New Metaphors from Old Practices—Mobile Learning to Revitalize Education in Developing Regions of the World

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Abstract—By drawing on practices and metaphors familiar to children in the Indian school environment, we aim to develop mobile learning solutions that are grounded on the existing educational practices but have the potential of revitalizing the approach to learning technologies in a developing world context such as India. This paper outlines key findings of our user-centric research to the Indian educational setting, to come to conclusions about how we see mobile learning solutions playing a role in developing world countries such as India, where the focus is still on literacy and not learning. The study is multidimensional because it is aimed to provide inspiration for an empirically justified mobile learning product concept. Field observations and interviews revealed challenges associated with the current educational context in India. The school visits also led to identification of a design metaphor, namely the “Slate,” that is believed to provide the research team with an inspirational approach for the design of the eventual concept. A creative workshop was arranged with children, the purpose of which was to come up with design drivers for mobile learning solutions.

Index Terms—Mobile learning, ICT4D, user-centric design.

1 INTRODUCTION

MOBILE phone penetration is increasing rapidly in India as well as other developing countries. In India alone, the operators registered 15 million new customers in the month of January 2009, with the total number of wireless subscriptions being at 360 million [1]. As opposed to mobile phone uptake, the growth in the use of Internet has been stagnant. According to a recent estimate, India had 45.3 million active fixed Internet users in September 2008, of which 42 million were from the urban community [2]. The large discrepancy in the use of PCs versus mobile phones indicates that an increasing proportion of individuals in India are leapfrogging directly to the mobile age, without prior familiarity in computer use. Moreover, while uptake of the Personal Computer (PC) has been modest, mobile telephony has become a natural part of daily life in India.

The fact that the mobile phone constitutes the sole or main access to ICT for a significant proportion of the Indian population is likely to play a role also in the evolution of educational technology for this country. According to a recent UNESCO report [3], more than one-half of all primary school children in India were in village schools that did not have electricity, sufficient writing and sitting places, science labs, TV sets, radio, tape recorders, computers, etc. While the PC is lacking from the schools, there is a simultaneous trend for mobile phones becoming adopted by the masses. It is, therefore, possible that mobile-based-learning solutions will one day become widely adopted in India, provided that they are affordable and designed based on understanding of the context.

The promises of mobile learning are also apparent in the developed West. However, the situation differs from the developing regions in that the introduction of mobility to pedagogies in the West is an evolutionary rather than a revolutionary step. Technology in India has more of a leapfrogging nature, meaning that they have not seen the gradual progression of people adapting to desktop and personal computers and the Internet. Instead there have been more people interacting directly with mobile technologies before experiencing any other computing technologies. The learning communities in India are thus likely to differ from their Western counterparts [16] in several respects, along dimensions such as technological savviness, familiarity with services and applications as well as basic enablers such as literacy and learning motivation. A key issue to be kept in mind is also affordability of the learning solutions.

This paper presents initial work that has been done in the domain of mobile learning solutions for economically challenged Indian school children. The most relevant prior examples from this field include One Laptop Per Child (OLPC) [6] and Simputer [7]. Having its origins in India, especially the latter is important when it comes to addressing educational technology opportunities in the Indian context. Bouvin et al. [4], for instance, describe the shift in thinking in the Danish pedagogical agenda by stating that it is becoming didactically desirable as well as technically possible to move learning outside of the classroom and take advantage of the rich sources of information available beyond books and computer screens. Benefits of m-learning solutions like games and other educational software have also been investigated in the Indian context [19] as well as other developing regions like Africa [17]. In comparison to these two projects, we use an alternative approach to designing affordable mobile learning solutions. Instead of an a priori stipulation of the technological composition, form factor and interactions with the technology, we turn to the process of user-centric product concept design [12] to guide the design process.

The aim of the present paper is to provide an overview of the initial stages of the concept design process that has so far consisted of field visits to Indian schools as well as an open-ended exploratory workshop in Bangalore. While the research has only covered India, we hope that the design framework will eventually be general enough so as to lead to a mobile learning solution that is applicable across the developing regions of the world. It should also be noted that this paper will not proceed to the level of a concrete product concept. Rather, our aim is to describe the early stages of the process, during which ingredients for an empirically grounded mobile learning solution are expected to emerge.

2 METHODS

2.1 Field Visits to Indian Schools—Articulating the Context of Design

In the first stage of the research, we conducted Contextual Enquiry [8], a method that is often used as part of the user-centric design process. Observations of educational practices were made in six government-run schools in low income urban and rural areas in South India. During these visits, we also ran a series of expert interviews with school teachers and individuals from nongovernmental organizations (NGOs) concerning pedagogies used and challenges faced in both formal and informal learning environments in India. In all, we conducted five individual expert interviews, and two group sessions with school teachers with five participants each.

The aim of the field visits as well as the expert interviews was to understand the background against which any technological intervention should be designed. There is a host of research questions that we thought to be of relevance here. What are the challenges associated with the current learning practices and furthermore, what is currently being done to revitalize the educational practices? Importantly, what are the design implications concerning mobile technology in this context?

2.2 Exploratory Workshop—Deriving Design Drivers

While the aim of the first stage was to understand the educational context in India, the second stage of the research aimed to engage school children so as to derive design drivers for the eventual
product concept. During this stage, we ran an open-ended, exploratory workshop that imposed the role of design partners [11] on the children. The workshop was conducted in a school for underprivileged students from Bangalore. The school was run by an NGO which follows an alternative method of learning, i.e., education with a focus on the environment, peer learning, and engagement with the neighborhood and community. Such a setup was preferred because the research team was interested in being able to work with children who had some prior experience of PC-based-learning solutions and would hence be in a better position than naive participants to reflect on the topic of mobile learning.

The educational software that these children were previously familiar with was Scratch [5], a graphical programming environment designed for children. In addition to creating simple animations with preprogrammed blocks (Fig. 1), Scratch also offers the option of using basic environmental sensors as input for the “projects” (programs created by children), such as illumination, sound volume, and resistance levels.

In order to conceptually align PC and mobile-based-learning solutions, and thereby facilitate full understanding of the potential of mobile learning among participants, we ported Scratch software to a mobile device, namely Nokia N810 Internet Tablet (Fig. 2). Although technical constraints prevented the porting of all features of Scratch on to the N810 platform, the prototype was nevertheless functional, enabling the children to use the application on N810.

A group of seven children were selected on the basis of their degrees of familiarity with the PC as well as using Scratch—while some were fluent, most were beginners. This was so that they could talk about their comparative experiences with using Scratch—from PC to mobile—and they would not have to overcome the learning curve of the software itself while simultaneously exploring the quality of mobility. The participants were aged 8-14, with two girls and five boys. The session had two parts. The first part started with the participants recounting their experiences using Scratch on the PC environment, and what they enjoyed most about it. We then introduced Scratch on N810 and the children were encouraged to use the device and discover the Scratch application at their own pace.

Interaction with Scratch on N810 was intended to act as a stimulus for the second part of the workshop, during which participants’ creativity was unleashed in terms of figuring out use cases for an imaginary mobile learning device.

The second part of the workshop was based on generation of artifacts. The intention was to engage the children in a process that was perceived as fun, but which would also reveal insights relevant from the point of view of the aims of the workshop. It may be hard to elicit explicit responses from children when presenting them with a novel concept. Thus, we wanted to create an interactive workspace where children could demonstrate their ideas in more creative ways, by using their hands and by simultaneously being encouraged to think-aloud. The participants were also encouraged to bounce ideas off each other, instead of working in isolation. We assumed that peer interactions and evaluations at the microlevel had the potential to reflect collective thought. This type of low-end prototyping was also explored in the Future Technology Workshop [18] while creating models for future technologies.

The main objective of the workshop was to 1) explore and observe how children preferred to work when assigned with creative tasks (at both individual and collective levels), 2) identify issues that children were interested in learning more about, and 3) identify the types of contexts children considered inspirational and suitable for learning in. From these observations, we hoped to gain Learner-Centric Design guidelines that would further inform our investigation into educational technologies.

The second, creative part of the workshop started by asking the children to visualize a hypothetical “magic box,” which could aid them in learning about any topic of their choice, in a context of their preference. The creation of magic boxes was followed by a session where children could chose where they wanted to take their magic boxes and then envision how they would prefer to use the magic box in that particular environment. For example, one potential use case could consist of taking the magic box to a garden to learn about plants.

The children were given a variety of craft materials and a basic cardboard box was to be used as a base to start from (Fig. 3). The
box was the only restriction provided to them, as we wanted to motivate them to think about an object that they could carry with them. The participants first translated their visions onto paper in the form of illustrations and sketches, and then used these as reference to create the actual product. Keeping the concept of mobility in mind was crucial, and the participants were encouraged to constantly be aware of how the “magic box” would facilitate learning in any environment that they desired.

The participants were asked to present their “magic boxes” explaining their concepts and demonstrating how they would help them to learn. They were given the freedom to choose the space in which their creations could be presented. Overall, the workshop was designed to throw open ideas of learning preferences and contexts, and was documented using video and still photography. The results were analyzed from the notes taken during the workshop and by studying the video footage in retrospect.

3 FINDINGS

3.1 Primary Education in India

When it comes to understanding the educational context and practices in India, two levels of findings emerge from the field visits and expert interviews. On one hand, general insights were extracted pertaining to challenges associated with the educational context. On the other hand, the educational practices were observed from artifact and process point of view. This analysis will be utilized in the subsequent section of the paper, upon deriving design metaphors that members of the learning communities would be familiar with.

3.1.1 Challenges Associated with the Educational System

The field visits revealed that push for educational reform in India is strong. The government has set up a program called the Sarva Shiksha Abiyan (SSA), which translates to “Education for All.” This program aims to provide useful and relevant elementary education for all children in the age group 6-14 by 2010. While the SSA is a very positive force in the push for educational reform, it still cannot be held accountable for making the necessary changes to educate India. Despite a utilization of almost 86 percent of its allotted funds, nearly 40 percent of children in the age group of 6-14 remain out of school in India [21]. Some other educational reforms are noteworthy—an attempt to introduce the voucher-based system to rural children where the child and her parents receive a voucher that is equal to the cash allotted to the child by the government for the purpose of education. The child is allowed to encash the voucher at any school of her choice, be it public or private. This gives the child the ability to receive the education of her choice irrespective of the background she was born into. With clear benefits like access to education and increased accountability of the schooling system, a program like this emphasizes the value of empowering children across the economic barriers of the country [22].

Technology can play a similar role in facilitating empowerment. To quote an example from an NGO working in periurban and rural areas of Bangalore, children in a cluster of government schools were given USB sticks loaded with installation software to particular educational software [25]. Each student was allowed the use of a shared computer at the school, but because of the portability of the USB stick could take their work home, and use the local internet parlor to also experiment further and save their work. The software was one that allowed children to visualize complex relationships between objects by drawing them and assigning values and characteristics to them. This helped the children understand complex concepts like the movement of satellites, small physics experiments, and geometry much better than their current educational setup, which was deprived of any laboratories of physical learning tools.

While there is a drive in small isolated pockets to incorporate technology into classrooms to aid educational practices, we learned that technology is sometimes also seen as pedagogically suspect. For instance, the OLPC initiative was rejected by the Indian Ministry of Education, since, it was argued that what is needed is better schools and teachers, not “fancy tools” [9]. The problem here is not with the technology itself, but rather in terms of a connection lacking between the role of technology and the problems that need to be addressed within the current Indian education system. Our interviews with the teachers revealed that schools were looking for ways in which students could gain better access to textbooks at affordable prices. At the same time, presence of qualified teachers who can ensure the progress of the students while also reducing the dropout rates was also expressed as an important aspect of improvement.

Programs like the SSA try to incorporate changes at a teaching level. In recent times, a method known as the Active Learning Methodology (ALM) (Fig. 4) has been adopted, the aim of which is to place the learner at the center of the educational process [10]. In this method, which was devised in collaboration with faculty from private schools, the student is asked to start any lesson by reading the subject matter by herself and then creating a visual mind-map of all that she has understood. This way, the student has a visual representation of the lesson to take back and review to cement classroom learning experiences. While this sounds like a tedious and time-consuming process, children are nevertheless able to grasp concepts easily and structure their learnings in a creative manner. This process, while currently static and time consuming, could easily be made dynamic, faster, and archivable with the aid of simple technologies.

The situation is uneven, however. Across the country, government schools are investing in novel educational techniques, and while some are well intentioned and results can be seen by students’ participation in classroom discussions, some schools demoralize students with poor teaching facilities and quality of education and the results of that are evident in the high dropout rates of students from those schools. Children across primary schools require a constant support from teachers to encourage them and guide them through lessons, given that most of them come from backgrounds where they have no qualified assistance at home to clarify doubts or monitor their homework. In an average school of 450 students, at the primary level, there are usually a total of 5-6 teachers who teach all the subjects as well as act as class teachers, responsible for individual grades. With this sort of ratio, it is impossible to deliver quality education and much required individual attention to all students at the pace that they can handle, in order to finish the curriculum.

![Fig. 4. Active Learning Methodology or ALM being practiced in a classroom in periurban India. The student has made a mind-map of the entire lesson in his notebook.](image)
As we observed from our field research, many schools placed an emphasis on peer-to-peer learning, more as a symptom of the lack of teachers than as a proactive teaching method. Older students who fared better than others were put in charge of younger students who needed extra classes after school hours to catch up on lessons or guidance while doing homework. This system was popular among both the teacher-student as well as the learner-student as they both had positive experiences of learning.

The introduction of technology into classrooms at the government school level is minimal. Some schools have been equipped with a single computer and some educational CDROMs that are shown to students in relevant classes. Currently, technology is seen as helping the teaching process rather than the learning process. While children had a basic knowledge of using technology by visiting Internet cafés and occasionally using the school computer, many of them were nevertheless familiar with mobile technology, as there was access to the parents’ mobile phones at home.

In addition, the prevailing educational practices in India place emphasis on “literacy.” Schools compete to achieve a 100 percent pass rate, and this is usually done by encouraging students to learn lessons by rote. Given the socioeconomic conditions of most of the families who send their children to the local government school, the children are often first generation learners, and hence learning stops at 5:00 pm when the child goes back home. To add to this, resources are scarce and teachers are trained to complete the curriculum without paying too much attention to individual learning styles and areas of interest of the children.

3.1.2 Context of Learning in Classrooms

An average classroom in South India in a public school consists of approximately 50 students to a class (Fig. 5), taught by one teacher battling issues of language, multiple learning capacities, and a lack of supplementary audiovisual learning resources. Textbooks are read out, word for word, and the children repeat after the teacher, thus creating an aural-oral component of learning a priority. There is also a dependence on paper as a proof of learning—the assumption being that if the student has written down the correct answer, he must have understood the lesson. In contrast to this, younger children in more rural schools use the slate—a personal mini-blackboard, which they use to practice writing. This is a far more sustainable solution, where writing is practiced, internalization is valued, and by erasing and reuse, zero waste practices are inculcated.

The research team found the slate artifact as a particularly salient concept for the design process around mobile learning solutions. See Section 4.1 for further discussion on this topic.

3.2 Mobile Learning as Expressed by Children

While Section 3.1 was concerned with describing the outcomes of the field visits, Section 3.2 is concerned with workshop insights.

In the creative part of the workshop, the magic boxes helped translate complex frameworks into simple digestible stories. For example, one participant who was interested in learning about aquatic life, made a simple game within her magic box where one would move a bigger fish to catch smaller sea creatures (Fig. 6). This formed a part of a bigger narrative of how these creatures could not exist if the water was polluted, and did not receive enough oxygen. Out of the seven magic box artifacts four were designed with functional moveable parts, making the mental image of the ideal product interactive and entertaining. The creation process of the magic boxes allowed the children to express some of the unarticulated areas of their personal interests and motivations with regard to learning.

On the basis of the process inherent to creating the magic boxes and the preferences and perceptions expressed while interacting with these artifacts, the following two high-level themes emerged: 1) individual and group learning and 2) learning without boundaries. Section 4.2 will discuss the design implications of these themes.

3.2.1 Individual and Group Learning

Devices should be designed to address individual as well as group learning dynamics. While the participants focused on creating individual concepts and products, there were active discussions and peer reviews that eventually led to an unconscious creation of an overarching theme for the creative processes. This had largely to do with understanding the immediate environment of the children and creating an awareness of the community. The children were able to identify overarching areas that would benefit from community involvement—such as water wastage, protecting the natural environment, etc., and realized the potential of such a “magic box” to act as a communication link between them and their community. Such an emergence could be a product of the nature of the alternative learning environment to which these children were exposed, but it should also be included as a design consideration for mobile learning experiences. Individual learning should be part of an overall group process that has a common goal, and allow individuals to share insights with each other at any point and have a means of communicating with each other when not in the same physical environment. Such collective learning experiences could have an influence on how the group of
participants as a whole performs while still allowing for individual cognitive processes.

Other e-learning initiatives have also supported such hypothesis [15], that increased engagement would lead to more learning, and that either or both of the competitive and collaborative environments would be more conducive to learning. Marsden’s work in Shared Mobile Interfaces [20] has also explored similar concepts.

3.2.2 Learning without Boundaries

In the initial sketches, there were a lot of drawings of natural environments like forests and aquatic life extending even up to the solar system. At the next stage, when the children were asked to keep in mind the context in which they would like to use this device, they started focusing on environments physically close to them. In more than one case, the device was designed to serve as a communication tool or aid to create awareness about certain subjects to a community or to their peers. This suggests that the participants, while still playing the role of content owners and key stakeholders of the product, wanted to use these magic boxes to impart their knowledge within social circles around them.

This immediate creation of a focal point placed the participant at the center of her learning experience, and gave her a sense of ownership and responsibility for the learning process. This also emphasized the notion of taking learning outside the classroom, into environments that the children inhabit and are keen to explore. When the products were complete, the students chose to take the magic box outside into the garden to present their creations. Some of the students wanted to use their ideal device within their community spaces, for example, to teach others about water conservation.

4 DISCUSSION AND DESIGN IMPLICATIONS

The expert interviews showed that the government education system suffers from a severe lack of resources. An opportunity emerges for educational technology, namely one related to revitalizing the learning processes and increasing the motivation of not only learners but also teachers. From the example of the rejection of the OLPC we can extrapolate that what is needed is a seamless integration of technology into the current system that is developed from the needs of the system, rather than adapting existing solutions that might not be appropriate. Needless to say, technology alone cannot achieve this; it can only have a supportive role in this change. We, nevertheless, want to turn this opportunity to a high-level objective for our design process, since the need to introduce changes to the learning culture and pedagogies was clearly underlined.

4.1 Slate as the Design Metaphor

The contextual enquiry stage highlighted one metaphor, in particular, namely the “slate,” that we decided to adopt as the key metaphor to guide our product design process. By selecting an object that has a high prevalence in the current educational practices as the metaphor, continuity is created. We also took into consideration the ecosystem the product is traditionally used in, and the elements that build that ecosystem—like student-teacher interactions, nature of the classroom, common practices, etc. This, in turn, may increase the acceptability of the products we introduce to this space. While reminiscent of the Dyna Book [24], the following is a list of attributes that were identified for a product concept designed along the lines of the Slate metaphor:

1. Touch—the ability to write and draw on the slate is one of the most important attributes of this product. In the earlier stages of education at the primary level, tactility is one of the most important factors that aid in developing strong motor skills of a child. This can be seen in multiple schools where children use the slate and chalk or pencil and paper to write, draw, and document classroom activities.

2. Small size—the slate is typically of small size and can be moved around, allowing the children to easily shift their position in the classroom, work on the floor, and importantly, take the artifact out of classroom. It should not be larger than the approximate size of an average notebook, and be rugged enough to withstand the harsh conditions of the context.

3. Copresent learning—combination of small size, movability, and visibility of output implies that the Slate has social affordance. It allows one to easily show the creations to others. It should also be possible for several children to use the slate simultaneously. It should also support near-range peer-to-peer sharing of work to allow children to communicate and have shared displays. Observations about copresent learning are also echoed in the Hole in the Wall project conducted by Intel in 2005 [23].

4. Audio as output—the Contextual Enquiry stage showed that auditory input and oral feedback were key to comprehension, especially with languages other than their native tongue. In many classes, oral repetition was used as a tool to develop fluency. In a Mathematics class, repetition served to acquire fluency in number sequences and arithmetic tables, while in English it was for pronunciation. In this observation, the slate was used as a supplementary tool that aided the memorization of what was being discussed orally in a classroom session, as the children would write down what was being repeated. The Slate, integrated with audio will also provide the student with additional practice, outside of classroom sessions. While audio is not a direct characteristic of the traditional slate, it is integral to the context in which it is used. The inclusion of Audio as a characteristic, thus, mimics the context of the use of the slate rather than the slate as an isolated object.

5. Sustainability—The digital medium lends itself easily to this quality, as an application can be designed to allow iterative work and new sessions to be started easily. Delivering and updating learning material can also be made cheaper than the cost of buying new textbooks. We believe that this principle can encourage children to explore and experiment, and have a way to reflect back on their own progress by retrieving past versions of their work. It is also interesting to note that in rural contexts, there was a practiced understanding of zero waste, even at the domestic level. The constant recycling and reuse of resources encouraged children to be cautious of the way in which they used their personal educational resources like books and stationery.

4.2 Design Drivers—Revisiting Workshop Outcomes

The two themes that emerged from the workshop can be turned to design drivers. It should be noted that the workshop attendees were not naïve to the notion of educational technology, consequently reducing ecological validity of the findings. It is also likely that introducing a specific mobile learning solution to the children before the onset of the creative phase may have led to bias in the creation of the magic boxes. However, the themes are high-level ones, applying to a wide range of mobile learning solutions. We are, therefore, confident that they can be used to guide our design process. The two drivers that emerge on basis of the workshop themes include:

1. The product should allow both for individual as well group learning. Students often share resources like textbooks and learn from each other in a classroom setting. A product should hence support these kinds of interactions. It was also observed that children in more rural contexts had less of a sense of singular ownership toward resources and
were naturally disposed to sharing limited resources with fellow classmates.

2. The technology should be usable across multiple contexts, both in formal as well as informal domain. Without expanding to the latter context, it will not be possible to increase the level of motivation that the child has for learning. This would lend the product to the transformative nature of learning. Mobile learning solutions should allow children to explore their environments and have easy means to record their observations. Using the environment as a live classroom for children to spend time in while learning natural sciences could revolutionize the way these subjects are taught in schools, where infrastructural resources are minimal, but handheld solutions like these could transform the practices of understanding the environment through investigation and inference.

Designing mobile learning experiences should facilitate different kinds of learning approaches like Socially Constructed and Situated Learning, where the importance of the social context to how one constructs their own learning is emphasized; Situated and Networked Learning, where the portability of mobile devices enables them to be used as educational support tools that free the learner from a classroom and the power grid; and Personalized Learning, where the user is in control of their own experiences and track their progress [13]. A combination of such approaches needs to be addressed while making design decisions about the form and function of mobile learning solutions. On the level of content development, a more Learner-Centric Design [14] approach is valuable, to look for ways to scaffold a learner’s process by providing temporary support mechanisms to guide the learner in the right direction and then gradually remove support as the learner's proficiency increases. Such an approach also clarifies the purpose of the task while keeping the goal in clear sight. Momentum is created whereby accumulation of insight and understanding becomes a driving force for further study and investigation.

From our observations, we have realized the value of technologies that are built from the understanding of the grassroots and its needs. What schools across the nation need are quality educational practices in India, bringing about a genuine motivation to learn. The field visits also led to consolidating a metaphor for the product that is familiar to the school children, namely the Slate. This can provide a fruitful design metaphor for mobile learning products aimed at developing regions. Finally, the workshop enabled us to articulate design drivers that are assumed to have a formative influence on learning processes associated with the eventual product concept. The type of learning process supported may have implications on a range of aspects, including, e.g., form factor, interaction, as well as application and service layer associated with the device.

As the sample selected for the workshop was not native to the domain of educational technology, we hope to conduct more participatory design sessions in the future by working with fellow classmates.

5 Conclusions and Future Research

In this paper, we have described research that was done to be able to progress to a conceptualization of a mobile learning product for the Indian market, grounded on understanding of the context. Summarizing the outcome of this preconcept stage research, the field observations and expert interviews crystallized the objective for the design process: our concept should support revitalization of educational practices in India, bringing about a genuine motivation to learn. The field visits also led to consolidating a metaphor for the product that is familiar to the school children, namely the Slate. This can provide a fruitful design metaphor for mobile learning products aimed at developing regions. Finally, the workshop enabled us to articulate design drivers that are assumed to have a formative influence on learning processes associated with the eventual product concept. The type of learning process supported may have implications on a range of aspects, including, e.g., form factor, interaction, as well as application and service layer associated with the device.

As the sample selected for the workshop was not native to the domain of educational technology, we hope to conduct more participatory design sessions in the future by working with children for whom mobility would truly mean leapfrogging to use of educational technology. Future research is also needed to study the extent to which the design framework that found its form in this study can be generalized also to other regions of the developing world.

To conclude, the Slate concept can potentially provide a transformative experience to learning rather than creating new cognitive hurdles. We also recognize that while the Slate has its roots in a research study done in India, it could well be applicable and meaningful to other learning contexts across the globe. Future research is needed to ensure generalisability of the framework, after which it will be possible to progress to the actual design of the product.

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