Exploring the Effectiveness of Tablet-Based Early Literacy Interventions in Rural Tanzania

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Abstract
Smartphone- and tablet-based learning systems are often posited as solutions for closing early literacy gaps between developing and advanced economies due to their increasing accessibility and affordability. These systems are often developed based on Western contexts and without considering the cultural and social needs of the target population. Some studies report positive outcomes from such systems that are attributed to children's innate curiosity and peer learning. However, a lack of process data leaves few contextualized insights on how students use these systems. We describe our deployment of a tablet-based educational intervention in rural Tanzania, and explore several educational and social aspects including peer vs authority interactions, and digital literacy.

Author Keywords
Early Literacy Interventions; Education Technology Across Cultures; Tablet-Based Learning;

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

Introduction and Background
The educational disparities between urban and rural areas of Sub-Saharan Africa are very well documented

[6]. Reasons for these educational disparities include the lack of access to skilled teachers in rural areas [4]. The opportunity costs for educating children in rural communities are also higher - families, especially those with farms, often depend on their labor for survival. Additionally, parents may not value formal education, whether due to their own limited experiences in school, or even to formal educational curricula that they cannot identify with culturally [2]. Finally, children in rural areas have less access to school resources like textbooks; in Tanzania, the ratio of children to textbooks has been reported as 8:1 [5].

Due to the increasing affordability of mobile technologies, and the difficulties associated with hiring qualified teachers for rural areas, organizations interested in reducing educational disparities have provided these communities with mobile phones, tablets, and portable computers loaded with educational software. This model of student-driven, teacher-independent learning bypasses the need for traditional schooling infrastructure, and allows students to learn at their own pace. Some of these technological initiatives have successfully demonstrated modest learning gains in these rural communities [1]. Popular justifications for these successes often cite children's innate curiosity and exploration to teach themselves the content, as well as the involvement of their peers for collaborative learning, while discounting the influence of adults in the learning process [3].

However, the learning applications provided to these communities are often developed without consideration for their cultural and social contexts, digital literacy, or their available infrastructure e.g. access to electricity and internet connectivity, which severely impedes their success rates. Little data is collected to describe whether children's curiosity and social environment contribute to their learning, or examine the roles that other factors play such as teachers and other adults in the environment. In fact, previous methodologies sometimes dictate only analyzing system log data, providing no insight into the processes underlying learning, or the types of support that a social learning environment provides. In our work, we take an Android-based early literacy learning system to a rural field site with little prior technology exposure. We collect rich data from 30 sessions across several weeks to explore how learning occurred in this environment. These scenarios include observing how students in grades K-2 learned with technology in the presence or absence of teachers, family members, and other adults; in the school or home environment; and in peer groups or working alone on one tablet. The goals of this research study are to:

- Provide rich insights on the types of support that peers and adults provide for children learning with tablets in rural, low digital literacy contexts in Tanzania;
- Demonstrate the benefits of social learning in the target population, as well its drawbacks;
- Suggest mechanisms to incorporate our insights in the design of learning applications targeted to similar demographics.

Methodology

This study is part of a larger effort to design Android tablet-based early literacy applications targeted at children in Sub-Saharan Africa who speak English and/or Swahili as a national language. At the time of the study, the application focused on the following learning areas, deployed in Swahili: alphabets (letter and phonemic sound identification, writing), math (number identification, number writing, addition/subtraction), shape identification, and reading[1]. We were interested in observing the children in different social settings across age, authority, gender, shared tablet, and knowledge

[1] From African Storybook Project Database: africanstorybook.org

and technology expertise. We conducted this study in partnership with a school located in a rural village in a Northwestern region of Tanzania. Swahili was the common language in the village. The village itself was quite limited in physical and technical infrastructure. At the time of data collection, there was limited electricity in the village, yet a majority of the villagers had feature phones whose internet service had a maximum of Edge data speeds. The city center had shops with places to charge phones as well as limited computing and printing services.

We conducted 30 study sessions over two weeks, each lasting about 1.5 hours, with 48 unique children - 26 girls and 22 boys in grades K-2 but ages 4 – 11. All but 8 children were enrolled in the school; the rest were their siblings. Of the 30 sessions, 22 sessions were conducted in the school with enrolled children, and 8 sessions were conducted in the home with other family members present. All sessions were video recorded and accompanied by field notes from two team members, synchronized post-hoc. Our 30 sessions were comprised of the following scenarios: 9 sessions with the teachers providing scaffolding, 14 sessions where the children shared tablets, 5 sessions with boys and girls in the same session, and 14 sessions where children who had participated in a prior session were paired up with those who had not. Following the conclusion of all study sessions, three members of the team reviewed all field notes and discussed the themes that emerged relating to collaboration and social interactions. We uncovered seven different themes: gesture support, application support, domain knowledge support, activity switching support, permission for engagement, role modeling, and collaborative problem solving. We triangulated our observations related to these themes with logs captured by the two researchers in field, debrief recordings, interviews, and photographs to ensure that all evidence was mutually supportive. All team members reviewed the findings for all 30 sessions, discussed all areas of disagreement, and re-categorized findings as agreed upon by the entire team. A native Swahili speaker from Tanzania engaged with the research team to contextualize and translate social interactions that occurred in Swahili.

Results and Discussion

We summarize our findings in four categories: gesture support; application and knowledge support; activity switching; and role modeling and collaborative problem solving.

Gesture Support

We observed students, parents or teachers explicitly teaching someone else how to perform gestures in 13 sessions. Adults were in the room for a majority of those sessions Peers generally demonstrated correct gestures by performing them on the tablet, while adults instead modelled the behavior on the table or physically held the children's fingers to teach correct gestures. The children's (lack of) digital literacy was a serious barrier to engaging with the applications. Several children in our study could add and subtract and read fluently, but could not navigate basic counting or literacy applications. While the tap gesture may seem intuitive, most children in this study did not know how to do it until they were taught. They either pressed the screen too hard or too long, or rubbed the screen with circular motions, as if they were wiping something. After the tap was correctly demonstrated children still tried variations on the gesture, even using other body parts (e.g. lips, fists) to select items (see Fig 1).

Application and Knowledge Support

We found evidence of application support in 18 sessions, across all experiment scenarios. Children always deferred to adults in the room for support even if a peer was navigating correctly. Peers provided this support by navigating the activities while other students watched, while adults supported by explaining the function of each of the buttons/icons in the activity, and their purpose. It generally arose from one child being stuck and asking




Figure 1: Digital Literacy Issues (Top 2) and Gesture Support (Bottom 2)

for help, pulling someone to their device, or looking at someone and then back to their tablet to indicate that they need help. For the level of activities in our system, simply navigating the activity seemed to be sufficient help.

Knowledge support appeared in 7 sessions; however, unlike studies such as (Mitra et al., 2005), we did not find evidence that children assisted each other with mastering the fundamentals of unknown domain knowledge. In all cases, it was provided by teachers and family members - not peers - in part because the children did not understand the fundamental concepts the activity was trying to teach. This was mostly evident in the addition/subtraction and writing activities. One kindergarten student in a home session knew how to count her numbers in English and Swahili, but did not know her shapes in either language. To help, her father told her to listen to the prompts carefully – in Swahili, the shape names include the number of sides e.g. 'pembe*tano*' = pentagon because *tano* = 5. She followed his instruction and was able to transfer that knowledge to identify other shapes.

Activity Switching

This was the most commonly observed type of support, occurring in 26 sessions across all experiment scenarios. In peer interactions, this support was initiated by the student who needed help – they were either tired of playing the same activity multiple times, had mastered the activity, or wanted to play the same games as their friends. To provide this support, peers reached out to a friend's tablet and selected a new game for them without saying why. In sessions with adults present, this support was initiated by the adult in the room. The adult intervened when the children stayed in the same activity for too long, or he felt they had mastered the current activity, and needed to practice something else in the application. Considering the difficulty that some children faced with engaging with their first activity, it is no surprise that they were not eager to switch to other games and repeat the same struggle. In two sessions, we observed students switching activities by swapping tablets with one another, especially if the person next to them was playing a game that seemed more interesting.

Role Modeling and Collaborative Problem Solving

Role modeling behaviors were present in 18 sessions across all the experiment conditions. In all observed cases, children learned how to engage with the activity by watching another child, particularly in the areas of gestures and game mechanics. Children were not just watching aimlessly, however; we observed that children were able to play by themselves after watching a peer play for only a few minutes – even if that peer did not specifically demonstrate the exact activity the child was working on. Although role modeling behaviors proved to be extremely beneficial, they is only effective when the right behaviors are illustrated (which happened rarely for children who had no prior experience).

Collaborative problem solving was evident in almost every session (25 sessions). This typically happened when children could not solve a problem on their own and worked together to figure it out. It often involved children abandoning their own tablet, and all working on a single tablet, or individually navigating to the same game on multiple tablets and using different strategies to overcome the difficulty. In sessions with adults present, the children often waited until adults left the room before they collaborated. It usually manifested as shared responsibility, with one child performing the gesture on the tablet, and the other saying the result aloud, or multiple children touching different parts of the screen to try different gestures. In one example, two boys were writing 'A', but took too long, so the game timed out after they wrote the first stroke. As soon as the teacher left the room, the children began collaborating, trying different strategies on their individual tablets until one boy figured it out. He then showed the other boy how to write 'B'. After this, both

boys played the letter writing game without issues. However, these collaborations were not always helpful; the children (boys especially) sometimes had different goals in the same game and started fighting to take primary control of the tablet. This caused multiple finger input and therefore recognition issues.

Conclusion and Future Work

Our results highlight the possible kinds of struggle that children in rural, and low digital literacy communities may encounter when trying to learn with tablet devices. We also highlight the differences between the support roles that peers play compared to knowledgeable adults. While learning may occur if children are left unassisted with learning technologies similar to [1,3], our research uncovers several factors that - when properly accounted for - reduce the barriers of engaging with technology, thereby increasing student learning and the and contributes to the body of knowledge on how we design educational interventions for such communities.

Future Work

Our current research studies investigate the effectiveness of different interventions to overcome digital literacy barriers, as well as culturally specific ways of designing instruction and games targeted at this demographic. We have gathered data on peer learning and support, collaborative learning within families, have implemented interventions to overcome digital literacy, and have observed classroom interactions in private and public school settings. We look forward to discussing our research and obtaining feedback about our work from the HCIxB community.

This work was supported in part by generous funding from the Jacobs Foundation

About Judith Uchidiuno

I am currently a PhD student studying HumanComputer Interaction at Carnegie Mellon University. I am advised by Amy Ogan, and Ken Koedinger. I am extremely passionate about under-represented communities, and how accessible technologies can be used to improve the quality of formal and informal education they receive especially in the areas of Science, Technology, Engineering, Mathematics (STEM), and basic literacy. My current research is focused on how to design culturally appropriate learning technologies among children in Sub-Saharan Africa.

References

1. Cynthia Breazeal, Robin Morris, Stephanie Gottwald, Tinsley Galyean, and Maryanne Wolf. 2016. Mobile devices for early literacy intervention and research with global reach. *Proceedings of the Third (2016) ACM Conference on Learning@ Scale*, ACM, 11–20.
2. Marlaine E. Lockheed and Adriaan M. Verspoor. 1991. *Improving primary education in developing countries.* Oxford University Press for World Bank.
3. Sugata Mitra, Ritu Dangwal, Shiffon Chatterjee, Swati Jha, Ravinder S. Bisht, and Preeti Kapur. 2005. Acquisition of computing literacy on shared public computers: Children and the" hole in the wall". *Australasian Journal of Educational Technology* 21, 3.
4. Aidan Mulkeen. 2005. *Teachers for rural schools: A challenge for Africa*. Africa region World Bank. Washington, DC: World Bank.
5. Tony Read. 2015. *Where have all the textbooks gone?: Toward sustainable provision of teachingand learning materials in Sub-Saharan Africa*. World Bank Publications.
6. Yanhong Zhang. 2006. Urban-rural literacy gaps in Sub-Saharan Africa: The roles of socioeconomic status and school quality. *Comparative Education Review* 50, 4: 581–602.