Practical Considerations for Participatory Design with Rural School Children in Underdeveloped Regions: Early Reflections from the Field

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ABSTRACT
This paper draws on a 2-week design workshop conducted at a rural primary school in northern India to provide recommendations on carrying out participatory design with school children in rural, underdeveloped regions. From our experiences in prototyping low-tech and hi-tech English language learning games with rural student participants, we advocate that researchers build a more equal relationship that is qualitatively different from one between teachers and students, enlist local adults and children as facilitators, and explore hi-tech prototyping to inspire the best designs.

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Children, Participatory design, Third World

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INTRODUCTION
Participatory design (PD) with children has accounted for computing systems that are more closely aligned with the needs of the intended child users [e.g. 1, 9, 15, 24]. But recent initiatives that aim to introduce computing to rural school children in developing regions have not extensively enlisted members of this user group into the design process, even though many international development practitioners would argue that active participation by local stakeholders in all stages of community development projects is critical to the success of these initiatives.

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The limited involvement by rural school children can be attributed to the challenges in giving them a voice in the design process. One reason is that they have very little exposure to high technology which may limit their ability to envision prospective designs. Another reason is that it is common for their education to revolve around rote learning such that they have very little experience with “design” or exercises in school that require creativity [e.g. 27]. A third challenge is that rural parents do not always appreciate the importance of formal schooling and instead prefer that their children help out with agricultural work, household chores, etc. [e.g. 3]. One implication is that appropriate incentives are needed to ensure high attendance at design workshops. PD with children also entails obstacles that are frequently cited in the literature, such as unequal power relationships between children and adult design team members [10], which may be more acute for rural students due to factors such as the conservativeness of some rural communities.

In this paper, our hypothesis is that rural school children in underdeveloped regions can participate in the participatory design of software. We use the term “participatory design” to refer to our design philosophy in which the distinction between the partner [11] and Scaife et al’s informant [24] is blurred. That is, we strive to work with rural students as full partners in the spirit of “participatory project planning” that several community development practitioners subscribe to, even as we keep our feet planted in Scaife et al’s concerns [24] about limited resources (e.g. time and children’s knowledge) to build the ideal design partnership with rural students.

In the next section, we situate the above definition of PD in the literature on involving the child in the design process, and discuss emerging technological initiatives which hint that rural computing is an idea whose time has come. We motivate this paper by showing how these initiatives focus on hardware issues, hence leaving gaps for locally-relevant software whose design could benefit from rural students' participation. We then elaborate on how we ran a 2-week PD workshop at a rural primary school in India and reflect on what we learned, with an emphasis on the steps that we took and found useful for building an effective design partnership. Due to space shortage, we report field results only insofar as they contextualize our recommendations.

RELATED WORK

Although there are children in underdeveloped rural regions who are out-of-school [3], we believe that it is more pragmatic to start with school-goers given the assumption that literacy is a prerequisite for effective computer usage. Moreover, even though over 70% of the world's poor live in rural regions [29], rural students as a potential user group have received less than their proportionate share of attention from technology designers and the field of human-computer interaction. To our knowledge, the only work that mentions rural children (and only peripherally) is [10].

Participatory Design with Children

Druin [11] identifies four roles that a child can play in the technology design process: (1) as a *user* of systems whose development lifecycles have ceased, (2) as a *tester* of prototypes under iterative development, (3) as an *informant* who provides designers with input at any stage in the design process [24], and (4) as a *partner* who negotiates group decisions with adult team members as an equal [9].

While the user (tester) is involved only in the final (later) stages of the process, the partner is involved throughout the entire process on a long-term basis. The informant occupies a middle ground: she can be involved in the initial or later stages depending on when her contribution is deemed necessary by designers, and usually for short periods. For both the informant and partner, the child often expresses her ideas for technology designs and scenarios by creating low-tech prototypes with paper and other everyday materials. Although the informant and partner may work with hi-tech prototypes, these prototypes are almost always developed by adults since programming is required.

These roles are not mutually exclusive. For instance, an informant may be asked to test work-in-progress prototypes [11]. This non-exclusivity is significant in the case of students in rural developing regions due to their limited prior exposure to computing, because they are very likely to need to acquire enough familiarity with technology as users and testers before they can become effective informants and partners. This developmental trajectory parallels Druin's observation that children largely progress from learners to critics and inventors before becoming partners [12].

Off-the-Shelf Hardware Adapted for Developing Regions

Computing in rural schools in developing regions is difficult to imagine – let alone achieve – due to unreliable electricity and prohibitive costs of off-the-shelf hardware. Nonetheless, one of the co-authors spearheaded a pilot initiative from 2001-2004 called Digdarshan [19]. Under this program, a shared computer was installed in each of six partner rural primary schools in Uttar Pradesh, India. The computers were powered by solar panels and other more conventional sources of electricity. In response to students' interest, a set of science courseware was subsequently developed in Hindi. The Digdarshan model seemed to be cost-effective in addressing the above obstacles, and the Uttar Pradesh state government has replicated it in 700 rural primary schools with another 700 schools in-progress.

Likewise, the Azim Premji Foundation (APF) [2] in Bangalore, India has set up over 10,000 centers throughout India to provide rural primary school children with access to shared computers. The APF has also created courseware aligned with the local curriculum for local language literacy (including English), mathematics and science, for use in the above centers. Similarly, Project Pygmalion [23] uses computers in rural schools to enhance the conversational English skills of rural Indian students.

Other Third World computing initiatives that do not strictly target rural school children but can nonetheless be argued to belong to this category include the "Hole in the Wall" [17] in India and SchoolNet Namibia [25] in Africa.

Hardware Designed for Developing Country Conditions

Other initiatives eschew off-the-shelf computing platforms in favor of designing hardware specifically for Third World school conditions. The US$100 "One Laptop Per Child" initiative [20] promises to be a significant milestone in this respect since it aims to make it economically viable for *millions* of rural school students to own individual laptops. The $100 laptop will include a hand-crank for generating electricity manually in rural schools that lack electricity.

Other Third World computing initiatives that can arguably belong to this category include the Jhai Personal Computer [18], Ndiyo Nivo [22], PCtvt [6] and the cellular phone "Personal Computer" proposed by Bill Gates [20].

MOTIVATION

Most of the above initiatives focus on technical concerns about making hardware work for rural schools. The $100 laptop initiative is also criticized on various newsgroup threads [e.g. 5, 8, 13] for being too top-down. But it is software which determines the usefulness of the overall system. Along this line of reasoning, an open letter on the $100 laptop by 25 leading educational technology researchers reiterates, among other preconditions, the importance of appropriate software and that it is the end-user communities who understand their needs best [16].

In other initiatives such as the APF's that have a strong focus on software development, rural students participated in the design process as testers and not partners [2]. In Digdarshan, the student recruited to join the team as a partner came from urban Uttar Pradesh. We are not aware of any major Third World software development initiative which has enlisted rural school children as design partners.

However, from the promising results of PD with children in the First World [e.g. 1, 9, 15, 24], we believe that it is worth investigating how rural students in underdeveloped regions can play a similar role in software development. To explore this issue empirically, we conducted a workshop from July 13-27, 2005 at a rural school in Uttar Pradesh, India.

FIELDWORK

This workshop grew out of our interest in using electronic games to promote the acquisition of English as a foreign language (EFL) among children from the rural schools and urban slums of India. From Digdarshan, we learned that many rural students were highly motivated to create digital artifacts but very few succeeded because of usability obstacles in existing authoring software [19]. As such, we expected more students to create EFL games if we could design more appropriate authoring software with them, for them. This workshop created such an opportunity for us to work with rural school children to design EFL games, so that we could observe and identify basic abstractions and primitives that these authoring tools will need to support. When referring to the workshop's PD agenda, we thus mean PD at the level of the game and not authoring tool.

When planning the workshop, we drew on our lessons from two previous field studies in 2004 with children from the rural schools and urban slums in Uttar Pradesh [19]. The co-author who spearheaded Digdarshan also discussed her responsibilities as our local host over four rounds with us when she visited the USA. The workshop hence benefited from her years of experience (besides Digdarshan) and local connections in rural education in her native state.

Study Setting

We held the workshop at the first school which participated in Digdarshan. This school is located in a remote rural area and we had to travel 75 km (1.5 hours) each way to reach it. It has about 250 Hindi-speaking students (grades 1-8) and classes are housed in over 5 classrooms in two single-story buildings. Regular classes take place at its premises only in the morning. Its computing facility has expanded from one computer during Digdarshan to a computing center with 3 computers during the time of the workshop. Even though students have weekly computer lessons, these classes are often cancelled or revert from hands-on training sessions to lectures because of frequent electricity shortage.

The workshop took place over 10 days at the rural school in the afternoon so as to not disrupt classes in the morning. Every afternoon lasted 2.5-3 hours. This timeframe was a major consideration: a longer workshop would ensure a more productive design relationship, but our findings from earlier fieldwork about irregular school attendance implied that any commitment exceeding 2 weeks would make it difficult to obtain parental consent for enough children to participate. Several other PD workshops in the First World adopt the alternative approach of holding design sessions on 1-2 days per week spread over several months, but high school drop-out rates in developing regions suggested the risk of participant attrition. Given this time constraint, we needed to use time wisely, e.g. focus less on polishing up the prototypes and more on generating design ideas.

Three considerations influenced our choice of this location. First, the principal and teachers were supportive of our study, and long-term relationships with local communities were integral to successful fieldwork in developing regions. Second, this school had sufficient indoor space (i.e. two rooms) for the workshop, whereas other rural schools that we visited lacked the necessary building infrastructure. Third, enough rural students could travel to this location without us having to provide transportation.

Recruitment of Participants

Based on our experience, we expected that it was possible to recruit up to 12 rural students from the same grade in one rural school. Prior to our arrival, the principal selected 10 girls and 2 boys from grades 4-8. Two of them did not know their age; remaining participants were aged 10-16. They were chosen from among their peers for their superior academic performance and computer literacy levels. (Even though we indicated our preference for the selected students to come from grade 5 only and that they reflect a balance in terms of sex, academic performance and computer literacy, these criteria were difficult to achieve in practice because the principal wanted to impress his foreign visitors, i.e. us.) Their computing experience was limited to Windows Paint, a little of Microsoft Word and some games; only one could use basic features in Microsoft PowerPoint. As a token of appreciation, each participant received US$20 of stationery.

Recruitment of Local Adult and Child Facilitators

Since the researchers who conducted the workshop are non-Indian natives (two of us are ethnic Chinese while one is a Non-Resident Indian), we believed that recruiting locals as workshop facilitators would help us to establish a stronger design relationship with rural students, whom we expected to have interacted very little (if at all) with foreigners. Facilitators would act as our translators even as they, just like us, worked with participants to design EFL games.

Facilitators were chosen for bilingualism in English and Hindi, experience in tutoring or working with children, and computer literacy. However, due to the above concern that an unequal power relationship between rural students and adults could hinder the PD objective of the workshop, we selected both adults and urban school children (because we did not have access to rural students who met the above criteria) as facilitators. In addition, to help participants identify with child facilitators, we asked the latter to wear their school uniforms to the workshop.

We recruited a total of 5 children (3 males and 2 females) and 2 adults (both males). One adult participated on a pro-bono basis while the other received a US$5 daily wage. We gave the child facilitators certificates of participation and souvenirs of books costing US $10 each.

Organization of the Workshop

We separated the 12 participants into 4 groups of 3 since it was easier for each participant to learn and have a voice in the design process in small cooperative teams. Each group was assigned a Tablet PC and facilitator, such that members mocked-up EFL games on paper and Tablets (see Figure 1). Researchers moved between groups to provide participants and facilitators with further assistance in the design process.

Figure 1. Researchers and facilitators provided rural student participants with assistance in using the Tablet PCs when working on design activities with them. Due to limited furniture – especially tables – each group set up its Tablet PC on a chair and placed its mouse on a separate stool.

But child facilitators entailed a complication. While it was possible to obtain consent from rural parents for 2 weeks, the competitive pressure associated with urban schooling in India [2] made it difficult to seek parental consent for each child facilitator to be involved for more than 3 days, especially after the semester has started in July. (And we could not organize the workshop at the rural school during the school holidays.) Groups with child facilitators would need to switch facilitators, hence potentially affecting the design relationships within these groups. But we were concerned that affected groups might feel discouraged to see other groups making better progress. Thus, to support uniform progress among groups, we switched facilitators for every group and randomly reassigned participants into new groups whenever a switch was made. This structured the workshop into 4 (~3-day) phases, such that facilitators were switched after Phases I and II.

Phase I: Warm-up (3 Days)

This phase was meant to prepare participants to contribute to the design and prototyping goals of the workshop in four ways. First, we need to get those participants who lacked practice or confidence with computers "up to speed." This is important because basic familiarity with the graphical user-interface as a user or tester is a first step to becoming an informant or design partner. Second, and on the same topic of the developmental trajectory, we wanted to engage the participants' creativity through an appropriate warm-up exercise. To meet both goals, we guided participants to create photo collages using Windows Paint and digital cameras. As a side benefit, this exercise provided us with a chance to understand their computing background better.

Third, we needed to provide participants with at least one example of an educational game, so as to equip them to brainstorm ideas for EFL games more effectively as our informants and partners. (Participants had access to computer games at the school but none of these games could be classified as "educational.") We selected Word Munchers [27] after pre-testing a selection of EFL games with a 10-year-old Taiwanese boy who was learning EFL. This game builds vocabulary through inductive learning.

Fourth, we established the following routine for the entire workshop. By giving participants an idea of what to expect on each day, we hoped that they and their parents would see the benefits of attending the workshop on a daily basis:

- *Daily briefings and group interviews*. We needed to "walk through" the planned activities for each day with all facilitators prior to arriving at the rural school, and to interview them on their experiences with the workshop after that. Due to time restrictions on the part of child facilitators, we used the 3-hour traveling time for these sessions. Potholes along the road made it impossible to write notes and we resorted to using a video-camera to tape these interviews (total of 17 hours).
- *Ice-breaker* at the beginning of each afternoon, which was especially important since participants were assigned to new groups and facilitators at the start of every phase.
- *Videotaping* every group of participants working on their design activities and interacting with their Tablet PC. In total, we recorded 4, 15, 16, and 3 hours of video data in Phase I, II, III and IV respectively.
- *"Star award ceremony."* We expected attrition to be a major challenge; in previous fieldwork, we learned that attendance at rural Indian schools could average 50% in July because children needed to help with the mango harvest. Similarly, two design sessions with urban slums children were cancelled due to heavy household chores (a rite of passage in preparing girls for marriage) and their involvement in festivals. Thus, to reward participants for attending each day of the workshop, we ended the day by awarding every attendee with a star-shaped sticker that she pasted on a large, publicly-visible attendance chart.
- *Daily reviews.* In addition to the "star award ceremony," an adult facilitator impressed upon us during the first day of the workshop that parents must witness their children benefiting from their participation in tangible terms. Otherwise, parents were likely to stop their children from attending, just as they had sometimes withdrawn support for their children to attend school. Fortunately, he also explained how the workshop's computing focus worked

to our advantage because parents would be delighted to see that their children acquire some degree of computer literacy, which is perceived by low-income communities in some underdeveloped regions as a stepping stone to economic advancement. We decided to wrap up every afternoon with a 5-minute review session, during which we helped participants to reflect on and summarize what they had learned that day. In this way, participants were prepared to "report" what they learned about English and computers to their parents upon reaching home.

- *Camera interviews*. We wanted to better understand the participants' everyday lives but lacked time for extensive fieldwork. Inspired by how digital cameras were used as cultural probes in [14], we allowed participants to take turns in borrowing two cameras home overnight and over the weekends. We asked them to photograph everyday activities which they think would be interesting to us, so that they could describe selected photographs to us.

Phase II: Low-Tech Prototyping (3 Days)

An important consideration was that contrary to most paper prototyping activities in the First World, we did not use "fanciful" art supplies such as post-it notes or colored construction paper. Instead, we used stationery and other inexpensive materials that were locally available, which was a position adopted by many development practitioners. Moreover, due to the shortage of classroom furniture, we taped pieces of paper to make large posters and pasted them onto walls using masking tape, for sketching storyboards.

We began this phase by asking participants to think, individually, of fun ways to teach English as a warm-up for designing the same games in groups. Participants seemed to find brainstorming stressful, however. Thinking that it was due to their limited command of English, as an intermediate step, we worked with every group to mock-up a game on paper that aimed to teach us six Hindi words in the context of a shopping scenario. We then worked with participants to adapt the Hindi learning games for EFL. We observed participants to be highly frustrated throughout this phase; it took tremendous effort before we designed two word matching games, a kinesthetic game similar to but more elaborate than "hopscotch" and a skit-based game.

We discontinued low-tech prototyping on the last day of Phase II since participants found low-tech prototyping to be frustrating. As a transition to Phase III, we had participants spend the last day of Phase II playing the collection of EFL games in Clifford Reading Pack [7]. We chose Clifford for two reasons. First, it included word matching games, which should demonstrate to participants how their above designs might look and behave after being implemented as software. Second, participants might have found low-tech prototyping to be challenging because they needed to see more examples of EFL games, which Clifford provided.

Phase III: Hi-Tech Prototyping (3 Days)

We decided to switch from low-tech to hi-tech prototyping for Phase III due to the above unsuccessful experience with low-tech prototyping. We speculated that participants may find hi-tech prototyping to be more enjoyable since they asked throughout Phase II when they could resume using the Tablet PCs. For Phase III, we selected Stagecast Creator (SC) [26], an end-user programming and run-time environment for interactive simulations, as our prototyping tool for two reasons. First, its extensive library of themed backgrounds and characters allowed participants to leverage on computer skills honed during Phase I's collage building exercise to create hi-tech prototypes by dragging virtual characters around on themed backgrounds. Second, arranging laminated cut-out characters on a background scene was found to be an effective low-tech prototyping technique with children [24] in terms of helping them to generate ideas, and our use of SC was based on this model.

We worked with participants to design and prototype matching-style games for EFL learning in SC. Although SC was the most usable end-user programming tool that we knew of, it was still complex relative to other software that participants had used. Hence, although we used example simulations to show participants what could be built, so as to help them contribute ideas for hi-tech prototyping, we used SC on their behalf on most occasions. Similarly, due to time constraints, we only implemented those ideas that were easy to implement in SC. Nonetheless, although the hi-tech prototypes were mostly unfinished, they embodied far richer ideas than the low-tech prototypes from Phase II. More importantly, participants enjoyed hi-tech prototyping more than low-tech prototyping.

Phase IV: Wrap-up and Evaluation (1 Day)

We conducted standardized questionnaire interviews with participants and facilitators to assess every group's design experience. Due to the sensitivity of these interviews, for interviews with participants, we depended on translators who had no previous interactions with the respondents. The interviews with facilitators were self-administered.

REFLECTIONS AND RECOMMENDATIONS

To provide further recommendations for the reader, we also reflected on the workshop after it was concluded. Our postmortem included transcribing and translating 38 hours of video records of the workshop into English, after which we reviewed the video alongside corresponding transcripts.

Relationship Between Participants and Researchers

Previous literature cites the unequal power differential between adults and children as a notable obstacle to building an effective design relationship [e.g. 10]. This differential also applied to rural school children; they seemed tense each time their curious principal and/or teachers approached to see what they were doing with Tablet PCs or cameras. Our most striking observation took place on the second day, when the teaching staff sat in a row where the workshop was conducted to view its proceedings. Participants were nervous to the extent that they could not focus on their design activities and both adult facilitators needed to request – with utmost politeness – that the teaching staff excuse themselves from the workshop. This observation showed that *adult researchers needed to develop a relationship with rural school children that was fundamentally different from one between rural teachers and students*. *As a corollary, it might not be a good idea to bring rural school children and their teachers together to cooperate on the same design tasks*.

We believed that we succeeded in building rapport with the rural child participants despite the barriers between us. This relationship could be characterized as one in which researchers and participants could learn from one another. Some steps that we took during Phase I laid the foundation for this partnership. For instance, at the first ice-breaker, we asked every participant to say why she thought we were conducting the workshop. The most frequent responses were "to teach us how to use computers" (5 participants) and "to test us on our knowledge of computers" (3). We hence took immediate measures to dispel their expectations of a teacher-student relationship by explaining that our goal was to engage them in the PD of EFL games and how this goal necessitated us working together as equal partners.

Next, when we asked participants to design games during Phase II to teach us Hindi, they felt more empowered as a consequence of having to teach us. Similarly, during the camera interviews, they easily assumed their roles as our teachers. They shared what they thought were special in their lives and took great care to photograph items that they expected to be unfamiliar to us, e.g. exotic plants in their gardens. They were especially excited to explain pictures whenever we expressed surprise, e.g. "Oh! Your family sleeps on the roof!" These incidents re-emphasized that they were on an even playing field with us, with their own unique knowledge to share.

The lesson was that *organizers of a PD workshop with rural school children could build a more equal design partnership by displaying a genuine interest to learn more about the local culture and language*. As a cautionary note, however, this interest to learn the local language from them should not cause them to misconstrue or lose sight of the workshop's PD objective. For instance, we learned from the questionnaire interviews in Phase IV that while at least two participants clearly understood the workshop's PD goal, five other participants gained the impression that the workshop was intended for us to learn Hindi from them.

Importance of Local Adult and Child Facilitators

In addition to the above steps, local facilitators proved invaluable in strengthening the design partnership. We stress, however, that more comparative research is needed given the preliminary nature of our observations about how both adult and child facilitators affected the workshop differently. The recommendations in this subsection should thus be viewed as directions for future comparative studies.

As cultural guides and as local intermediaries between us and community stakeholders, adult facilitators helped the workshop to progress smoothly. For instance, it was an adult facilitator who explained the rural parents' mindset that necessitated the daily review sessions. Similarly, both adult facilitators understood the importance of maintaining good relationships with the teaching staff and took the initiative to explain to them, after the workshop had ended, how their presence affected the rural student participants and had forced us to request that they excuse themselves.

Child facilitators presumably lacked the maturity for the above roles. Along this line, while both adult facilitators understood their role as design partners, nearly all child facilitators displayed a tendency to spend too much time on teaching their rural counterparts English even though this was only a means to facilitating the design of EFL games.

Despite coming from different socioeconomic backgrounds, however, we observed that (urban) child facilitators and rural students interacted spontaneously with each other. More importantly, child facilitators were highly enthusiastic in encouraging rural child participants, such as by clapping and cheering them on. By complementing the adults, c*hild facilitators seemed to be effective in reaching out to their rural peers and in establishing an encouraging atmosphere for them, hence making rural student participants more confident in performing the design activities*.

Low-Tech vs. High-Tech Prototyping

We had indicated earlier that participants enjoyed high-tech prototyping significantly more than low-tech prototyping. In this section, we reflect on these observations and discuss their implications for PD with rural school children.

Low-Tech Prototyping

Low-tech prototyping was highly frustrating because rural student participants found it difficult to come up with initial ideas and to iterate on their initial designs. To illustrate the tensions associated with these moments, we show a typical low-tech prototyping scene that included a participant (P), a researcher (R) and facilitator (F):

P: I can just tell you the meanings whenever you want.

R: But I want to learn the meanings from the game itself. I like this game, but how can I learn the words from the game itself?

(10 minutes pass; participants take frequent breaks and look unenthusiastic.)

P: I can't think of anything.

F: Nothing? Try and change the game that you have.

P: I don't understand.

F: So what don't you understand? You can't learn meanings from this game, can you?

P: No, I don't know what I can change.

Even though participants should have found low-tech prototyping to be easier by drawing inspirations from Word Munchers, they continued to respond with blank stares and silence after we asked them to recall features in this game.

Hi-Tech Prototyping

In sharp contrast to low-tech prototyping, participants told us that they enjoyed Phase III because they were given the opportunity to create games using the computer. Their enthusiasm was remarkably different from Phase II. A characteristic hi-tech prototyping scene looked like this:

R: So now you know how to do animations. How can you change your game to be as fun as Clifford?

P1: Using animations for example? We can make it move left and right…. we can make things go left and right like in Clifford.

R: Right now, you're matching labels to pictures. How can you change that to be more fun… What did Clifford do every time you got something right?

P2: (nods)…When we see a door, we can make the door open. The lion in the picture can roar. The man can fall at some point.

P3: If we write the man's name correctly in the box, maybe he can climb up the ladder. Can we do that?

R: Sure, yes you could do that. What else would you want to do?

P2: When the elephant comes on the screen it should trumpet.

Participants also expressed pride and ownership over their hi-tech prototypes:

F: How does [this hi-tech prototype] compare to Clifford?

P: I like this game more.

F: What is in this game that you like that's not in Clifford?

P: The numerical point system and the messages constantly spoken by the central character.

Despite limited time and experience with SC, participants seemed to have gained more insights into what they could accomplish as co-designers of games. There appeared to be five important lessons. First, although participants took ideas from Word Munchers and Clifford, they expressed their preferences in designs that came to differ eventually from these examples. That is, *a small selection of examples seemed to be sufficient for stimulating rural school children to get started in brainstorming alternative designs*.

Second, participants used primitives (e.g. animation, audio playback, textual labels, etc.) in SC as building blocks for their designs. The more important point was that *it was feasible to teach rural school children in a very short time about features that they could incorporate into their designs by demonstrating constituent primitives to them*.

Third, our findings ran counter to most of the literature, which showed and/or assumed that low-tech prototyping was effective with children [e.g. 9, 24]. It was likely that rural students had little exposure to software and could not imagine how software worked via low-tech representations. We concede that our high-tech prototyping attempt might have been just as unsuccessful as low-tech prototyping if we had started the former on a "blank slate", as opposed to showing participants how they could import characters from the SC libraries and drag these characters around on a themed background. In other words, it was likely that high-tech prototyping resulted in more creative designs because it was based on the laminated cut-out model [24], which was effective in stimulating children to generate ideas for low-tech prototypes. Nevertheless, because participants asked throughout Phase II when they could resume using computers, *a hi-tech medium seemed more appealing to rural school children regardless of the ideation approach.*

Hence, the fourth lesson is that more comparative studies between low-tech and hi-tech prototyping, as well as more research into the latter as a candidate methodology for participatory design with rural school children, are needed since the latter departs from several previous participatory design attempts with children. In any case, *we do not think that low-tech prototyping alone would excite rural parents, who are more likely to support their children in attending the workshop if their children could gain computer literacy.*

Fifth, *hi-tech prototyping did not necessarily replace low-tech prototyping; both approaches in fact complemented each other.* For instance, whenever participants could not implement their ideas in SC, either because of inadequate time or unfamiliarity with SC, we observed that they would switch to using paper to prototype envisioned features. *Hi-tech prototyping could therefore inspire participants to create more comprehensive low-tech prototypes.*

Videotaping

Whereas videotaping was not recommended based on prior experiences in the First World because children tended to "perform" or "freeze" in front of the camera [e.g. 9, 10], *we found videotaping to be highly indispensable*. We concede that video cameras were novel to our participants but their excitement at being videotaped wore off quickly. More importantly, participants did not react nervously to video cameras that were mounted on tripods or carried around by researchers, and showed signs of tension only when looking directly into the camera. As such, *video cameras can be used inconspicuously with rural school children by seating them so as not to face the camera*.

We found video to be useful for two purposes. First, much of the interaction during the workshop took place in Hindi and contained valuable design ideas, especially in Phase III. It was only after transcribing and translating these records into English that we understood the extent of creativity that had taken place during these sessions. Second, participants encountered usability challenges with software much more frequently than their peers in the First World. The video records provided us with many insights into how we could improve usability design and tutorial sessions for them.

CONCLUSION

Current initiatives in making computing hardware more accessible to rural schools in the Third World have made some progress and promise to make further strides. But for these platforms to deliver greater value to their end-user communities, hardware innovations must be accompanied by software that targets local conditions and needs, and this calls for participatory design with rural school children and other local stakeholders. Otherwise, contemporary efforts to extend the information technology revolution to these underserved communities are not likely to succeed – not because critics are necessarily correct that rural school children in these regions have no need for computing technology – but simply because we have not listened closely to them when designing technology for their needs.

Although rural students were our target users, we found that gaining the support of parents, local facilitators (both adult and children) and local teaching staff was critical for a productive design workshop. We showed that a small but well-chosen sample of example EFL games was useful in guiding rural school children to grow as effective co-designers who were capable of adapting on ideas in these examples to culminate in designs that they were proud of. The opportunity to think in terms of and to manipulate virtual characters seemed to be another key factor in helping rural school children to generate ideas. Despite the benefits of low-tech prototyping, however, we also argued that salient aspects of low-tech prototyping should be incorporated into hi-tech prototyping media so as to facilitate a more creative co-design experience.

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