Designing Educational Technology for Developing Regions: Some Preliminary Hypotheses

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Abstract

Based on our findings from an ongoing pilot with shared computers in rural primary schools in Uttar Pradesh, India since 2001 and two follow-up field studies in the same schools in 2004, we propose some principles for designing educational technology for developing countries as hypotheses. They include constructivist, small-group collaborative learning through digital storytelling and integrating paper- with computer-based practices. We also discuss the need to balance pedagogy, usability and mobility.

1. Introduction

A computer scientist colleague who works with us on information and communication technology (ICT) for development recently asked us: "How is designing educational technology for developing regions different from designing similar systems for the 'First World'?"

While technologists with similar interests would benefit from principles that guide them in designing educational technology for underserved communities, it is not entirely clear what directions they should adopt. There is certainly consensus on a few principles, such as the need to support the local language. But fellow technologists and educators could benefit even more from principles that provide deeper insights on how applications could be designed to address specific educational challenges in developing regions.

In this paper, we propose some design principles that we are starting to observe in our work on designing learner-centered authoring tools for primary education in India. Due to the preliminary nature of our work, we present these principles as hypotheses, in the hope that fellow researchers will help to illuminate these issues, particularly with experiences from outside India.

2. Background

Among the states of India, Uttar Pradesh (UP) has the highest number of residents below the poverty line in terms of income [4]. One of the authors has worked on primary education in rural UP for about two decades. Her previous work includes initiating and managing a school reform project involving 62 schools, 16,000 students and 258 teachers in rural UP, as well as launching an in-service program for the United Nations Children's Fund (UNICEF) with 30,000 kindergarten and first-grade teachers in 28 UP districts.

In 2001, this author piloted a shared computer and custom Hindi CD-ROM courseware in a rural school. Today, it has been extended to six other rural schools and an urban after-school program for girls from the slums, and is currently being replicated in 700 schools by the UP state government. This ongoing pilot provided us with three years of experiences when the authors began collaborating in 2004 to explore more innovative designs of systems and their uses in rural UP schools.

3. Data Sources

The preliminary hypotheses proposed in this paper are mostly based on two field studies in UP that the first author conducted in the summer and winter of 2004, in addition to observations of the pilot between 2001 and 2004. Each of the two field studies took place in and around the state capital (Lucknow) over two weeks and was assisted by Hindi-speaking translators.

The summer study was intended to provide the primary author with his first exposure to the conditions of rural schools in UP. While he had worked for five years in the USA on educational computing, this study was his first contact with computers in rural schools. In total, 5 rural schools and the after-school program for

urban slums students were covered. We interviewed 6 students and 8 teachers from rural schools, as well as 2 slums families, on their experiences with the pilot and their everyday routines. We also observed how students used the computers when electricity was available.

The summer study helped us to better appreciate the constraints and enablers that define the "space" of possibilities. By then, we had some ideas on how to extend the existing pilot using technology. Still, we felt that it was more sensible to perform a feasibility study before implementing any system, particularly when the functional requirements were not fully understood.

Hence, we set out to assess the viability of selected ideas in the winter. We formulated them as hypotheses that we plan on refining with results from the winter study. We experimented with Microsoft PowerPoint and KidPix [3], which is similar to PowerPoint but is targeted at children. We chose both software packages because they most closely resembled the multimedia story authoring application that we envisioned; our objective was to assess how well prospective end-users will accept them as well as limitations which we can address in our design. In total, we used PowerPoint briefly (3 students, 1 hour per person) before switching to KidPix (15 students on average, 3 hours per person) when usability issues in PowerPoint became acute.[1]

For reasons that will become clear in Sections 4 and 5, we also experimented with Tablet PCs, a micro-phone and two low-cost digital cameras, all of which we are considering to deploy on a *shared* basis. We also held a 2-hour design session with 10 children[2], in which we asked them to brainstorm on how they would teach and test fellow students on academic concepts using electronic games, and they mocked-up 3 games on paper for our analysis.

While it was premature to systematically test any hypothesis that we formulated from the summer, results from the winter study nonetheless helped us to better understand several hypotheses.

4. Key Considerations

In this section, we highlight the primary constraints and enablers that should be considered when designing and implementing educational technology for rural UP schools. These considerations are based on the pilot that commenced in 2001, as well as field studies in the summer and winter of 2004. For brevity, we will not discuss evident factors, e.g. irregular electricity, lack of Internet connectivity and shortage of qualified teachers, although we took them into account when formulating the hypotheses that we propose in Section 5.

4.1. Collaborative Learning

There appeared to be a culture of peer tutoring and collaborative learning, based on how the CD-ROM courseware was used. Students viewed its content on the computer in small groups, and in the process, helped one another to understand the material. In particular, they enjoyed the interactive quizzes[3] so much that they persisted in re-taking them until they attained full scores; when doing so, they helped one another to understand why initial answers were wrong. Moreover, older students who were accustomed to teaching their juniors (due to the lack of teachers) found the courseware to be a useful teaching aid.

4.2. Pride in Personal Accomplishments

Rural school children appeared to be enthusiastic producers and consumers of digital content. For example, one of them said she was proud to show what she had accomplished with Microsoft Paint to teachers and fellow students. Another student disliked studying, but was so motivated to create a multimedia digital story using PowerPoint to explain soil erosion that he persisted at the task for three days to complete it.

The digital creations seemed to be well received by other students primarily because they were made by their peers; one student added that she was excited to see her classmates capable of authoring such content.

4.3. Limited Time to Use Computers

Having one computer in every rural school implied that there was highly limited time for children to use it. Hence, we were not surprised when students told us that each person spent at most 15 minutes per day on the shared computer (when there was electricity). But we were surprised when a student clarified this usage to be adequate because she had to spend time on her classes.

There is limited time under the present curriculum

[1] PowerPoint and KidPix sessions were carried out with urban slums students who migrated from rural areas in India. As we will elaborate in Section 4.3, we found it difficult to schedule computer sessions with them and expect more logistical challenges with rural schools.

[2] The games design session was carried out with "approximate users," i.e. middle-income children in UP because they had adequate exposure to electronic games in their homes. We believe that low-income students are similarly capable of being our design partners, but it will require more time (longer than our field study) to provide them with similar preparatory exposure.

[3] It should be clear to the reader at this point that we are considering electronic games as an extension to the interactive quizzes.

and lifestyle for computer usage. For example, interviews with families from the slums suggested that girls in India were expected to perform extensive household chores to prepare them for married life. Most of all, students failed to show up for two KidPix sessions because they were participating in festivals and we had to cancel both sessions. This was the first time that we attempted to schedule time with children to observe their use of computers, and it reinforced our belief that it could be challenging for them to set aside time to use computers.

4.4. Usability Problems

Despite children's motivation to create multimedia stories, only 3 out of 239 students succeeded and were referred to as "computer geniuses." Even then, at least one of them required intensive guidance from an ICT trainer throughout the authoring process. It seemed that PowerPoint was too difficult for the average child to learn and use, possibly because s/he lacked time to practice using it. For example, 125 out of 239 children had learned to use Word to some extent after a year in the pilot program, vis-à-vis 10 out of 239 students in the case of PowerPoint. Moreover, we understand from interviews that it was almost time for students to graduate from primary school when they finally learn PowerPoint.

There were also usability issues associated with hardware. In particular, we observed that students were not proficient at typing, which was only to be expected given the limited time that they spent on typing.

4.5. Limited Built Space

In the five rural schools that we visited, the shared computer was either kept in a previously disused room, or an existing classroom if no spare room existed. The latter option was an inconvenience since the computer, which was already a scarce resource, could not be used by other students when a class was taking place.

But there were plenty of open fields close by.

4.6. Preference for Mobile Devices

On a related note, urban slums girls who used the Tablet PCs told us that they preferred them to desktop computers for two reasons. Firstly, the form factor of the slate tablet PC that we used (Compaq TC-1000) is more conducive to the smaller size of the female palm: "I like this because it can be just held in the hand." Secondly, they were intrigued by the possibility of using them outside school premises.

4.7. Ubiquity of Paper, Print and Writing

In contrast to the lack of time, usability, physical space and other opportunities to access computing technology, paper-based artifacts appeared to be more accessible. For instance, each student carried a bag to school that contained stationery and textbooks. We learned that most items were either affordable or free.

Unfortunately, even though the UP state government distributed textbooks to low-income students for free, respondents found the content mediocre.

4.8. Parental Resistance

Finally, when asked to name the most difficult challenge that they face in their work, teachers unanimously cited the lack of parental support for their children's schooling.

After the shared computer was introduced, however, parents became more willing to allow their children to attend classes regularly because they understood the importance of ICT literacy.

5. Hypotheses

In this section, we elaborate on the hypotheses that are emerging from our work. For each hypothesis, we discuss how it relates to developing country conditions highlighted in Section 4, practical implications, and most importantly, its potential learning impacts.

5.1. Learning through Digital Storytelling

In some low-income regions such as rural India, rich oral traditions have made storytelling a dominant mode of sharing values. Moreover, since children were observed to be motivated and persistent in creating multimedia digital stories that explain academic concepts, we hypothesize that many more children can create such content. But because they were hampered by usability obstacles in existing systems, they must be provided with more usable authoring technology.

We plan to design such a tool that enables children to work collaboratively in small teams to author digital stories. The primary educational objective is to foster active learning, in which users discover and address gaps in their understanding when explaining concepts to others. Cooperative learning in small teams, which has been demonstrated to yield learning benefits [1], is another objective. Other expected learning outcomes include teamwork, independent thinking (vs. rote learning), as well as writing and communication skills.

While we advocate constructivist, small-group learning because learners need to construct their own understanding of the material for themselves, we are aware that students need coaching for their digital stories to communicate concepts correctly. Due to the shortage of qualified teachers in rural UP schools, we are collaborating with Professor Randolph Wang at Princeton University to develop an Internet-accessible repository [5] where such digital stories can be downloaded and uploaded, as well as networking infrastructure for rural schools to access this repository. Experienced remote teachers and the well-educated diaspora can use the repository to give feedback to students on their work.

By connecting children to an audience, we expect the repository to further motivate them into creating quality content. We are learning from the games design sessions that children are able to explain and test other children on their understanding of academic material in compelling ways that never cease to amaze adults like ourselves, and this is consistent with the literature on peer learning [2]. As such, student-authored content can plausibly supplement existing textbooks, which respondents commented to have mediocre educational quality. The same content can also address the shortage of local-language courseware, which can be used as teaching aids by older students to coach their juniors.

We expect the proposed educational practice to have a reasonable chance of being adopted in India because it is an incremental improvement over the current situation, in which both teachers and students are already supportive of authoring digital stories to explain academic material but lack appropriate tools.

5.2. Usability Engineering and Pedagogy Must Go Hand-in-Hand

The limited time that students have to use shared computers suggests that user interfaces for educational applications must be designed to be usable, learnable and efficient. That is, users who lack practice should nonetheless make minimal errors, understand and remember how to use the system even without regular practice, and be able to perform tasks without excessive steps or time. These requirements, especially the last, represent research opportunities in novel human-machine interaction methods (particularly for user input) and user interfaces that we are investigating.

Our observations in the summer about children's lack of proficiency with the keyboard (and PowerPoint) further suggested that a pen-based user interface such as the Tablet PC which allows the user to write (vs. type) on it may be more usable. As such, we came back in winter with 3 Tablet PCs preloaded with KidPix. Within 3 hours, we succeeded in training the students to write on the Tablet screens using the styli, record audio-clips of their voice recordings, create individual slides, import photographs from the digital cameras into slides, and arrange slides into a slideshow. In comparison to the usability problems observed during the summer with PowerPoint, students were creating attractive slides using KidPix and Tablet PCs.

But the children did not use KidPix to organize individual slides into digital stories. Neither did they annotate the slides with written bullet points using the styli. We expected the users not to create digital stories spontaneously since we did not train them to compose a script and to make a slideshow based on the narrative. But we were surprised to learn that children focused on beautifying individual slides because they found it more mentally demanding to organize slides into a coherent sequence. Similarly, we learned that children disliked writing and very much preferred to draw.

We now hypothesize that while usability remains important, usability improvements to systems need to be accompanied by training children to organize their thoughts, to communicate coherently, etc. Equally important, conducive learning environments must be established for children to develop a love for writing.[4]

5.3. Mobile Technology Can Help Overcome Constraints in Access to Education

The shortage of built space in rural schools implies that it is very difficult to accommodate more computers in existing premises even if there are means of obtaining more machines. Furthermore, the shortage of stable electricity inside rural classrooms and the abundance of open fields in rural schools lead us to hypothesize that with educational models and software appropriate for outdoor spaces, battery-powered mobile devices can overcome space-related constraints.

Similarly, given the limited time that students have to use shared computers, it is not clear if acquiring more machines will lead to greater computer usage in schools. It is possible that students may have more time at home to use mobile devices if students could borrow the equipment to take home. This offers more learning opportunities because the time that learners have for interaction with educational material such as digital stories is a major factor in learning.

As such, on top of the Tablet PCs, which children reacted positively to due to their compact form factor,

[4] The urban slums girls who participated in the KidPix sessions were about 14 years old. We believe that they need to be fairly conversant in written communication at this age, at least in Hindi.

we also brought two low-cost digital cameras for the winter study. These cameras are simple and have only two buttons: an on/off switch and a button for taking photographs. We expect the cameras to be very useful for children to take pictures from their everyday lives, which they can subsequently import into their digital stories and use to relate their everyday lives to academic concepts. The children learned how to use the cameras in less than 10 minutes. More importantly, we found that the children were responsible with the cameras and returned the equipment promptly and in their original condition after the KidPix sessions.

Besides overcoming physical constraints related to space and time, mobile devices may also be applicable in addressing social barriers in education. For instance, as mentioned in Section 4.6 urban slums girls indicated a preference for Tablet PCs. While mobile computing cannot overcome social problems such as gender inequality that is deeply rooted in the cultures of some developing regions like rural India, it can nonetheless make technology and ICT education more appealing to girls. As a result, it will be easier for them to grow up as confident users of technology in the workplace.

5.4. Shared Computing Can Be Augmented Through Paper-Based User Interfaces

We expect shared computers in telecenters and schools to be the most economical means of providing ICT access for children. But we hypothesize that being scarce resources, computers could be used more efficiently if augmented by paper-based practices that are relatively more prevalent. Paper can also help to overcome constraints in low-income students' access to education for similar reasons as mobile computing.

Here is an illustrative scenario: children draw on paper the individual slides that comprise a digital story, either at home or in school. A digital camera is used to capture these sketches once they are finished, after which users color, manipulate and organize these sketches electronically into a slideshow.

By preparing as much of the digital story as possible offline, the shared computers can be made available for more users. In a déjà vu sense, this shared usage of computers in developing regions parallels the batched use of mainframes when they first appeared.

In terms of learning, having students perform more tasks offline and restricting the amount of time that they have on the computer will help them avoid the "perfectionist urge" to keep tweaking their work when composing it online. When students are less able to spend time perfecting the aesthetics of the end product, they can focus better on their original learning tasks.

Paper is not only useful for expediting user input; it can also be used for sharing and exchanging information between individuals. We expect paper-based input and output devices like scanners and color printers to play a role in this aspect.

6. Conclusion

Further initiatives to examine the above hypotheses are in-progress. For instance, we are conducting regular KidPix classes in which students are taught to compose narrative scripts.

Similarly, we plan to conduct a design workshop in the summer of 2005 with rural school students during which we will ask them to sketch most of their digital stories on paper and assess the feasibility of using cameras and other technologies to facilitate their seamless integration with the computers.

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8. References

[1] D. Johnson, and R. Johnson. "Cooperation and Competition: Theory and Research." Interaction Book Company, Minnesota, 1989.

[2] E. Mazur. "Peer Instruction: A User's Manual." Prentice-Hall, New Jersey, 1997.

[3] Riverdeep Interactive Learning Initiative, "KidPix", http://www.kidpix.com, last accessed: February 25, 2005.

[4] R. S. Srivastava, "Anti-Poverty Programmes in Uttar Pradesh: An Evaluation", Report of the Planning Commission Research Project, Institute of Human Development, New Delhi, India, 2002.

[5] R. Wang, U. Sahni, S. Sobti, N. Garg, J. P. Singh, M. Kam, A. Krishnamurthy, and T. Anderson. "The Digital StudyHall." Technical Report TR-723-05, Computer Science Department, Princeton University, March 2005.