single purpose devices that are not of much value if stolen are more likely to be left alone so children have access to them. It's also important to note the game's 812 specifications must align to targeted user devices.

Access to digital games

Many schools and parents from developing countries lack access to digital games for literacy learning. This is largely due to the prohibitive cost of many digital games as well as to limited access to the Internet. R&D could explore free or low-cost as well as offline or low-bandwidth means of accessing and distributing such games and other literacy learning resources, especially for those in the poorest and most remote communities.

CASE STUDIES

The authors selected the following case studies that illustrate a range of possible approaches to game development. These are also intended to encourage developers to reflect on their design and learning goals and to be aware of the challenges and risks they may face when designing games for early childhood literacy in developing countries. Some of these games were developed for use in highly developed countries, while others are targeted at developing countries or refugees.

Winners of the EduApp4Syria competition, Antura and the Letters and Feed the Monster, teach reading in Arabic and were developed for Syrian refugee children. The remaining case studies, while not designed for developing countries, may be adapted for those contexts.

ANTURA AND THE LETTERS

- **Objectives:** Alphabet, letter sound recognition, decoding, vocabulary, oral fluency, problem-solving, and working memory

- **Ages:** 5 to 10 years

- **Developer:** Cologne Game Lab, Video Games Without Borders, Wixel Studios

- **Platforms:** iOS 7.0 or later, Android 4.0 or later, and Windows XP SP2+

- www.antura.org

DESCRIPTION

Antura and the Letters is a free smartphone game that mixes entertainment technology with practical Arabic educational content to give children an engaging learning experience. Collaborating with expert educators and psychologists, the development team transformed the primary school Arabic literacy curriculum into a fun journey in which learners progress at their own speed. The game rewards players as they improve their Arabic skills.

GAME DESIGN

The game opens to the main menu (Figure 3, top left). Here, first-time players can create their own profile. They are then introduced to the world of the dog Antura and shown the first of six maps that represent their path to learning how to read (Figure 3, top right). Each post on the rope path signifies an assessment. Each dot on the rope path denotes a lesson-based mini-game that introduces a new concept and is primarily focused on fun. Thirty-two mini-games (Figure 3, middle left) unlock as the player progresses through the game. The player's recall of previous lessons is tested in one of 12 ways (Figure 3, middle right) before they can progress.

Players are rewarded based on their performance on each game and assessment with bones and unlockable customizations for Antura (Figure 3, bottom left). A player can feed and personalize their dog with more than 500 different item combinations (Figure 3, bottom right). This encourages players to play and replay the mini-games to improve their scores and earn more rewards.

LEARNING DESIGN

Antura and the Letters was designed using the Syrian national curriculum for basic literacy, which teaches:

- Arabic alphabet phonology
- Vowels (long and short)
- Consonants (sun and moon)
- Letter sounds
- Letter shapes (initial, medial, final, separate)
- Letter articulation and letter combinations
- Diphthongs
- Diacritic signs (Harakat)
- Removing affixes to return a word to its base form (Tajrid)
- Vocabulary (nouns, adjectives, verbs, adverbs, and prepositions)
- Reading of phrases and simple sentences.

The themes covered by the vocabulary include family members, body parts, food, animals, nature, home, community workers, days/weeks/months, colors, numbers, and everyday conversation (greetings, daily communications, and short questions and answers).

Figure 3. *Antura and the Letters. Used with permission from Cologne Game Lab.*

This section provides information about each learning goal, whether or not it has been achieved, as well as general information such as play time. Here, parents or teachers can also create tests that allow players to access all mini-games and assessments.

Each mini-game was crafted to promote the flow state in players; that is, a state of optimum focus that occurs when player skills and game challenges are perfectly balanced. Observations of game players have shown that a flow state improves learning by supporting sustained focus and lowering anxiety. Tests were conducted with refugee children—the target population—during the game development phase to enhance the balance between player skills and challenges. The game developers refined the game based on this result, and a major update will be released in February 2018.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Antura targets early literacy foundational skills among 5 to 10-year-old learners in a manner that immediately attracts their interest. The mini-game approach allows developers to easily add new mini-games that target additional skills or higher levels of existing skills. Building the literacy learning on the foundation of the Syrian curriculum will help students integrate into school when possible. The parent section would be stronger if it offered specific advice on how to help a child succeed, based on the data collected.

Antura and the Letters uses a stealth learning approach where the primary focus is on fun and engagement. Each mini-game is themed with a literacy lesson that requires a learner to complete tasks that require aiming, precision, and timing (e.g. identifying the correct letter from a display of letters after hearing the letter pronounced by the narrator, aiming a slingshot at the letter, and hitting the correct letter). Once a player has played a set of mini-games, he or she is tested with an assessment. Since a player cannot level up without successfully completing the mini-games and assessments, learning progress is constantly tested and measured. Through the mini-games, assessments, rewards, and the feeling of progress, players are supported to develop specific cognitive abilities such as problem solving and working memory.

Learner progress can be viewed through a "parent section," which is accessible from the start screen.

FEED THE MONSTER

- Objectives: Alphabet, phonological awareness, phonics, vocabulary, and comprehension

- Ages: 5 to 10 years

- Developer: Center for Educational Technology in collaboration with AppsFactory and the International Rescue Committee

- Platforms: iOS 7.1 or later and Android 4.4.4 or later

- www.feedthemonsterapp.com

DESCRIPTION

Feed the Monster was designed to pave the way for early reading success. Its educational content covers pre-school and first grade fundamentals in a fun and immersive game experience. Throughout the game, players advance from learning the letters' sounds and shapes to reading syllables and words by fulfilling the requests of pet monsters. Players receive constant verbal and visual feedback on their performance. Letter tracing and a memory game are introduced to add more versatility and interest to the gameplay.

GAME DESIGN

The premise of Feed the Monster is that, as the game proceeds, players are exposed to multiple monsters, which they collect and "feed" with Arabic letters, vowels, and words.
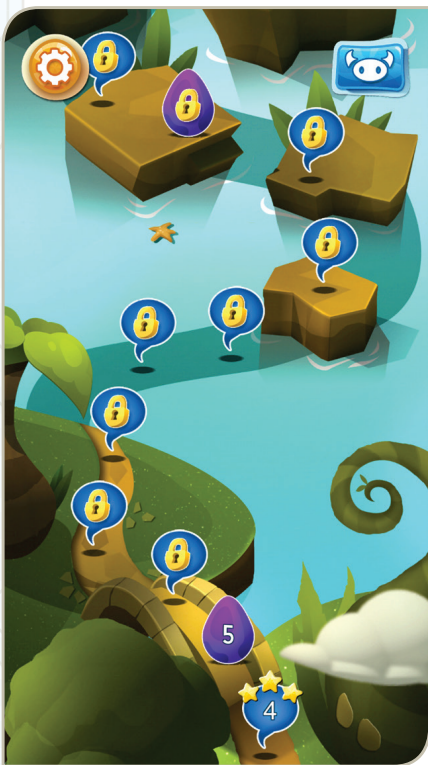

Figure 4. *Feed the Monster level map. Used with permission from the Center for Educational Technology.*

As the game begins, players meet their first monster in its unevolved egg state. Players go on to solve puzzles, gaining points on accuracy and speed that help the monster grow while learning new letters and words in Arabic. The expectation of this design is that the desire of the players to collect more monsters and to see them grow will encourage them to continue playing and thereby acquire more knowledge.

Players navigate through the game in a linear manner (Figure 4).

Each level presents players, in a visual or audible manner, with a letter or word they must feed to the monster. Success in the level rewards players with stars and points, which results in faster evolution of their monsters (Figure 5).

Additional features include letter tracing (Figure 6) and a progress tracker for parents and teachers.

Occasionally, the monsters become unhappy and players must complete a letter-tracing or memory mini-game to acquire more knowledge in Arabic vocabulary or writing and thus improve their monsters' mood.

Feed the Monster includes boosters that can help players cope with difficult levels. The boosters add more time to a level, remove wrong answers, or slow down moving obstacles. The game can also provide parents and teachers information on a player's progress.

LEARNING DESIGN

The pedagogical rationale behind the design of Feed the Monster is based on insights obtained from scientific literature, considering the challenges

Figure 5. *Feed the Monster. Used with permission from the Center for Educational Technology.*

Figure 6. *Feed the Monster letter-tracing. Used with permission from the Center for Educational Technology.*

the corresponding sounds when reading. Letters at this point are introduced in their basic form.

The learner is then introduced to a target vowel, after which he advances to reading syllables composed of the letters and vowels learned. As the shape of an Arabic letter changes in accordance with its position in a word, the learner is introduced to the different possible shapes of a letter at the beginning of a word (e.g. ح- , م, س, د, ر]), in the middle of a word (e.g. ادر-ار, -ح-,م-, س-.د-], and at the end of a word (e.g. حاح-,مام ساس .داد,ر-ار].

The difficulty level of the game has been modulated both between and within the various letter clusters by increasing the number of correct and incorrect answers, manipulating the correct and incorrect answers' visual similarity and adjusting the amount of time given to solve the challenge.

Finally, the learner learns how to read words composed of the target letters and vowels before moving on to the next letter cluster. Culturally specific words are used. These are taken from a dictionary of over 1,100 lexical items in standard Arabic developed by the Center for Educational Technology in Israel based on a large-scale study conducted among Kindergarten and Grade 1 children.

While learning to read, learners are also exposed to basic writing practice through letter-tracing tasks.

of Arabic reading acquisition, as well as data collected from the educational field. Specifically, the instructional paradigm is based on the phonetic approach, which is the method currently implemented for reading acquisition in several educational systems worldwide.

Arabic letters are presented to players in six clusters, beginning with letters representing non-fricative sounds (since these follow a similar and distinguishable pattern, facilitating letter-sound correspondence mastery). Each letter cluster introduces four to five visually distinct letters. As the game proceeds, the learner advances from learning letter sounds and shapes to reading syllables and words.

For each letter cluster, the learner is first introduced to the letters' sounds. This fosters grapheme-phoneme correspondence knowledge, which is the foundation for reading acquisition as it enables learners to discriminate between the different letters of the alphabet, to understand that different graphemes represent sound units of their language (phonemic awareness), and to convert letters to

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Feed the Monster targets early literacy foundational skills among 5- to 10-year-old learners in a manner that immediately attracts their interest. Developers could consider expanding the literacy pedagogy and corresponding gameplay to attract slightly older learners who wish to further their learning and who would also benefit from the inherent "fun" the game offers.

CHINESE FOR KIDS WITH LINGOKIDS

- Objective: Character recognition

- Ages: 2 to 8 years

- Developer: Monkimun

- Platforms: iOS 8.0 or later and Android 4.0.3 or later

- www.lingokids.com

DESCRIPTION

Chinese for Kids with Lingokids (formerly Monki Chinese Class) is a Chinese character recognition and drawing game for phones and tablets in which players learn how to recognize and pronounce characters by engaging in a drawing activity. This free, single-player game app offers additional content through subscription, payable as an in-app purchase. The game has an online component for viewing and downloading content.

GAME DESIGN

This app helps children learn basic Chinese characters through symbol and graphic association. It starts with an interface for parents or teachers to provide information about the player (Figure 7, left). The app then uses a three-step process that makes it easier to remember individual Chinese characters: 1) showing the character being written (Figure 7, center); 2) associating the character with a symbol that represents (and resembles) the character (Figure 7, right); and 3) animating the symbol. After the character is introduced, the player is guided through three opportunities to trace the character.

Chinese also has terms that combine two or more characters. For instance, *fire + mountain* makes *volcano* while *mouth + water* makes *saliva*. Each word is presented with interactive writing instructions for players to learn the correct order and direction of strokes. After the demonstration, the player traces the strokes with the help of guidelines. Once the player completes the task, the character is illustrated with animations and sounds. The correct pronunciation of the Chinese word is sounded out and the English word for the character is displayed.

LEARNING DESIGN

To learn a Chinese character, one must learn its shape, sound, and meaning. Chinese-written characters are composed of several strokes. The learner must learn to write each stroke in the proper order. The vision- and motion-based
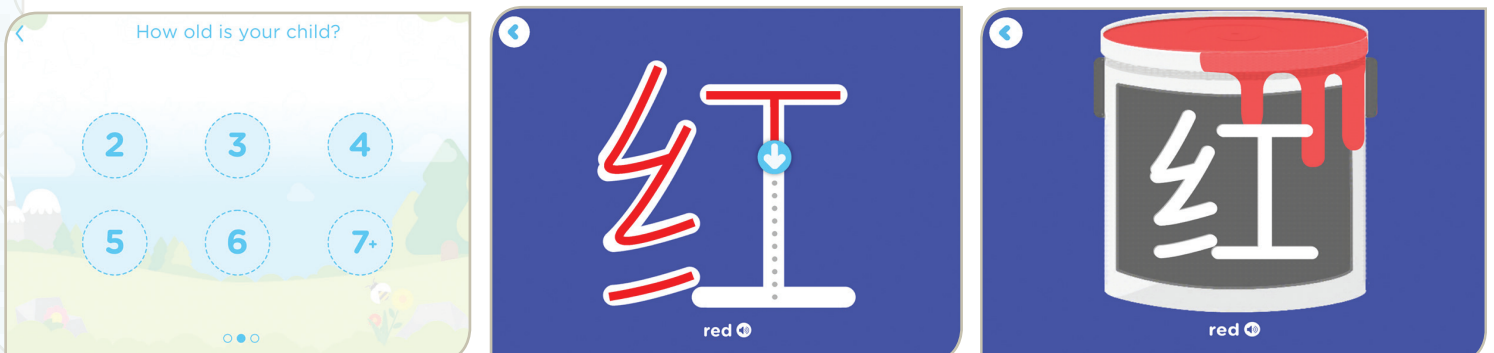

Figure 7. *Chinese for Kids with Lingokids. Used with permission from Monkimun.*

approach of Chinese for Kids with Lingokids makes the challenging task of learning Chinese characters more interesting and engaging. The game-based learning experience is easy and may be best suited for beginners. The user interface is intuitively designed. Each box in the brightly colored grid represents a Chinese word that can be accessed. The individual animations are also minimalistic and to the point. The in-game text (including the parents' guide) is in English, although all spoken narration is in Chinese. Thus, the game may be more suitable for multilingual parents and learners.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Developers could consider adopting the vision- and motion-based approach of Chinese for Kids with Lingokids particularly for complex writing systems such as Korean and Japanese. Because of the large number of characters in these writing systems, the game development work and time required would be considerable. Developers could consider narrowing their focus to words that are considered basic or foundational.

DEXTERIA JR

- Objective: Fine motor skills

- Ages: 2 to 6 years

- Developer: BinaryLabs

- Platform: iOS 9.0 or later

- www.dexteria.net

DESCRIPTION

Dexteria Jr is a motor skills development game for phones and tablets in which players can improve their motor skills and dexterity by engaging in a series of hand and finger exercises. This is a single-player, paid game app with no online component.

GAME DESIGN

Dexteria Jr allows young learners or those with special needs to practice fine motor skills on a touchscreen. The app prepares children to learn to write. Three gestures are used throughout the game for interacting with fun, lively pictures: tap, tap and drag, and pinch. Three activities are offered by the app: Squish the Squash, Trace and Erase, and Pinch the Pepper. For each of these activities, play is timed and the timings recorded. Players or their parents can choose the appropriate level of difficulty at the onset. Each subsequent level is more challenging than the last. Data can be reviewed under the report section on the main menu.

In Squish the Squash, simple auditory directions are given to "Tap the squash." An index finger can be used to squish the smiley squash to improve fine motor control. Squashes appear all over the screen, initially one at a time; as the levels increase, so do the number of squashes. In Trace and Erase, shapes appear with an arrow at one end and a star at the other. The auditory directions tell players to "Drag the arrow toward the star." The finger must stay inside the lines of the shape and end at the star or a "boing" noise is heard, letting the players know they must try again. Once all the lines have been properly drawn, players then drag erasers down the lines to end the activity. A variety of special effects are revealed as the eraser moves. This is the only activity with a reinforcer at the end: once all the lines

are erased, a photo of the player is taken. Special effects are applied to photos. In Pinch the Pepper, the app tells players: "Using your thumb and index finger, pinch the pepper." Level one starts with three stationary peppers. The peppers start moving and increase in number in level two.

LEARNING DESIGN

Dexteria Jr targets the development of learners' motor skills through a series of mini-games. The gameplay is mainly achieved through tapping or tracing on-screen objects. The three activities may be simple but are effective first steps in engaging young learners to develop their motor skills. The touch and drag controls are intuitive; learners should have little or no trouble understanding how the game is played. However, being a tablet app, it is important to consider whether this kind of flat screen practice is transferable to the real world. Will pinching a pepper on the screen really prepare a child to hold a pencil? The tracing activity seems to be the most promising in this regard, since it mimics traditional letter-tracing workbooks.

The app's automatic tracking and reporting feature makes it easy for parents, teachers, and occupational therapists to assess time on task and general progress. The progress reports can be emailed from the app. This can be useful as a therapeutic tool; in the long run, this will probably be less expensive and more reusable than workbooks. One possible way to enhance the authenticity of the physical writing tasks is to perform the activities with a stylus. Letters of the alphabet could also be added to the patterns featured in Trace and Erase.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Dexteria Jr targets younger learners or learners with special needs. Developers may want to conduct an analysis of their target markets to determine the level of unmet learning needs that could be addressed by a specialized game such as this. The app was developed in consultation with occupational therapists to serve as or supplement a therapeutic tool.

DRAWNIMAL

- Objectives: Alphabet and phonological awareness
- Ages: 5 years and below
- Developer: Yatatoy
- Platform: iOS 6.0 or later
- www.yatatoy.com/drawnimal

DESCRIPTION

Drawnimal is a letter recognition game for iOS phone and tablet devices in which the player learns how to recognize and pronounce letters by engaging in a drawing activity. This is a single-player, paid game app with no online component. It is available in English, Spanish, French, German, and Italian.

GAME DESIGN

Players are first instructed by a narrator to place their device on a drawing surface and then to choose

a letter from a main menu. The chosen letter is displayed along with an incomplete drawing of an animal whose name starts with that letter (Figure 8, right). Players are then shown how to complete the
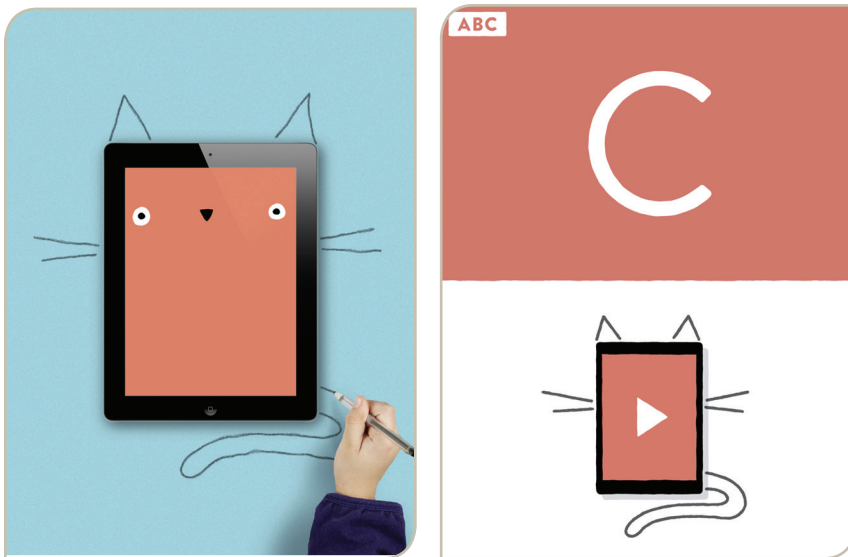
drawing of the animal by adding body parts such as a tail, ears, or fins on the paper around the edges of the device (Figure 8, left). Players can tap the screen to hear the letter and the name of the animal (e.g. "C is for cat") [Figure 8, right]. A short animation of the animal is shown when the screen is tapped again.

LEARNING DESIGN

Drawnimal is a creative blending of digital animation and pencil–and–paper drawing that combines traditional craft activities with digital learning of the alphabet. Learners practice fine motor movements as they draw around the device. Since they draw the outline of an animal by themselves (or with help from an adult), they can associate the animal and its name, and thereby improve their oral vocabulary while learning letters, letter sounds, and words. This is a simple game that can quickly engage a learner. The way the game introduces an extra dimension (i.e. drawing on paper alongside the device) enables learners to be creative while learning letters. Since the game allows parent–child interaction, a parent can guide a child in their learning and reinforce the learning with praise.

Although simple in design, Drawnimal nonetheless effectively targets the cognitive, affective, and psychomotor domains. The learner develops vocabulary and phonological awareness through learning different words and their pronunciation. By employing a common children's activity – drawing on paper – the game guides the learner into making complex shapes. This builds psychomotor skills. The game's animation feature can motivate the learner to produce a good drawing. This can lead to sharing and collaboration with peers, teachers, and parents, which in turn builds effective skills.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Drawnimal has low system requirements and is compatible with many older iOS devices (running iOS 6.0 or later). However, its use of the iOS platform limits its usability in developing countries where the Android platform has a larger market share.

ENDLESS ALPHABET

- Objectives: Phonemic awareness, decoding, and vocabulary

- Ages: 4 to 10 years

- Developer: Originator

- Platforms: iOS 9.0 or later and Android 2.3.3. or later

- www.originatorkids.com

DESCRIPTION

Endless Alphabet is an English language learning game in which players learn how to spell 70 words that start with different letters of the alphabet by playing simple puzzle games. This is a single–player, paid game app with an online component for downloading in-game content.

GAME DESIGN

Players pick a word to spell from a word list in the main menu. A narrator pronounces the selected word, the letters of the word are scrambled and scattered around the screen, and the whole word is shown in a light-gray area of the screen. The player must spell the word correctly by dragging and dropping the letters in the right order. When the player taps and drags a letter, the narrator sounds out the letter and the letter transforms into an animated monster. Once all the letters have been arranged in the proper order, the narrator pronounces the word again and a short animation illustrating the word's meaning is shown (e.g. a group of monsters playing in a band for the word *musician*). Players progress from word to word on the list in the main menu that includes at least one word that begins with each letter in the English alphabet.

Endless Alphabet is a simple game that is easy to learn and is designed for young children to play repeatedly. There is clear audio and visual feedback during the game and a simple reward for completing a puzzle: a colorful animation of the word's meaning.

LEARNING DESIGN

Endless Alphabet has two primary learning objectives: 1) phonemic awareness and decoding, and 2) vocabulary knowledge. The former is facilitated by the voicing by a narrator of the letters as they are selected as well as of completed words while the latter is facilitated by animations of word meanings.

This wordplay or word scramble game allows the learner to see words pulled apart and then discover how to use letter sounds to put the words back together. The game also enables a learner to discover a word's meaning through animation, thereby increasing the learner's vocabulary. By using an activity a child may already be doing in their classroom or at home, the game turns their interest and familiarity into an opportunity to practice decoding words and building a body of sight-words.

The gameplay is intuitive, and the game's drag-and-drop format is easy to learn. Mindful of the developmental needs of the age cohort at which this game is targeted, gameplay and format are consistent throughout all levels. Interactive visual animations and audio media keep learners engaged.

Several versions of the game, which vary in difficulty in terms of the range of vocabulary offered, are available. Versions with more challenging word lists would be suitable for older children or teenagers who want to deepen their vocabulary. But for younger learners who are just learning to string letters into words, a list of simple words would be more appropriate.

The animations of word meanings may be confusing for some learners as these may not be specific enough. For instance, a monster eating a bowl of spaghetti to illustrate the word *eat* may lead some children to think that *eat* refers to the bowl. This is an example of how it is often more difficult to learn verbs compared to nouns via the app.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Endless Alphabet has low system requirements and is compatible with older iOS devices (running iOS 9.0 or later) and Android devices (running Android 2.3.3. or later). This is a good example for developers to follow as it will increase the size of their potential audience. However, the game requires players to be online if they want to play the puzzles for letters H to Z. This is not a suitable design for players without reliable Internet access as is the case in many areas in developing countries.

Developers should also be mindful of the cultural specificity of any texts or scenarios used in a game. For instance, in developing countries where Christmas is not commonly celebrated, another holiday could be chosen instead. Furthermore, literacy games could be enhanced with the addition of an adaptive feature whereby word difficulty increases automatically as the player expands his or her vocabulary.

HEY MONSTER! ENGLISH FOR KIDS

- Objectives: Letter sounds, phonics, decoding, vocabulary, reading, and math
- Ages: 4 to 8 years
- Developer: TechSpaghetti
- Platform: iOS 9.3 or later
- techspaghetti.com

DESCRIPTION

Hey Monster! English for Kids is an English language learning game for the iPhone, iPad, and iPod Touch in which players engage in interactive stories that they can customize (e.g. in relation to the creatures they encounter during the story). This free, single-player game app offers additional content through subscription, payable as an in-app purchase. The game has an online component for in-app purchases and for downloading new content.
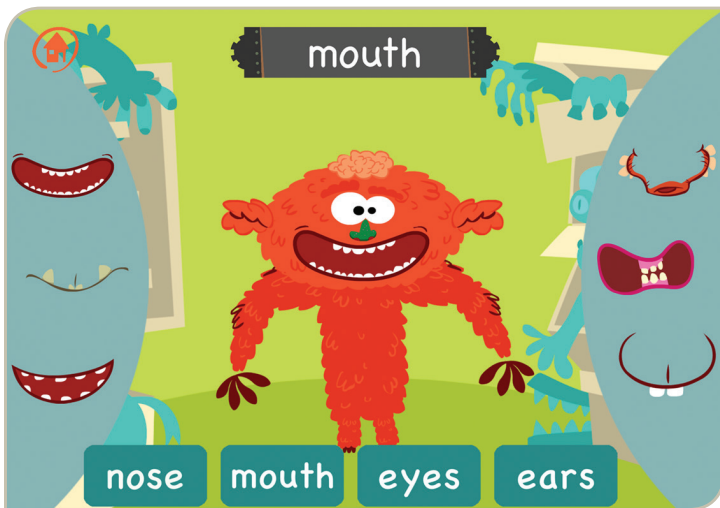

Figure 9. *Hey Monster! English for Kids. Used with permission from TechSpaghetti.*

GAME DESIGN

The Hey Monster! app opens with an animation of monsters building a new monster with a machine that converts words into pictures. After the introductory animation, the home screen provides access to several areas including character selection and character dress. In character selection, the player can choose to play as a boy or girl and customize his or her appearance (e.g. hair and clothes). Players receive gifts (such as hats and costumes) after completing tasks during gameplay, which can be used to customize a character.

The game is a series of narrated scenes that form a story. During each scene the player is given the option to interact with and customize the scene and character. For instance, when there is supposed to be an animal in the scene, the player can choose an animal by tapping the word *dog*, *cat*, or *bird*. The player can decide the animal's color and other features. Hey Monster! makes it clear which words are the keywords the player is meant to pick up and reinforces these words by allowing players to customize the on-screen choices associated with each (Figure 9).

LEARNING DESIGN

Hey Monster! is an interactive app that uses interesting storylines to help learners stay engaged. It teaches English words using visuals and allows learners to associate the taught words with interactive mini-games. The "four, choose one" nature of the storyline gives the game a *choose-your-own-adventure* feel, providing an incentive to replay the game and learn more. When a word is selected at a key juncture, the story is animated in relation to the word chosen. This allows learners to better associate a word and its meaning, engage with the story, and expand their vocabularies.

This app is a storytelling exercise with several different storylines. Learners explore new words, receive gifts for completing tasks, and have fun using those gift

items to customize their character and scenes in the story. This is a piece of game psychology in which rewards earned through certain activities are supposed to motivate a learner to complete activities and continue doing similar activities.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Developers can learn from the variety of storylines and degree of player's choice Hey Monster! offers. Whereas a fixed storyline may bore learners once they have gone through it multiple times, different storylines may engage them more in learning, especially if they can choose the storylines and characters themselves.

Hey Monster! was developed by teachers, and the game's learning method was based on their teaching experiences. Developers may want to consider bringing a teacher on board, either as a consultant or as a core development team member, to help design their game's learning tasks and activities. Developers should also take care to craft stories that are appropriate for the target players' cultural contexts (e.g. the clothing choices available for players' characters should be familiar to them).

Most of the main content in Hey Monster! —the interactive stories—must be unlocked by purchasing a monthly subscription via in-app purchase. The subscription section is only meant to be accessed by adults, who must answer a math question that is too difficult for young children before they can gain entry to the section. This may be suitable for games marketed to parents in developed countries who have high purchasing power but not for those in developing countries who may not be able to afford monthly payments for game content. That said, offering new content every month does increase the game's value. Developers could consider alternative forms of revenue to fund the extra development costs.

MINECRAFT

- Objectives: Various
- Ages: 4 years and above
- Developer: Mojang
- Mobile Platforms: iOS 8.0 or later and Android (version varies with device)
- Desktop Platforms: As listed on the developer's website
- minecraft.net

DESCRIPTION

Minecraft is an open-ended sandbox game for computers, game consoles, phones and tablets in which players explore a world, collect resources, and build their own structures. Through its emphasis on "crafting" and "construction," Minecraft affords learners opportunities to shape their own worlds, thereby indirectly revealing their nascent worldviews and paradigms. Both *in situ* and *post facto*, learners can be encouraged to talk through their creations, thus developing oral and textual literacy as their own personal narratives emerge. It has both single-player and multiplayer modes played either offline or online. The game must be purchased.

GAME DESIGN

Minecraft is a sandbox game that places the player in a procedurally-generated world for the player to explore. It can be described as a digital Lego set where players choose items from a toolbox—such as glass, bricks, flowers, and chests—to construct and shape a virtual landscape (Figure 10). The player interacts

Figure 10. *The crafting interface in Minecraft. Used with permission from Mojang.*

with the environment and with items obtained from the player's adventures to form new tools. The game's appeal lies in its endless construction possibilities and the opportunity to collaborate with other online gamers. With the introduction of different game modes (namely Survival, Creative, Adventure, Hardcore, and Spectator), the game can be played in many ways depending on the player. Games can also be imported via other sources through custom-made maps.

LEARNING DESIGN

Minecraft offers an open world in which learners explore, hunt for supplies, and build structures. Initially, the "technology" available to players is relatively simple (e.g. wooden and stone pickaxes). As the learner explores further, additional materials and crafting options are unlocked, including a form of circuitry which can be used to control mechanical devices. These options broaden what the learner can do in the environment. While not intended to be educational in nature, the open-ended and collaborative nature of the game engine allows the game to be played in a variety of ways. It has been used for educational purposes by both parents and teachers, some of whom have designed custom environments to use during lessons for various subjects.

Minecraft can be a rich learning experience depending on how it is played. It can be a creative platform for exploring and building objects. It can

also be a platform for oral expression when it is played as a role-playing game. Learners must also rely on their digital literacy skills to communicate with fellow gamers in their search for resources to build their desired landscape. Like an infinite set of programmable Lego blocks, Minecraft can be used to enhance spatial reasoning, logical thinking, and math skills.

Regarding early grade literacy learning, there could be some play into how letters and phonics are represented to give the player an interesting perspective on language. The game's crafting system and hierarchy of tools and objects lend themselves well to learning the names of objects (nouns), actions (verbs), and relationships between objects. As the game also includes a multiplayer component, it can be used to encourage children to communicate with each other in-game using text chat.

The five learning design approaches for open-ended games described in Section 4—*learning by exploring*, *learning by being*, *learning by building*, *learning by collaborating*, and *learning by expressing*—can be observed in Minecraft. Developers can look at the game, and at the customized learning environments that parents, teachers and even students have designed in the game, for inspiration for their own open-ended game designs.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Minecraft's sandbox environment, together with the random seed that is generated for each play-through, ensures that no two worlds are the same, and consequently no two play-throughs are similar. With the game mechanics being relatively straightforward, the game's randomness is its own novelty. What Minecraft demonstrates is that mixing different mechanics together allows for some interesting games to be created. Furthermore, the simplicity of its crafting system, combined with how materials are made available in the game as the player spends more time discovering the world, makes for a stimulating game progression.

While the idea of developing a game as complex as Minecraft may seem daunting, it is useful to remember that the game was originally developed by a single developer who did not have access to much in the way of development resources. Furthermore, the game's procedural world generation system allowed the developer to create large, complex worlds without spending a significant amount of time on it. The advantage of this kind of approach is the high degree of customization afforded users. Players can customize their own play experience while others (parents or teachers) can create customized learning environments for different learning needs. This allows such games to be used in a wider variety of contexts compared to more focused games.

READING RAVEN

- Objectives: Letter sounds, phonics, decoding, reading words and sentences, cognitive skills, affective skills, and psychomotor skills

- Ages: 3 to 7 years

- Developer: Early Ascent

- Platform: iOS 8.0 or later

- www.readingraven.com

DESCRIPTION

Reading Raven is an English language learning game in which players engage in a series of game activities designed to help them learn how to recognize, pronounce, and form letters and words. This is a single-player, paid game app with no online component.

GAME DESIGN

Reading Raven is an educational app designed to teach children reading skills, from pre-reading to reading short sentences, using voiceover instructions and mini-games. Parents or teachers can configure Reading Raven for use by children aged 3, 4, or 5 years. The curriculum varies for each of the three age levels. There are five lessons within a level, each with multiple parts. The player accompanies Reading Raven, a backpack-wearing bird, to explore five themed locations on the map. Each location has a different lesson presented as an adventure (Figure 11). As players go on their journey, they periodically earn stickers to help Reading Raven decorate its three-story birdhouse. Reading Raven introduces the player to every letter of the alphabet; letter recognition, phonics, tracing letters and words; forming simple sentences through letter-tracing (Figure 11, right); word recognition (Figure 12, left); and word spelling (Figure 12). The game also enables the players to record their pronunciations of words and sentences and play back the recordings to check for accuracy.
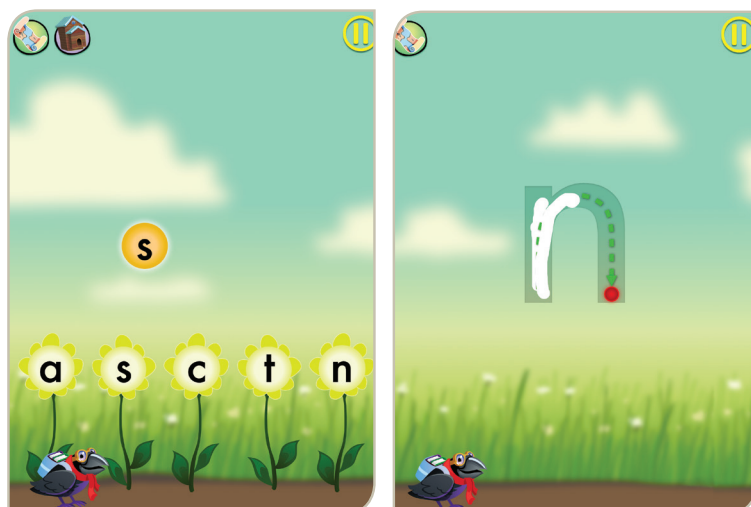

Figure 11. *Reading Raven. Used with permission from Early Ascent.*

LEARNING DESIGN

The first few tasks for learners aged 3 years and above involve letters of the alphabet. Through repetition, children learn about each letter's shape and sound. Tracing letters aids in the development of learners' fine motor skills. Introducing learners to the shapes of words helps them in later learning stages. Tasks designed for learners aged 4 years and above use letters to form a few simple words. Getting learners to use letters they know to build a new word strengthens their spelling skills and expands their vocabulary.

One of Reading Raven's innovations is enabling learners to record themselves saying a word or a sentence and then playing back the recording when they encounter the word or sentence again later in the game, thus reinforcing their learning. Not many early grade literacy games make use of the microphone. This is certainly a feature that game designers should consider.

Reading Raven addresses all three domains of learning: cognitive, affective, and psychomotor. Depending on the age level, the game teaches phonemic and phonological awareness, vocabulary knowledge, and oral reading. The letter-tracing is useful in developing psychomotor skills, and the game keeps learners motivated by using a reward system. The ability to listen to one's voice is intrinsically motivating since it encourages players to take an interest in developing their oral skills to better perform the story. While this game introduces variety into the storyline, the storyline is still linear and is disconnected from the room decoration stages. The exercises for each set of letters are also like each other, which may decrease motivation to continue learning.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

A unique feature of Reading Raven is its voice recording functionality, taking advantage of a standard feature in all modern mobile devices. Developers are encouraged to consider using this feature in their own games as appropriate.
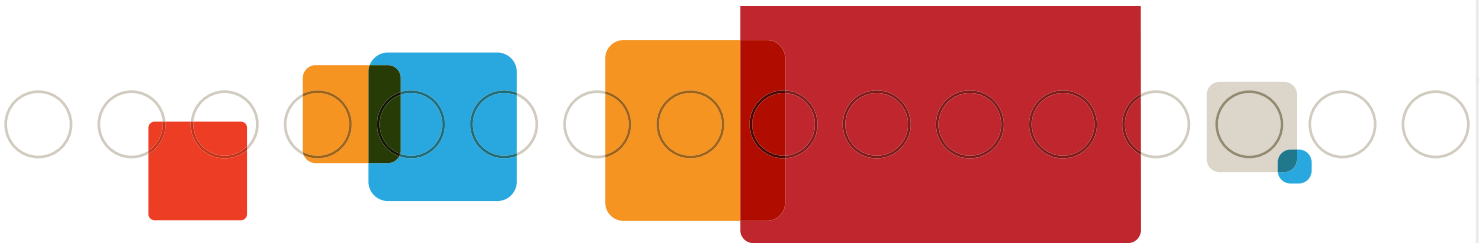
SAGO MINI DOODLECAST

- Objectives: Drawing, creativity, oral expression
- Ages: 2 to 6 years
- Developer: Sago Mini
- Platform: iOS 7.0 or later
- sagomini.com

DESCRIPTION

Sago Mini Doodlecast is a letter recognition game for phones and tablets in which the player learns how to recognize and pronounce letters and words by engaging in a drawing activity. It is a single-player, paid game app with no online component. Players may upload videos created during the game to video-sharing sites.

Although ostensibly a drawing app, Doodlecast is included as an exemplar in this guide as it underscores how literacy learning can be broadened beyond an explicit focus on oral and textual competency to include scaffolding activities that foreground a child's other talents and dispositions toward learning.

GAME DESIGN

Doodlecast is an easy, user-friendly tool for children to express themselves verbally and artistically as they create and narrate a drawing "movie." Players can choose a story-starting question, a partial drawing, a photo from the device, or a blank screen, and then draw and talk through their drawing while their voice is being recorded. As the game begins, the app randomly selects a pre-populated canvas for the player (Figure 13, top). At the bottom of the screen is a simple question to spark the player's imagination (e.g. "What's in the cart?" or "Who lives on this planet?" or "What makes you feel sad?"). The player then responds to the prompt by drawing and speaking, and then combining the two into a video (Figure 13, bottom).

Many of the prompts allow players to reflect on and articulate their feelings in a non-threatening manner. They can sing, narrate a story, or just chat. They can also change brushes and colors or erase and start over. Players can pause the recording, if necessary. The built-in app gesture and voice recording feature automatically records all the strokes while the player is drawing. This allows the player to replay the drawing sequence one stroke at a time. In addition, the player can replay any

Figure 13. *Doodlecast. Used with permission from Sago Mini.*

narration or conversation recorded. Recordings can be a maximum of three minutes. Players can save their work to the camera roll or upload it to a video-sharing site. This is a good example of an open-ended game (or tool) where players are encouraged to express themselves instead of being given explicit goals or challenges. While the story-starting questions provide some scaffolding, the in-game parents' guide encourages parents to use the blank template and either provide guide questions themselves or allow their children to tell their own stories freely (once they are comfortable doing so).

LEARNING DESIGN

Doodlecast is not only about drawing. It's an easy-to-use tool for young children to express themselves, tell their own stories, and have meaningful conversations with parents and teachers on what matters to them in very simple, intuitive steps. Children can practice their affective, psychomotor, listening, and oral skills in a non-threatening environment. A literacy learning game that promotes oral expression is rare, as the emphasis in such games is usually on letter/word recognition.

Doodlecast enables learners to express themselves in ways in which they are comfortable (drawing and speaking) and on topics on which they have an opinion. The question, "What is your favorite toy?"

may not seem important but may be significant for a child. Taking part in these activities can help parents and teachers better understand and relate emotionally with the learner, while the learner can gain self-confidence from expressing his or her opinions and having them acknowledged by others.

Three of the five learning design approaches for open-ended games described in Section 4 can be observed in Doodlecast. Allowing learners to create unique artifacts with in-game help is a form of *learning by building*. Having an adult or a peer answer questions and create artifacts alongside learners is a form of *learning by collaborating*. Allowing learners to share their creations either in person or online is a form of *learning by expressing*.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Doodlecast is unique in that it incorporates drawing tools and an audio recording feature for creating short movies. Furthermore, as a template for a "blank canvas" game, it provides the basic mechanics and offers sufficient variety in its templates to make the game both effective and engaging. Its design both significantly reduces the content creation workload, particularly in terms of art assets, and minimizes the need for localization since learning tasks are almost entirely player driven.
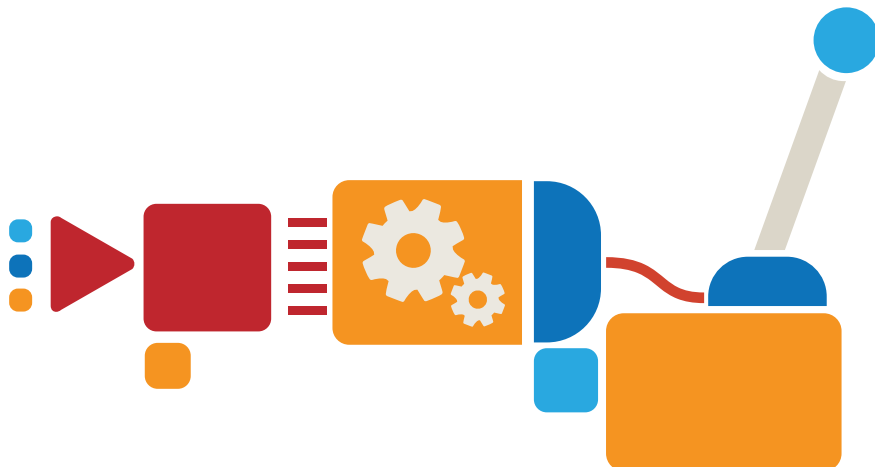
SCRIBBLENAUTS

- Objective: Word writing

- Ages: 7 years and above

- Developer: 5th Cell

- Platforms: iOS 6.0 or later and Android 2.3.3 or later

- www.5thcell.com

DESCRIPTION

Scribblenauts is a series of puzzle games for computers, game consoles, phones, and tablets in which the player solves an increasingly complex set of puzzles by writing words (usually nouns) to create the object or creature represented by the words in the game-world. This is a single-player, paid game app that has online components such as sharing features and leaderboards. This game requires literacy skills. It is presented here as an example of a game that would motivate children to write once they have learned decoding.

GAME DESIGN

Scribblenauts is a visual and interactive puzzle-solving game with progressively more difficult levels. The player controls a customizable avatar that interacts with objects in the game-world. In each level, the player is presented with a scenario. For the player to achieve the scenario's objectives (e.g. rescuing a cat from a tree), he or she must create the tools needed by spelling the tools' names (e.g. ladder, rope). The player then directs the avatar to use the tools to complete the required task.

Scribblenauts has a set of rules and relationships for its puzzles, some of which play out comically in gameplay. A player must guess these relationships between objects and use their knowledge to earn a star, part of the game's scoring system. Some examples of relationships are: 1) zombies chase people, 2) a toaster in water kills a shark, and 3) a black hole sucks in all objects. The game has a large dictionary of words; each word has customized animation. The game requires reading and writing skills and contains mild violence.

LEARNING DESIGN

Scribblenauts' game mechanics can be divided into two parts: 1) the input of objects into the game-world by spelling their names and 2) the interaction of the items in the game-world by the player-controlled avatar. The method whereby learners add objects into the game-world is open-ended—almost anything can be conjured within the game-world if the learner can spell its name. The game mechanics are versatile, allowing the learner to include adjectives (e.g. large, small, friendly) to alter how the object will behave in the game-world. For instance, introducing an angry bear into the game-world may cause the bear to chase the player's avatar. This creates various pathways for the player to achieve the level objectives.

The in-game player avatar is also able to interact with the objects in the game-world. While the interactive activities the avatar can make in the game are limited (e.g. swinging an axe, driving a car), they represent key verbs (or actions) that the learner can do and are therefore as important to the problem-solving process as the previous input step. The game allows learners to use the vocabulary they have learned to solve problems, thereby improving their problem-solving skills. As the game becomes more difficult, learners have fewer ways to tackle their obstacles. This means they must be flexible and try many different words and adjectives to solve the puzzles and complete a level. This allows learners to practice adapting and adjusting to changing conditions and expectations in their learning environment.

Scribblenauts is focused on vocabulary and on understanding relationships between characters and objects. Learners may even find enjoyment in simply writing down words to see if they can stump Scribblenauts. Collaborative gameplay is possible when multiple players discuss the best way to solve a puzzle.

Three of the five learning design approaches for open-ended games discussed in Section 4 can be observed in Scribblenauts. Allowing learners to create unique artifacts with in-game help is a form of *learning by building*. Being able to explore a world with various interactive elements is a form of *learning by exploring.* And the possibility of collaborative play is a form of *learning by collaborating.*

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Replicating Scribblenauts' mechanics exactly would require tremendous time and effort. Game developers could instead adopt similarly open-ended designs where players choose and use objects to solve puzzles but limit the number and variety of objects to a manageable degree in terms of development. If the game is meant for young learners, onscreen directions and other written aspects of the game would have to be converted to verbal or be kept within the target player's vocabulary.

STARFALL'S LEARN TO READ

- Objectives: Letter sounds, phonics, decoding, vocabulary, reading, and math

- Ages: 5 years and below

- Developer: Starfall

- Platforms: iOS 6.0 or later, Android 4.0 or later, and online

- more2.starfall.com

DESCRIPTION

Starfall's Learn to Read is a comprehensive English literacy learning game for phones and tablets in which learners can engage in a series of activities—either playing games or watching animations—that help them learn letter sounds, basic phonics, and word decoding. The game advances to sentence reading and short books in several formats. This free, single-player game app offers additional content via subscription. It has no online component.

GAME DESIGN

The Learn to Read app is a phone and tablet version of the online educational website Starfall. For many years, Starfall.com existed as a free public service to teach children literacy and has been a popular website among early elementary teachers and parents.

The app opens to a main menu (Figure 14, top). When the player taps a letter, a new window opens

to start an activity. In the example shown in Figure 14 (bottom), the player chooses the letter c and hears the word *can.*

The app has the same content as the Learn to Read section of the free website. There are 15 sections presented as mini-books, each focusing on a specific letter or letter group, with videos and activities to enhance literacy learning. The app provides numerous short and simple activities that have been developed over many years. The
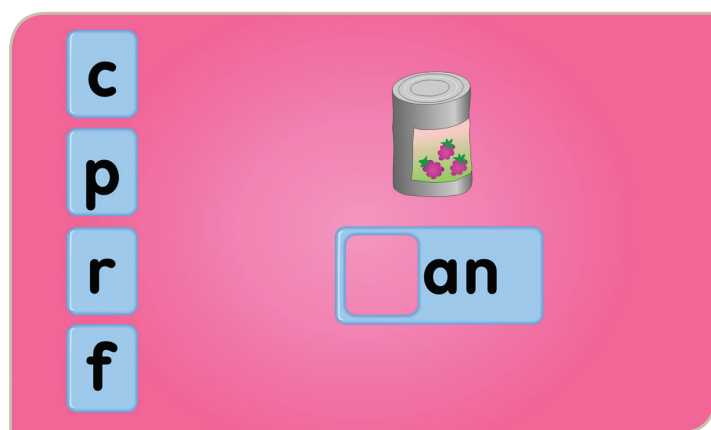
Figure 14. *Starfall's Learn to Read. Used with permission from Starfall.*

activities were originally Flash games that use simple graphic and voice narration to present a lesson series to learners, usually as short movie clips (cartoon and live action). The activities build on one another, starting with learning the alphabet and its associated sounds, followed by reading simple online books, then on to more advanced reading activities.

LEARNING DESIGN

Starfall's Learn to Read introduces basic English and math concepts. The app and its online resources cover all the component skills of reading.

Activities are designed to be short, presenting a letter or letter group each. Most involve drag-and-drop controls, which are intuitive to learners. A variety of methods are used in the activities to reinforce concepts including songs, puzzle games,

spoken words, pictures, and word-sorting. Each section has at least one learning game. The activities and stories often involve highlighted text to enable young learners to read along; the majority of words are voiced by a narrator. Learners can tap on a letter or word to hear it voiced. The modular nature of the activities allows learners to revisit concepts they have come across but might have forgotten.

The math section of Learn to Read constitutes a small portion of the app. Its topics include basic addition and subtraction, money, and time. Although these concepts may seem simplistic, Starfall has managed to transform them into fun storytelling games a learner can go through with ease. For instance, in the money mini-game, learners follow a monkey's journey as it traverses urban areas, collecting pennies along the way by tapping on them. Once the learner has collected sufficient pennies, these can be exchanged for another coin of a higher denomination (e.g. five pennies, worth one cent each, are exchanged for one nickel, which is worth five cents). Another feature is short videos on math concepts. Each video is engaging and most include animation and music.

DESIGN CONSIDERATIONS FOR DEVELOPING COUNTRIES

Overall, Starfall's Learn to Read is a comprehensive app that helps children learn basic reading and math. However, navigating the main menu is a daunting task. Activities are grouped by concept (e.g. short vowels, long vowels, phonics, and chunking). Thumbnails of the activities are used as icons and the connection between the icon and the concept can be confusing, especially since the thumbnail takes up more on-screen space than the description of the concept. The game seems to be designed for a learner to play with an adult guide, which has its own merits, but it could be played by learners on their own once they learn how to use the app.

Designing activities in such a way that they each contain a small "dose" of learning can certainly

help learners with a low attention span. Game developers could also consider incorporating this kind of modularity into their games: since literacy skills cannot be learned in one sitting, allowing children to revisit earlier concepts would be beneficial to their learning.

Learn to Read is a good example of a game that was originally developed for one platform–web (using Flash) and adapted to another (Android and iOS mobile devices). The mobile app uses content previously developed for the original web version, making the adaptation process mostly a matter of packaging a subset of the website content. Developers, especially those who want to target both individual children (who tend to download games to play on mobile devices) and schools (that tend to have desktops or laptops available for use), may want to adopt this approach, i.e. releasing a game on one platform that is suitable for one market first, then adapting it for a secondary market later.

Both the website content and the mobile games are available free of charge with no advertisements or in-app purchases. While the developer is a publicly funded non-profit organization that relies on donations for funding, both the website and the game apps offer a subscription option that unlocks extra premium content (such as animations and mini-game activities). The subscriber section is only meant for adults, who must answer a math question designed to be too difficult for young children to access the section.

From its earliest development stages, the Starfall team included teachers who helped devise the website's curriculum and contributed to the designs of the initial games and books. As the website grew, the developers expanded their offerings to include a full Kindergarten English language literacy learning curriculum. This approach may seem overly ambitious for small development teams. Partnering with schools and other creators or owners of educational content may facilitate this process. High quality open educational resources in English or other major languages may be adapted to other target languages.
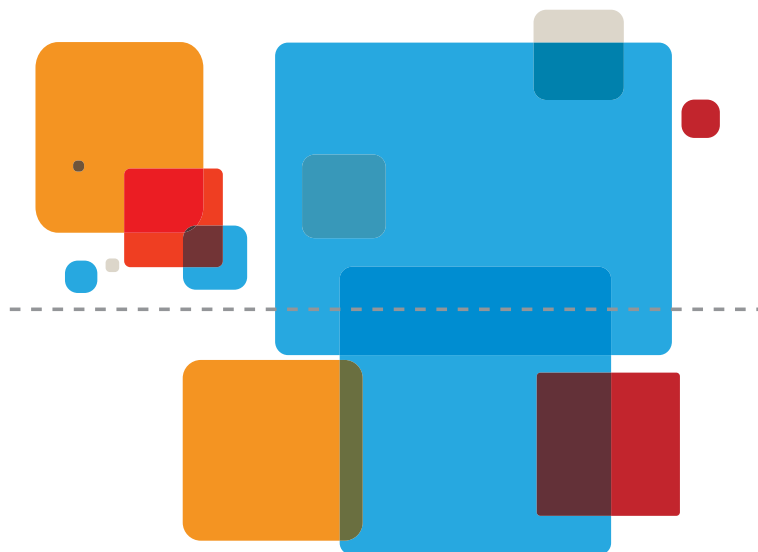
SUGGESTED RESOURCES

Gaming

Zimmerman, E. & Salen, K. (2004). *Rules of play: Game design fundamentals.* Cambridge, MA: MIT Press.

Fullerton, T. (2014). *Game design workshop: A playcentric approach to creating innovative games.* Boca Raton, FL: CRC Press.

Koster, R. (2014). *A theory of fun for game design.* Sebastopal, CA: O'Reilly Media.

Schell, J. (2015). *The art of game design: A book of lenses.* Boca Raton, FL: CRC Press.

Gaming and learning

Gee, J.P. (2003). *What video games have to teach us about learning and literacy.* New York, NY: Palgrave MacMillan.

Lim. K. Y. T., "*The Six Learnings of Second Life: A Framework for Designing Curricular Interventions In-world.*" *Journal of Virtual Worlds Research*, 2(1) pp. 4–11: 2009.

Shaffer, D.W. (2006). *How computer games help children learn.* New York, NY: Palgrave MacMillan.

Squire, K. (2011). *Video games and learning.* New York, NY: Teachers College Press.

Sources of literacy games

All Children Reading: A Grand Challenge for Development https://allchildrenreading.org/

EduApp4Syria https://www.norad.no/eduapp4syria

Global Learning XPrize https://learning.xprize.org/

Learning

Anderson, L.W. & Krathwohl, D.R. (Eds.) (2000). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* Boston, MA: Pearson Education.

Bigge, M.L. & Shermis, S.S. (2003). *Learning theories for teachers.* Boston, MA: Pearson Education.

Harasim, L. (2017). *Learning theory and online technologies.* New York, NY: Routledge.

Schunk, D.H. (2011). *Learning theories: An educational perspective.* Boston, MA: Pearson Education.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wadsworth, B.J. (2003). *Piaget's theory of cognitive and affective development: Foundations of constructivism* (5th ed.). Boston, MA: Pearson Education.

National Center on Universal Design for Learning: http://www.udlcenter.org/aboutudl/whatisudl

Literacy

Adams, M.A. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Vaughn, S. & Linan-Thompson, S. (2004). *Research-based methods of reading instruction: Grades K–3.* Alexandria, VA: Association for Supervision and Curriculum Development.

Comings, J. (2015). An evidence-based model for early-grade reading programmes. *UNESCO Prospects*, *45*, pp. 167–180.

The relationship between literacy and other development outcomes

Kelly, S. & Graham, J. (2017). *The case for investment in early grade reading.* Retrieved from https://www.scribd.com/document/343662491/A-Policy-Report-The-Case-for-Investing-in-Early-Grade-Reading-Interventions.

LeVine, R., et al. (2012). *Literacy and mothering: How women's schooling changes the lives of the world's children.* New York, NY: Oxford University Press.