
Supporting Parent-Child Literacy Interactions with Feature Phones in Côte d'Ivoire

Michael Madaio

Carnegie Mellon University
Pittsburgh, PA, United States
mmadaio@cs.cmu.edu

Amy Ogan

Carnegie Mellon University
Pittsburgh, PA, United States
aao@cs.cmu.edu

Abstract

Low literacy rates in many developing countries present barriers to educational attainment, exacerbating existing socio-economic inequities. Low-cost mobile interventions may present one method for addressing low literacy rates. We propose a design of a mobile literacy support tool for low-cost feature phones that can leverage parental support, despite low adult literacy in the target language. We discuss here a proposed research design and propose a set of research questions we hope to discuss at the symposium.

Author Keywords

Educational Technology; Literacy; Feature phones; Interactive Voice Response; ICTD

ACM Classification Keywords

L.7.0 [Wireless/Pervasive Computing]: Miscellaneous; L.2.0 [Adaption/Adaptive eLearning]: Miscellaneous; L.6.2 [Collaboration]: Miscellaneous

Introduction

Literacy is essential to educational attainment and full participation in modern society. For a variety of reasons, in Côte d'Ivoire, like many Sub-Saharan African countries, adult literacy rates lag far beyond the global average [14]. Without a foundation of literacy taught at the early grades, children struggle with learning more advanced material.

However, the variety of stages that Ivorian children are at in their literacy development presents a challenge to intervening in a classroom, where students may differ greatly within the classroom in literacy level. Therefore, an adaptive technological solution that can tailor the content to the students' level of ability may be able to have a positive impact on early childhood literacy.

Due to the high (and increasing) levels of mobile phone adoption in Côte d'Ivoire [13], even among rural areas of the country, we propose a mobile delivery of an adaptive French literacy curriculum designed to function on 2G networks and low-cost feature phones, using interactive voice response (IVR) coupled with SMS for content delivery and assessment. We seek to extend existing work on mobile literacy tools [17, 10] through adaptation to low-cost feature phones able to be used in low-resource areas.

Extensive prior literature has demonstrated the benefits of parental involvement in early child literacy, from providing a "secure base" for learning via socio-emotional supports [11] to engaging children in practice with recognizing syllables and their letter correspondences [19]. However, if parents are not themselves literate, which is likely in Côte d'Ivoire given the low overall literacy rates, parents may not be able to support their children's literacy development without being supported themselves. We thus propose a method for supporting parents (who themselves may not be literate in French) in supporting their children's progression through the literacy curriculum, in order to improve early childhood French literacy outcomes in Côte d'Ivoire.

Our proposed work attempts to cross geopolitical borders, through our collaboration between researchers from Carnegie Mellon University, University of Delaware, and researchers in Abidjan, Côte d'Ivoire. Our proposed work also attempts to cross generational borders by designing a tool to sup-

port literacy-building interactions between children and their parents. We believe we would benefit from the HCI Across Borders symposium by getting feedback from researchers working on similar technical and theoretical challenges, in similar contexts.

Ivorian Context

Literacy Context

Before discussing the theoretical background for our proposed work, it is worth saying a bit about the literacy context of the site of that proposed work. In Côte d'Ivoire, the literacy rate was 53% for males and 33% for females in 2016, well below the global average literacy rate of 90% and 82%. Indicators of this can be seen in early childhood as well. In recent work from our co-PI Jasińska, basic literacy components were not evident even among 5th grade children (mean age of 11), with 20% of 5th graders sampled unable to read a single age-appropriate word, and the remaining 80% correctly reading only 30% of words from a set of 50 age-appropriate words. These results suggest that earlier precursors to literacy, such as phonemic awareness and letter-sound knowledge are not present at earlier stages of development. Jasińska then sampled children from earlier grades (1st, 3rd, as well as 5th), finding that 30% of those sampled could not identify *any* French letters, with 20% having limited ability to even identify the phonemes aurally.

Language Context

As this proposed work intends to improve childhood literacy, it is also important to understand the linguistic diversity of Côte d'Ivoire. While French is the official language and the one in which business is conducted, only 6.9 million of the 23.7 million Ivorians speak French, and of French-speakers, 6.8 million speak it as their second language (as of the 2013 census) [22]. There are over 60 languages ac-

tively spoken in Côte d'Ivoire, which makes it crucial that a literacy intervention support bilingual instruction, building off of speakers' phonemic knowledge in their first language. Prior work from our co-PI indicates that the predictive relationship between phonological awareness and literacy is stronger for bilingual children who learn both languages early, compared to their monolingual peers [7]. In our proposed work, we intend to explore how second language literacy instruction can build off of speakers' knowledge of phonemes in their first language (here, Attié).

Mobile Penetration

The high variance in children's literacy and the large variety of linguistic diversity suggests that a technological solution that can be adapted to each child's literacy level would be most effective, as suggested by prior work in Uganda [20]. Mobile penetration is relatively high in Côte d'Ivoire, with 53% of adults having access to some type of mobile device. Of those with a mobile device, however, only 25% have smartphones, and 30% have an internet connection, as of 2015 [13]. Therefore, we propose a mobile literacy intervention that can function on low-cost, non-smart feature phones, and need not rely on an internet connection.

Theoretical Background

Phonological Awareness and Literacy

Before words can be learned and sentences decoded into meaning, early readers must first be able to map sounds to letters and decompose words into their fundamental visual and auditory units [6]. The awareness of distinguishable fundamental sounds of language, or, "phonemes", is a necessary precursor to mapping those phonemes to letters [12]. This phonemic awareness can be developed auditorily first, before mappings are made to written characters [6], through such activities as segmenting words into their constituent phonemes by clapping or counting each phoneme

[6], telling stories, rhymes, or songs with repeated rhyming phonemes [9], or other methods. After phonemic awareness is established, mappings between phonemes and their corresponding characters can be developed, either through simply displaying the character and hearing the corresponding phoneme [9], or through displaying objects or images that start with the phoneme being taught, accompanied by that letter [6], among many other methods.

Mobile Literacy Interventions in Developing Contexts

Some prior work has developed mobile literacy tools to support these methods for early literacy development, specifically for phonology, and some focusing on developing contexts in particular. Ojanen et al. developed a mobile tool for 3G-enabled smartphones that follows the phonological process outlined above, guiding learners from single phoneme recognition, to single letter-sound mappings, to multi-letter syllables and more complex mono or polysyllabic words [17]. Their curriculum is the most directly relevant for our proposed work, but because their approach relies heavily on high-bandwidth internet-enabled devices, high-quality graphic displays, and touchscreen interaction, with on-device processing requirements, their approach is not feasible for the rural Ivorian context, with low-bandwidth 2G internet in the majority of the country and smartphone adoption lagging significantly behind the 53% of the population that owns a phone at all [13].

Others, such as Kumar et al. (2012), have developed voice-controlled apps for literacy development in developing contexts in rural India. They used on-device voice recognition software trained for this particular context, allowing for less reliance on mobile networks. They still used a visual display and touchscreen on the device [10], which is likely not possible on many low-cost feature phones. We build off of their work by proposing an IVR- and SMS-based approach

to allow for greater access on low-cost devices.

Parental support for literacy development

While such technological interventions may be effective, prior work has argued that literacy is a socially-constructed skill [1], and many others have highlighted the crucial role of parents and caregivers in fostering early childhood literacy (see [11] for a review). Sénéchal found, in a systematic meta-review, that parental "involvement" (broadly speaking) has a strong positive effect ($d=0.36$) on early childhood literacy outcomes, though such effects have large variance, perhaps due to the nature of the support parents provide, or their own literacy skills as well [21].

To support early childhood literacy development, prior work has identified productive sets of supportive behaviors in which parents engage. These range from direct instruction of letters or other content-based support, to socio-emotional supports to provide encouragement, also known as a "secure base" from which children will be more willing to take risks in learning difficult phoneme-letter mappings [11, 19]. If parents choose to (or are able to) provide direct transmission of phonemic knowledge, prior work has shown that beneficial activities include singing songs to reinforce letter-sound mappings, telling stories or rhymes to children with similar initial or ending phonemes, or asking children to provide lists of objects in their environment that begin with the same phoneme [6, 3]. However, all of these activities presume a certain amount of time, knowledge, and self-efficacy from the parents to be able to engage in these sorts of direct instruction. In low-literacy contexts such as Côte d'Ivoire, this may not be possible without support.

Some prior work has developed interventions to help scaffold parental support for early literacy. In San Francisco, York and Loeb developed "READY4K", a system that sent direct SMS on a weekly basis to parents, suggesting spe-

cific literacy-building behaviors they could engage in with their kids [23]. In Uganda, the MobiLiteracy program provided instructional materials to parents in the form of downloadable audio instructions [20]. While they found that these downloadable instructions were more effective than a paper-based curriculum, they were not always accessible due to connectivity issues, and navigating their file directory to find the relevant audio file required digital literacy skills that not all of their participants possessed [20]. They also pointed out the impact that parental self-efficacy in their own literacy or instructional abilities has on their likelihood to engage in productive literacy-building activities with their children, which we will need to address in our work.

Proposed Work

Literacy support tool

Based on the crucial role that phonemic awareness plays in early literacy, and the evidence from prior work that parental support can better scaffold early literacy development, we propose a mobile literacy support intervention that can deliver instruction and assessment to children developing phonological awareness, as well as facilitate parental support as well. We propose a literacy curriculum that builds off of existing first-language (Attiié) phonemic awareness to develop French phonemic awareness, letter-sound mappings, and ultimately monosyllabic word reading in French. Given the state of mobile penetration in Côte d'Ivoire, our proposed intervention will rely on combinations of interactive voice response (IVR) and short messages (SMS) to deliver the instructional content and assess learners. We propose an adaptive curriculum such that students will be provided with the lessons that correspond to their current level of literacy, from auditory phonemic awareness (i.e. being able to recognize and distinguish spoken syllables), single letter-sound mappings, more complex syllable-letter combinations, to, ultimately, monosyllabic words.

Interactive Voice Response

We propose to use an interactive voice response (IVR) system to deliver content and assess learners, particularly early in the curriculum, when learners may lack any letter-sound knowledge. Thus, we propose initial auditory-based lessons such as selection of a rhyming words or syllables, perhaps using touchtone (which would require sufficient numeracy to recognize the number on the keypad corresponding to the correct response) or voice response (which requires sufficient computational capability to correctly assess the speaker's phonemes, challenges for which are discussed in [10]). To inform the IVR portion of this work, we look to prior literature in HCI and ICTD which has previously used IVR in low-resource, developing contexts, such as [15, 5, 8, 18], among many others.

We additionally propose a parent or caregiver-facing support tool designed to help scaffold their support for their children's literacy development. As many parents of our study participants may not themselves be literate in French, or even French speakers at all, we want to explore how a similar type of low-cost, IVR and SMS-based mobile intervention can scaffold parents' support of their children's literacy. We take as inspiration the work of York and Loeb [23] in sending short messages to parents in San Francisco about how to engage their children in literacy-building behaviors, as well as the MobiLiteracy project in Uganda [20], which provided a more structured curriculum for parents to engage their children in. To support all parents, regardless of their literacy level, we may focus more on scaffolds for parents to provide socio-emotional, motivational support, in line with the "secure base" theory of literacy development [11, 19], or may provide more auditory activities, perhaps involving phonemic awareness and segmentation in Attié first, before moving to French.

Research Questions

1. How can the design of an adaptive mobile intervention using IVR and SMS on feature phones support literacy in an Ivorian context?
2. How can the design of mobile tools scaffold parental support for their children's literacy, given parental language and literacy levels in the Ivorian context?
3. How do individual factors such as learners' and parents' self-efficacy affect their participation and learning gains with such an intervention?

Proposed study

To evaluate those research questions, we intend to conduct two studies. Prior to the studies, we intend to iteratively design and develop a set of low-fidelity prototypes to evaluate with a small set of Ivorian participants (both children and their parents or caregivers). Through a qualitative design-based research approach [16], we will first interview our participants about their beliefs about language, literacy, and the role of parents in their children's education (following [4]). We will supplement those interviews with questions for parents about a set of storyboards we have drawn to explore our interaction space, through a "speed dating" approach to user needs validation [2]. Participants in this preliminary data collection will also be presented with a minimally functional prototype of our IVR system, and we will prompt users to call in and complete a lesson, observing breakdowns and pain points in this process, and asking them questions about the experience.

We will then use the qualitative insights gleaned from this process to inform the redesign of the system. Study 1 will involve a small-scale pilot of a working system, and we will use literacy benchmarks to assess students' progress. Then, in study 2, following iterative cycles of redesign, we

propose a larger, randomized controlled trial over 12 weeks, with one condition receiving the mobile intervention for children alone, and another group receiving the intervention for children as well as the parental support tool. We intend to supplement the assessment and system log data with interviews and surveys with the participants, to better understand their perception of the intervention and add to our understanding of how socio-emotional motivational supports from adult caregivers can support early childhood literacy development in this context.

Attending HCI Across Borders

As this is work in progress, we hope to use the HCIxB symposium as an opportunity to connect with interdisciplinary researchers working across HCI, ICTD, and related fields. We invite feedback and discussion about our proposed system, research questions, study design, or other aspects of this work, particularly as it relates to the crossing of borders, both disciplinary, generational, and geopolitical. We welcome rich discussions around the nature of bilingual education, the challenges of designing, prototyping, and deploying IVR and SMS interventions on feature phones, and the social nature of education, particularly as it plays out in international, multicultural contexts.

Michael is a 3rd year Ph.D. student in the Human-Computer Interaction Institute at Carnegie Mellon University. His research focuses on how to design educational technologies that can shed light on and support the benefits of social relationships on learning. Because the nature of social interactions and their role in learning is so dependent on cultural norms, Michael is interested in how educational technologies intended for international contexts can be designed in ways that are appropriate and authentic for those contexts of use, in collaboration with the people for whom those technologies are intended. By attending HCIxB, he hopes

to broaden his perspective on how HCI methods can be integrated along with ICTD methods to most effectively design educational technologies for international contexts.

Acknowledgments

We would like to thank the Jacobs Foundation for their generous funding of this project, as well as our partners at University of Delaware, Eneza Education, and the TRECC program. We would also like to thank our team members at CMU, our participants, and the members of the communities in which we will be working.

REFERENCES

1. Jenny Cook-Gumperz. 2006. *The social construction of literacy*. Vol. 25. Cambridge University Press.
2. Scott Davidoff, Min Kyung Lee, Anind K Dey, and John Zimmerman. 2007. Rapidly exploring application design through speed dating. In *International Conference on Ubiquitous Computing*. Springer, 429–446.
3. Susan E Dieterich, Mike A Assel, Paul Swank, Karen E Smith, and Susan H Landry. 2006. The impact of early maternal verbal scaffolding and child language abilities on later decoding and reading comprehension skills. *Journal of School Psychology* 43, 6 (2006), 481–494.
4. Betsy DiSalvo, Parisa Khanipour Roshan, and Briana Morrison. 2016. Information seeking practices of parents: Exploring skills, face threats and social networks. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 623–634.
5. Krittika D'Silva, Meghana Marathe, Aditya Vashistha, Gaetano Borriello, and William Thies. 2014. A Mobile Application for Interactive Voice Forums: Design and

- Pilot Deployment in Rural India. In *Proceedings of the Fifth ACM Symposium on Computing for Development*. ACM, 121–122.
6. Linnea C Ehri and Theresa Roberts. 2006. The roots of learning to read and write: Acquisition of letters and phonemic awareness. *Handbook of early literacy research 2* (2006), 113–131.
 7. Kaja K Jasińska and Laura-Ann Petitto. 2017. Age of Bilingual Exposure Is Related to the Contribution of Phonological and Semantic Knowledge to Successful Reading Development. *Child development* (2017).
 8. Abdullah Kharal, Mustafa Naseem, Sacha St-Onge Ahmad, and Agha Ali Raza. 2017. Sustainable IVR-Based Social Media for the Developing World. (2017).
 9. Paul Kim, Teresita Hagashi, Laura Carillo, Irina Gonzales, Tamas Makany, Bommi Lee, and Alberto Garate. 2011. Socioeconomic strata, mobile technology, and education: A comparative analysis. *Educational Technology Research and Development* 59, 4 (2011), 465–486.
 10. Anuj Kumar, Pooja Reddy, Anuj Tewari, Rajat Agrawal, and Matthew Kam. 2012. Improving literacy in developing countries using speech recognition-supported games on mobile devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 1149–1158.
 11. Susan H Landry and Karen E Smith. 2007. The Influence of Parenting on Emerging Literacy Skills. *Handbook of early literacy research 2* (2007), 135.
 12. Christopher J Lonigan. 2006. Conceptualizing phonological processing skills in prereaders. *Handbook of early literacy research 2* (2006), 77–89.
 13. Barbara Arese Lucini. 2016. Connected Society Consumer barriers to mobile internet adoption in Africa. (2016).
 14. Barbara Arese Lucini and Kalvin Bahia. 2017. Country overview: Côte d'Ivoire Driving mobile-enabled digital transformation. (2017).
 15. Meghana Marathe, Jacki O'Neill, Paromita Pain, and William Thies. 2015. Revisiting CGNet Swara and its impact in rural India. In *Proceedings of the Seventh International Conference on Information and Communication Technologies and Development*. ACM, 21.
 16. Susan McKenney and Thomas C Reeves. 2014. Educational design research. In *Handbook of research on educational communications and technology*. Springer, 131–140.
 17. Emma Ojanen, Miia Ronimus, Timo Ahonen, Tamara Chansa-Kabali, Pamela February, Jacqueline Jere-Folotiya, Karri-Pekka Kauppinen, Ritva Ketonen, Damaris Ngorosho, Mikko Pitkänen, and others. 2015. GraphoGame—a catalyst for multi-level promotion of literacy in diverse contexts. *Frontiers in psychology* 6 (2015), 671.
 18. Neil Patel, Deepti Chittamuru, Anupam Jain, Paresh Dave, and Tapan S Parikh. 2010. Avaaj otalo: a field study of an interactive voice forum for small farmers in rural india. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 733–742.
 19. Robert C Pianta. 2006. Teacher-child relationships and early literacy. *Handbook of early literacy research 2* (2006), 149–162.

20. Sarah Pouezevara and Simon King. 2014. MobiLiteracy-Uganda Program Phase 1: Endline Report. (2014).
21. Monique Sénéchal. 2015. Young Children's Home Literacy. *The Oxford handbook of reading* (2015), 397.
22. Gary F. Simons and Charles D. Fennig. 2017. Ethnologue: Languages of the World. (2017).
23. Benjamin N York, Susanna Loeb, and Christopher Doss. 2018. One step at a time: The effects of an early literacy text messaging program for parents of preschoolers. *Journal of Human Resources* (2018), 0517–8756R.