A Design Process based on Field Research:

An Adjustable Desk for Children in Rural India

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Abstract

Learning is an essential element for social, cultural, and economic growth in developing countries. Effective learning requires education materials like desks, books, and writing instruments. However, most students in developing countries do not have sufficient access to these basic materials.

This research examines desk designs for children in developing countries that are having trouble in learning due to lacking education materials. We conducted field research in the West Bengal region of India over the past three years. The study was performed using human centered design (HCD) toolkit developed by IDEO.

Because entire families were living together in a single small room, we found that what students needed most was study space. The desk we designed uses a folding structure so that it can be used in small spaces. It is also height-adjustable, making it possible for any students to use it. Moreover, it is designed for both floor-sitting and chair-sitting positions to meet the needs of local students.

In this research, we utilize a design process that is based on field research and catering specifically to local needs to create suitable product for users in developing country. The findings of this research can apply to students of other developing countries.

Keywords

Adjustable desk; Human Centered Design; Field Research; Research based design

Although education is one of the most important issues in developing countries, students in poor areas, both socially and economically, are not given the resources required for learning. Achieving primary education is presented as an important goal in the Millennium Development Goals set by the UN in 2000.

The most important aspect in providing learning resources is to figure out what the students need and what benefits them the most. This is important because the optimal learning resources can be differ depending on the level of the students. As these variables are dynamic, learning resources should not be provided without understanding the students. However, most design projects for developing countries design their product and decide which materials to use from the viewpoint of people not familiar with the local context. In other words, the circumstances of local people need to be taken into consideration.

As providing resources without field research will be more likely to bring them what the project manager believe to need, it will be likely to be neglected in the end because the local people do not know well how to use or what to use.

In this research, we determined the needs of students using field research. Methods used include interviews, house visitations, creating prototypes and conducting a workshop to gather feedback. Through this process, we managed to devise localized solutions that can be used locally, giving people the ability to create the products on their own.

Motivation

To conduct this study, we visited a rural area that is located one and a half hours from Kolkata in the Bengal region of western India. The research was carried out in cooperation with the Southern Health Improvement Samity (SHIS), one of the largest NGOs in the region. SHIS has been operating deaf and dumb as well as girls' schools for free, to promote the development of the region and to improve local women rights.

As part of a cooperative project, the authors of this paper were part a research team that visited schools operated by the SHIS since 2011. The research team is continuously visiting this area, as part of a volunteer activity program. Thanks to these trips, we came to realize that the learning environments in SHIS schools and the surrounding areas were not good. We took this a chance to be able to advance the research and to develop a solution aimed at improving the learning environment of the region.

Related works

The Need for the Desk

The gap between the rich and the poor is a serious problem in India; it is primarily caused by its class system and the economic sociological structure (Marilyn, 2006). Students continuing their education and moving on to senior schools can be a factor in breaking the vicious circle of wealth only being handed down. Improved education also contributed to the improvement of human rights and income levels (Marilyn, 2006; Hill & Sandfort, 1995). It has been pointed out that an overall improvement of the educational environment is needed for improved academic development; opportunities to learn are relatively limited for elementary school children in developing countries, which are one of the causes of low academic achievements in these countries, according to many studies. They also insisted that individual habits of voluntary learning will help to improve academic achievements and thus facilitates students continuing their education at senior schools. Despite individual learning spaces greatly affecting academic results, most researches focus on building a classroom atmosphere in schools, rather than focusing on individual learning.

Design and Fabrication of the Desk

The size of desks and chairs for students is important, as physical growth can be impaired by improperly sized products and issues like backaches and arthritis can be caused. In India, students enroll in school at slightly different ages, meaning that their physical growth rates cannot be assumed to be consistent. This has to be accounted for when designing the desk (Ashiedu et. al, 2013; Marilyn, 2006).

Studies on the varying sizes body sizes and growth rates of student indicate that size groups can be subdivided in three to five levels, with appropriate sizes of desks and chairs varying in each group. More specifically, other research shows that the posture when using desks, in conjunction with different factors of body sizes, should influence the design of chairs and desks. The designs were mainly based on gender, age, grade and size of body.

Field Research Methodology

Field researchers mainly use the naturalistic survey method. Even though it is the best method, other methods are preferable if research is only conducted over a short period, like in this case. The human centered design (HCD) method is a tool kit that was designed by IDEO and it is intended to help devise solutions for improving the lives of people in developing countries in particular. Its effectiveness has been validated by the researchers who shared their experience on the website 'ideo.org'. The HCD method makes use of products, services, environments, and organizations, and it will help facilitate emotional interactions between people. Data obtained in this manner can be converted into ideas or new opportunities and solutions (IDEO, 2009). For these reasons, we chose to use the HCD method in our research.
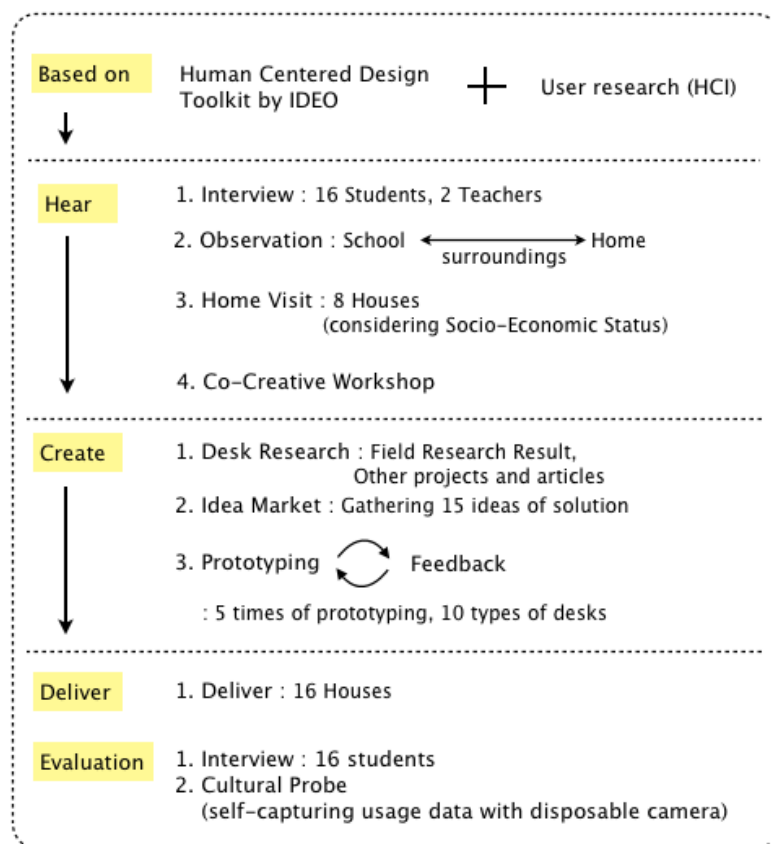
Method

Fig 1: Research process.

Human Centered Design Toolkit by IDEO

The HCD toolkit was developed by the consulting firm IDEO; it provides a new solution specifically for people, non-profits, and social enterprises (IDEO, 2009). The concept consists of three parts: 'Hear,' 'Create', and 'Deliver'. 'Hear' is the process of listening to the needs of the people and communities, and 'Create' is the process of finding solutions on the basis of their needs. The purpose of the 'deliver' phase is to successfully implement solutions in specific contexts (IDEO, 2009).

Hear

At first, we conducted various interviews, observation and workshop to gain an understanding of the local context and educational problems. Based on the HCD guideline, semi-saturated interviews were performed with eight students from girls' school, eight students of a deaf school and two teachers of each school. To select participants, we divided whole students into 3 groups by their socio-economic status. After that, the participants were randomly selected from each group.

First, we asked the students about relations with friends, their future dreams, and their education environments. We used a whiteboard to let them draw their daily life patterns, bypassing language problems and helping us to understand their situations. Then, we asked the teachers about subjects, preparations of lessons, and classroom environments.

Next, we observed the overall school environment, including the classrooms, corridors, educational materials and facilities, play grounds and course works.

We also performed group interviews with the students' families in their homes, so that we could understand the education situation in more detail. Starting with the basic information of a family, we asked about their educational philosophy, the structure of decision-making, the marriage, and education issues. In addition, we observed the general situation in their homes, including the living spaces of students, so that we could better grasp the cultural context.

Lastly, we conducted co-creative workshop to generate comments from local people including students, their parents, teachers and NGO members. We showed them the collected interview data and observation results and shared what issues we found to get more feedback from them.

Create

After we completed first phase, we analyzed the interview data and held a workshop to generate ideas on how to solve the problem at hand. We developed a number of concepts in this workshop. Individuals showcased their solutions explained them to other team members. Then, the research team members chose a variety of desks they thought addressed the most important issues relevant for primary students.

We then created desk prototypes using agile methods, repeating and reproducing the design process. Because almost every prototypes needs to be refined several times to meet the exact need of users. So we also shared our concepts with local people and received their comments through regular contact with SHIS in India. This input helped us to enhance our concept and influenced the final shape of the desk. Thus, the design was at least in part a bottom-up one.

We sent several design drawings to local contacts in India so that they could review them. After we arrived there, we produced the desk using local materials and workers.

Delivery

The prototype of desk we produced in India was distributed to eight students in both the girls' school and the deaf school. When visiting their houses to deliver the desks, we observed how the students were using the desks and interviewed them to evaluate its suitability in terms of size and weight. After a simple explanation, we investigated how to use the limited space students had available at home. In addition, an interview about how the students studied at home was conducted and the desks were assessed.

To observe the students' daily usage patterns with minimal observer contamination, we used the cultural probe method as per the HCD toolkit. (IDEO, 2009) We asked students to photograph themselves for three days with disposable cameras each time they used

the desks. The students received various 'photo-taking missions' for all of the 13 different types of desks. They had missions like "Where to place my desk" and "images of desk in case of folding the desk". The photos from these missions allowed us to understand how they used the desk in their daily lives, which is something that cannot be gained purely from investigators observing the students.

After the cultural probe for ran for three days, we performed a brief survey to review the desks. It could be rated on a 'Good / So-So / Bad ' scale and it also included questionnaires about preference associated with the overall usability, weight and assembly of the desk. After the survey, we interviewed the students based on their answers.

Result

Hear

1) Interview

We interviewed 16 students, two teachers, and eight households. Every interview took two hours and the results are shown in the following diagram.
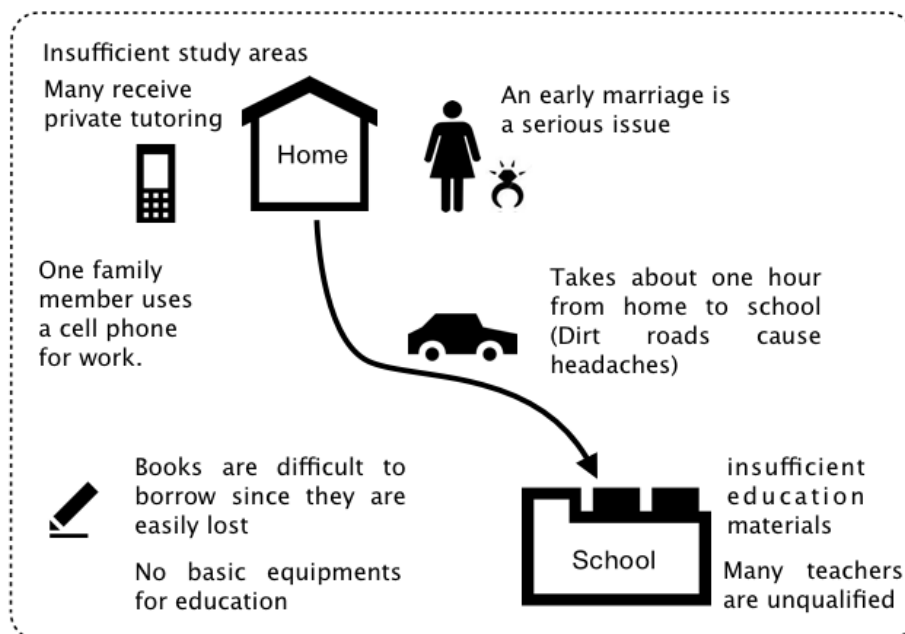

Fig 2: Profile of students attending the girls' school.

Only have access to hearing aids in bad conditions due to high cost

Although they have dreams, they cannot achieve them due to poverty

Home

Poverty and insanity

Insufficient study areas (all the family members share one room)

private tutoring is required for school entrance

No household possesses computer (Yet, if one is able to use computer, one may work to receive twice the salary)

School

School is a secure zone for students
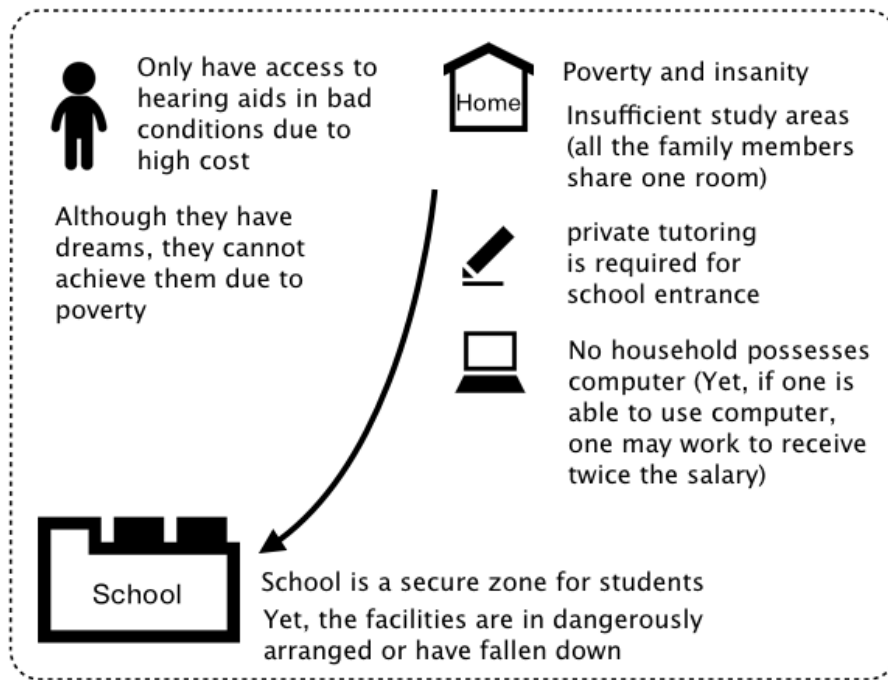Yet, the facilities are in dangerously arranged or have fallen down

Fig 3: Profile students attending the deaf & dumb school.

The interviews showed four important results:

i. Study behavior.

Students are educated not only through their school but also by private tutors and they need to take two tests per year. To get a good score, they have to study by themselves at home, review lessons, and complete homework. However, they study on uncomfortable wooden beds or on the floor with pencils, notes, and textbooks.

ii. Lack of educational instrument in their house.

Except for the three richest students we interviewed, most did not have a study space available at their homes. Most of the homes had one or two rooms that were shared by six to seven family members. There was no space available exclusively for studying as all the spaces had multiple purposes and were occupied by other family members regularly. In addition, most of the houses were made of wooden walls and poor fences. Also, almost half of the structures were open in nature and thus prevented students from concentrating.

Fig 4: House visit interview

iii. Understanding the purpose for studying

Most of the students have the enthusiasm to study hard for three to four hours per day, on average. Even though there are many disruptions and the environment is generally poor for study purposes, most students keep their occupational goals for the future in mind and are thus intent on attending senior schools.

vi. Parents' thoughts

We also interviewed the parents of the students and asked what they wanted their children to be. They hoped their children would become doctors, teachers, or civil servants—all of which are occupations that are regarded as successful by society. The parents of the hearing-impaired students were hoping that their children would work in tailoring or desktop publishing. We found that the parents wanted to support their children's dream so that they could live without economic burdens; however, most could not afford the books, reference materials, writing instruments, and the private tutors.

2) Co-creative workshop

By analyzing the results of the interviews, student profiles for both schools were created (Figure 2, 3). The co-creative workshop continued and the students were invited to vote on issues they felt were most relevant. The students in each school pointed out that the main issues were insufficient study materials and the long distance between home and school.

Create

1) Field study and idea workshop (idea market).

The research team analyzed the results of the field research to design a solution to the problems that were found. We developed and shared an idea through the idea workshop, which we called 'idea market'. The idea market produced a total of fifteen ideas, for example, supporting library that everyone in the classroom could use; an entire wall of the classroom was used as a board for collaborative learning in this case. After considering the cost of implementation and the local problems we found, we decided to develop a solution for the ideas associated with the study spaces.

2) Prototyping

The trial and error process of making a prototype went through five phases, beginning with the idea meeting and continuing with the processes of implementation, production, test, and evaluation. Whenever a prototype was completed, we received comments from Indian local members (students, teachers, NGO head) via e-mail and telephone. We also invited experts of various fields to evaluate the finished prototypes. The comments at each stage were used to incorporate improvements in the next prototype. The basic requirements of for the production of the next prototype were as follows:

1) Considering the age range of school students, from 5 years old to 16 years old, we set the target user of this prototype.
2) When not used, it must be foldable so that it can be stored in narrow spaces.
3) It should be light enough to be moved by the students themselves.
4) Height adjustment must be possible so that any student can use the desk regardless of his or her physical condition.

Each prototype was crafted with a production and development cost of less than USD 40. The cost of the final production was targeted to be below USD 20. The desk prototypes were produced for two months, with each prototype taking one to two weeks.
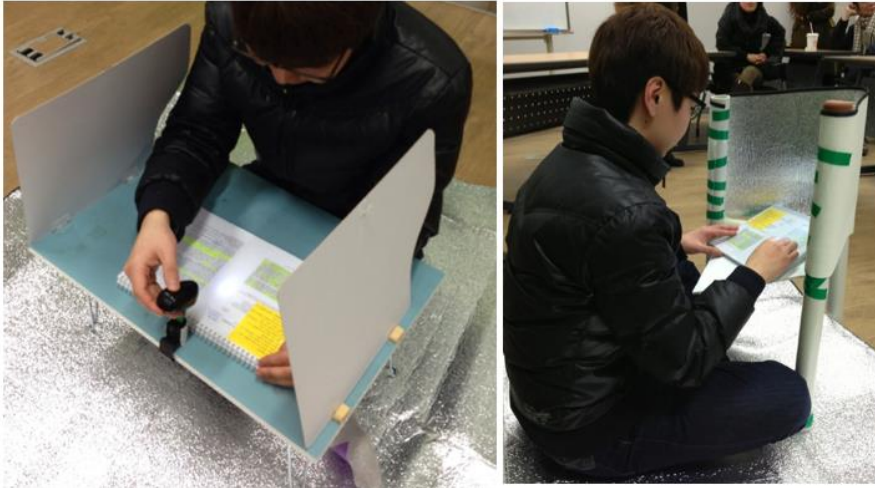
Fig 5: Prototype 1, type A (left), type B (right)

The first prototype had two sub-types. Type A was a folding desk designed for a sitting position. This structure was stable and showed no signs of shaking, but there were two problems: the viewing screen did not protect the desk properly and the space was not sufficient to study. Type B was produced later and consisted of two H-shape frames. This offered an improved viewing screen thanks to the adjustable angle of the curtain and was very light, but it was not stable.

Fig 6: Prototype 2, Type A (left), Type B (right)

The second prototype also had two types. Type A used a triangle shape to reduce the weight. During study, space was not perceived to be too limited, but it was difficult to use in a sitting position because a height adjustment was not possible. Type B was made using wood instead of PVC. Shaking was reduced a little, but the improvement was not sufficient for everyday usage.

Fig 7: Prototype 3

There was only one type of the third prototype. The desk used an adjustable folding structure, making it easy to store, and the viewing screen was also adequate. The screen wall allowed posting notes on it during study. By expanding the doors and putting a plate on them, a study space could be created. The table could be adjusted in height by grooving four parts. In addition, assembling a supporting post next to the intermediate plate reduced shaking. However, it was heavy and difficult to produce because drilling the middle part of the wooden plate was required.
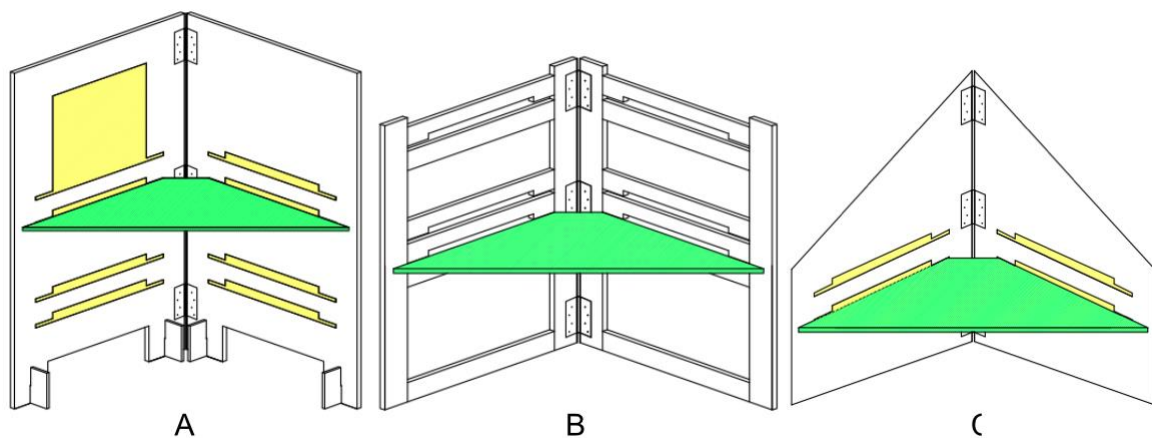

Fig 8: Prototype 4 - window type (A), frame type (B), lap type (C)

The fourth prototype was produced in three variants. The primary goal with this prototype was to reduce weight while not significantly affecting shaking. Type A used a window model and type B used a frame. The window type allowed the selection of various heights by creating a window. We tried to reduce the shaking by placing the support in the lower part of the desk. The frame type consisted of several wooden sticks that functioned as frames and replaced the large plates. After reconsidered the sitting habits Indians showed in their daily life, we created a new version that could be used in the sitting position. This was labeled as lap type (C).

The drawings of three types of the fourth prototype were sent to India. After arriving there, each desk was produced using tougher wooden materials. The work was completed with the help of existing materials and in consultation with the NGO, as well as the staffs of the

local woodworking shop. The prototypes were evaluated by the local NGO staff, students, and parents.

Fig 9: Prototype feedback session

The parents submitted the following feedback:

"It is good because of the foldable design, but too unstable."; "It would be better if the curtains were a little larger."; "It would be better if the desk boards were a little larger."; "It would be better if the height was more adjustable."

The students commented:

"We need more desks."; "It's shaky."; "Memo board looks good."; "Convenient to use in lying position or sitting position on the desk"

The teachers commented:

"It is useful when using a notebook while reading textbooks." The fifth prototype was designed by synthesizing the comprehensive advantages of the three types based on the comments from the local users.

Based on the feedback, we updated the requirements for the desks:

1) The frames in the wooden columns should not shake.
2) The curtain should be wide and spacious. It needs to also function as memo board.
3) The desk should be foldable so that it can be easily stored and the height needs to be adjustable.
4) Moisture resistance and durability should be improved by coating the desks with paint.

A final prototype (Figure 10) was created based on these principles. A simple design was developed that can be assembled in less than thirty minutes by connecting the wooden materials. It should be height adjustable and a memo board should be available both in the sitting position and on a chair. It should withstand moisture after it is painted.
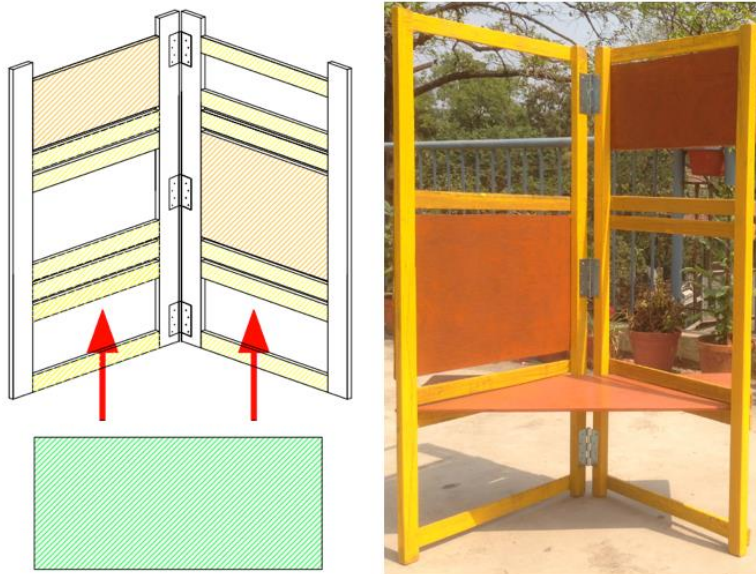
Fig 10: Final prototype drawing (left), product of prototype (right)

Delivery and Evaluation

After the desks were delivered, we observed their usage and received comments. As discussed, most students have no rooms of their own or even space due to a lot of family members being around while cooking, eating, knitting, and sleeping in the same space.

Even if houses had more than one room, it would be rare for students to able to use the room alone. It is difficult to study in a bed for a long time because there is only one bed per room. Thus, we designed foldable desks that allow students to create independent rooms to study. A feature that attracted attention is that you can open the desk when studying and then fold it back together. This was received very well because the foldable nature in conjunction with the ample viewing screen helps students to concentrate on studying even in the aforementioned conditions.

The height adjustability function was also well-liked from the parents and the students. Since siblings can use the desks at different height settings, the usefulness of the desks is increased. Students can also customize tables for both floor-sitting mode and chair mode, depending on the situation.

However, there were several problems that still need to be addressed. The stability of the desk was the main issue. Most students still said that the desk was "too shaky". In addition students that preferred to study in sitting positions commented that the height of the desk was too high. Further, students also needed space for books and other materials.

The images we received from by the parallel cultural probe showed how the locals used their desk in practice when no observers were present. Looking through the photos showed that they were using the area on the outside of the desk because the desk area itself was too narrow and did not allow opening two books at the same time. Most students sat on the floor or used the desk while sitting on the floor and few students used the memo board.

Fig 11 : Result of Cultural Probe

Discussion

This research focused on two main aspects; the first is the experience of designing through both field research and communication with local users, and second designing a desk for children in a developing country. The desks were made locally and distributed to 16 households based included in the field research. During the evaluation by local users, the following issues were found.

1) Importance of the field research

The local situation makes it difficult to make substantial use of the desks because there is a lack of personal spaces for study through, as found by our field research. The idea of creating folding desk was derived from this. This allows students to secure a space for their own folding desk so that they can study.

Our research showed that Indian families rarely buy furniture due to its price. The furniture, they buy is often used for a whole life-time. The height-adjustability feature of the desks was based on this finding; we intend for students to be able to use the desk from a young age through to adulthood. Without the field research, it would have been difficult to determine the most significant problems local people have.

2) Localization is important.

Localization is the most important thing for solutions in developing countries. Even though the solutions were based on field research, the results are useless if the solution cannot be localized. In the case of the desk, for example, we were trying to figure out a way to make assembling the desks in local areas possible right at the beginning of our project. We found that the desks could be manufactured locally if there were no financial hurdles. This means that a localized product allows for the production of additional desks without the help of foreign experts.

3) Customized designs are important.

The manufacturing and design process must be repeatable. Sometime the designers' intention and the needs of local people do not match perfectly because the designer

cannot completely understand the local situation and constraints like time and cost factors. Sometimes it can seem as if products are not providing enough utility despite actually meeting the local needs. This is why a product evaluation by both locals and experts is crucial during the prototyping stage. In this study, the final model was produced based in design iterations that were incorporated feedback from the end users.

Conclusion

The goal of this study was to provide a folding desk for studying to local students in the West Bengal region of India. The design process started by the research team visiting the locals to determine design parameters based on the problems we found with the learning resources students had available locally. This was the first of many visits.

Our field research was conducted using the HCD and the HCI research methodology. Based on our evaluation of the local context, we designed a desk that was both foldable and height adjustable; 16 desks were distributed to students for further evaluation and observation purposes.

We found the value and necessity of field research to meet the needs of local student and understand local context in designing appropriate product. If designer make a product without field research, the product would be useless because local people may not accept the product to several reasons like normal consumer in urban market.

However, the final prototype in this study is still shaky and needs more table space. For our next study, we would like to visit India again and re-evaluate the desk. In next study, we try to minimize the cost of this desk (now it is 20US$ each), and we will discuss new structures and auxiliary furniture which can help using this desk.

References

Marilyn Jacob, M. (2006). Changes in the wage gap of gender and caste groups in India.

Hill, M. S., & Sandfort, J. R. (1995). Effects of childhood poverty on productivity later in life: Implications for public policy. *Children and Youth Services Review, 17*(1), 91-126.

Ashiedu, F., & Amiebenomo, S. O. (2013). Investigation into the applications of ergonomic principles in the design of school furniture in Nigeria.

IDEO, HCD Toolkit. (2009). from http://www.ideo.com/work/human-centered-design-toolkit/.

Hira, D. S. (1980). An ergonomic appraisal of educational desks. *Ergonomics,23*(3), 213-221.

Marschall, M., Harrington, A. C., & Steele, J. R. (1995). Effect of work station design on sitting posture in young children. *Ergonomics, 38*(9), 1932-1940.

Knight, G., & Noyes, J. (1999). Children's behaviour and the design of school furniture. *Ergonomics, 42*(5), 747-760.

Gouvali, M. K., & Boudolos, K. (2006). Match between school furniture dimensions and children's anthropometry. *Applied Ergonomics, 37*(6), 765-773.

Floyd, W. F., & Roberts, D. F. (1958). ANATOMICAL AND PHYSIOLOGICAL PRINCIPLES IN CHAIR AND TABLE DESIGN∗. *Ergonomics, 2*(1), 1-16.

Ray, G. G., Ghosh, S., & Atreya, V. (1995). An anthropometric survey of Indian schoolchildren aged 3–5 years. *Applied Ergonomics, 26*(1), 67-72.

Savanur, C. S., Altekar, C. R., & De, A. (2007). Lack of conformity between Indian classroom furniture and student dimensions: proposed future seat/table dimensions. *Ergonomics*, *50*(10), 1612-1625.

Storr-Paulsen, A., & Aagaard-Hensen, J. (1994). The working positions of schoolchildren. *Applied Ergonomics*, *25*(1), 63-64.

Bae, K. (2010). A Study on Development Cooperation Policy Model of Korea : Focused on International Comparative Analysis of ICT4D. *International Development and Cooperation Review.* 3(1)

Benavot, A., & Amadio, M. (2004). A global study of intended instructional time and official school curricula, 1980-2000. *Manuscrit non publié, BIE-Genève.*

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