Evaluating Netbooks in Education: A Discontinuity in Mobility

Erik Geelhoed, Jhilmil Jain, April Slayden Mitchell

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We studied the use of netbooks (HP Mini-Note 2133) by students in the age range 11 - 14 years in three schools in different geographical locations: Fresno (California), Sao Paulo (Brazil) and Shanghai (China). We found that netbooks are a major departure from traditional laptops: they are moved around in the class room with great ease, are much more part of the social flow in the classroom, and stimulate collaboration. In addition, the power and small form factor of the device stimulated the children's visual creativity. Looking at the wider ecology of home computing, other mobile devices and social networking, we gained further insights in how future netbooks can be embedded and integrated into the highly social and emotional flow of teenagers' lifestyles. From the schools' perspectives (teachers, IT-decision makers), we learnt that the form-factor and price of the netbooks are ideal for the educational environment, but challenges lie in creating innovative solutions for content management, infrastructure support, and integration of educational software with school curriculum/standards. From the parents' perspectives, we learned that they were supportive of the netbook usage in the classroom and described their children as being more engaged in class when using the netbook. We also present a simple model of mobility and place the netbook device in this framework.

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ABSTRACT

We studied the use of netbooks (HP Mini-Note 2133) by students in the age range 11 – 14 years in three schools in different geographical locations: Fresno (California), Sao Paulo (Brazil) and Shanghai (China). We found that netbooks are a major departure from traditional laptops: they are moved around in the class room with great ease, are much more part of the social flow in the classroom, and stimulate collaboration. In addition, the power and small form factor of the device stimulated the children's visual creativity. Looking at the wider ecology of home computing, other mobile devices and social networking, we gained further insights in how future netbooks can be embedded and integrated into the highly social and emotional flow of teenagers' lifestyles. From the schools' perspectives (teachers, IT-decision makers), we learnt that the form-factor and price of the netbooks are ideal for the educational environment, but challenges lie in creating innovative solutions for content management, infrastructure support, and integration of educational software with school curriculum/standards. From the parents' perspectives, we learned that they were supportive of the netbook usage in the classroom and described their children as being more engaged in class when using the netbook. We also present a simple model of mobility and place the netbook device in this framework.

Author Keywords

netbooks, education, user studies, mobility, mini notebooks, subnotebooks

INTRODUCTION

Netbooks (also known as mini notebooks or subnotebooks) are a quickly growing category of small, light and inexpensive laptop computers. They are designed for mobility, wired and wireless network access, and general office applications. They typically weigh approximately 2-3 pounds and feature LCD screens between 6-10 inches.

Although ultra portable laptops have been on the market as early as 1993 (e.g. HP's Omnibook 300), the trade-off between portability and functionality has met with limited success. However, the sales of recent netbooks, which have most of the features of traditional laptops but in a much lighter and smaller form-factor, has been encouraging, particularly in education [e.g. 18, 19]. By focusing on the next generation mobile computer users in the highly social setting of the classroom and the home, the current study sheds light on what the value points are for netbooks.

Research firms such as Gartner [20], DisplaySearch [21] and IDC [22] report that 1 in 5 laptops sold today is a netbook, and the market share of netbooks is growing with the economic downturn. Gartner claims that 2009 is the "*year of the mini-notebook*" [23]. Yet currently, in the public domain, there are not many published in-depth user studies around netbooks, and hopefully our study will make a major contribution.

RELATED WORK

Understanding Netbooks

There have been two high-level online surveys conducted by ThinkFree and ABI Research to understand the netbook devices.

In 2008, ThinkFree conducted an online survey [13] of office suite & online business tools usage. The survey mainly covered European users (readers of PCplus, MACplus magazines). The main finding of the survey [14] was that with consumer confidence tumbling, users have become extremely sensitive to price points. Thus affordable and user friendly cloud computing applications may gain further market proliferation over the coming months. Netbook computers make a perfect companion to cloud computing applications. The top 3 uses for netbooks were for blogging, entertainment (web browsing, music) and communications (email, IM). Finally, the survey found that people demand their netbook applications to have speed (quick start up); small footprint (light on resources); simplicity (easy to learn and use); optimization (adaptation to smaller screen dimension).

In November 2008, ABI Research conducted an online study [15] among adult US consumers concerning their interest in and expectations of a number of consumer technology products, including netbooks and mobile internet devices. Questions were asked about interest, reasons for not being interested, whether netbooks are

viewed as primary or secondary to a PC, applications, preference for pre-installed applications, optimal size, operating system preference, and price. While their low price does cause some consumers to view netbooks as a replacement for a laptop given the current economic conditions, the majority (80%) view a netbook as being a secondary device.

Our more in-depth study not only confirmed the above findings but we uncovered a number of different issues around mobility, collaboration, integration with other devices etc.

Mobility in Education
While the netbook devices themselves have not been studied, there have however been a number of publications highlighting that mobile phones are well suited to being used as a learning tool [16, 17].

Considering a more developmental angle, recently an unusual study has been reported on the development of the social brain [1, 2]. The pre-frontal cortex, which is associated with social behavior, undergoes significant changes during puberty, resulting in a (up to) 100 fold increase in speed of transmission. In addition, as people develop from neo-natal to adulthood, a (non-linear) decrease takes place of grey matter in the brain whereas there is a linear increase of white matter. Around the age of 14 there is a cross-over of these developments which is associated with 14 year olds (in particular girls) having an unusual intensity in (peers) social (networking) behavior. This would make them an interesting exemplar age category for social networking.

METHOD
We studied the use of Hewlett-Packard's rugged Mini-Note 2133 [3] across a four day period in three schools in separate geographic areas - the United States, Brazil, and China.

Participants
At each school we interacted with students at the 7-8th grade level most of whom were 12 – 14 years old.

In Fresno, California, the students had been using netbooks for about three weeks. We interviewed 13 students, and 192 students filled out a questionnaire. The netbooks were used by the students while in a particular classroom only and they were not allowed to take the devices home. Students accessed the network via wireless access points. Fresno includes areas with high "concentrated" poverty levels. The area has large numbers of immigrants and 85% of students in the *Fresno Unified School District* migrate from one school to other within a school year.

In contrast, the *Chapel School* in Sao Paulo, Brazil, is an International school with children of wealthy and often foreign families. At the time of our visit, the students had been using the netbooks for about three to five weeks. We interviewed 19 students who also completed a questionnaire. They were allowed to take the netbooks to other classes, to the school library and, most importantly, home. While at school, students had wireless internet access on their netbooks.

At the *Wujing School,* in the outskirts of Shanghai, students (with parents making below average incomes) had been using netbooks for about three weeks. We interviewed four students and 20 completed a questionnaire. Usage was restricted to one classroom only, and the netbooks were tethered by LAN and power cables.

In spite of the economical differences, all three schools had good computing facilities, good quality (healthy) food in the canteens, and a mostly young and enthusiastic teaching staff dedicated to their students.

Methods Used
We employed a number of complementary qualitative and quantitative data gathering techniques: observations, interviews (with students, teachers and parents) and questionnaires. We observed their use of netbooks in the classroom during lessons; we took notes, photographs and we recorded video (and audio) footage. We interviewed students at school during the day and some at home, with questions centered on netbook use in class as well as a wider context of computing and other technologies. The questionnaires were organized under the headings:
- About your Mini-Note
- At school
- Taking the Mini-Note with you
- Home computing
- Mobile phone use

For the majority of questions, we used a graphic rating scale [4], rather than an absolute scale like Likert. In a graphical rating scale, participants show the intensity and direction of their response to a scale by making a mark on a line drawn between two labeled extremes (e.g. Very much…………Not at all).

There were two versions of our questionnaire. The first was used in Fresno, and the second was refined based on our experiences and used both for Sao Paulo (in Brazilian Portuguese) and Shanghai (in Chinese). For Sao Paulo, while we had translated the questionnaire to Portuguese, the students had strong English language skills and did not need to use the Portuguese questionnaire. In Shanghai, all questionnaires were in Chinese, and we used native translators when students had questions about the questionnaire.

Procedures
We recorded our interviews with the students and the audio files were transcribed, annotated, and categorized. We analyzed the quantitative data with SPSS (Statistical Package for the Social Sciences), using Analysis of Variance (ANOVA, for legibility we only provide p-values) and Multi Dimensional Scaling (MDS). The observational data analysis resulted in a number of video clips

highlighting key points. (Note: due to privacy/legal reasons, we will not be able to share photographs).

FINDINGS

Student Observations

New dimension of sharing: ease of movement
The observational data were most informative. In the classroom, the netbooks were moved around by the students, with great ease, sometimes using just one hand. A few reasons for the movement were: to show other pupils what is on their screens, to quickly grab another pupil's netbook in order to help them with a problem, or to walk up to the teacher and ask for advice. In addition to liking the portability of the netbooks, students also preferred being able to stay in the class environment while using their computers and not having to go to a (remote, sterile) computer lab.

"It's actually really light; you can pick it up and take it to the other people across the room. You don't have to say 'come here, come here.'"

"We could use the Mini-Notes instead of going to the Computer Lab, which was nice. If it's not in a bag or anything, I would carry it like this with both hands. If it's shut it's easier to carry because then you can usually carry it with one hand."

The students also move traditional laptops around (although less frequent); thus, movement is part of their behavior. However, they did describe laptop portability as a more precarious situation requiring carefully handing over the larger devices.

Usage at home
The Sao Paulo students were allowed to take the netbook elsewhere on campus and home.

"I take it home every day and I bring it to school every day too; that's when we have Science class. I use it in English to type some things, come to the library sometimes and sometimes to my Mum's office, she works here."

"At home, I'd use it mostly to finish work or something because for me it's easier just to continue it here [on the mini-note] *than to take it from the mini-note and put it on the laptop.*

In response to: "Where do you use it at home?

"*Next to the staircase we have a room and then we have a table with the laptop we use on it and some papers behind that and I would just put it next to the other computer we normally use. Sometimes I would use it in the kitchen but that was mostly when my sister was using the computer room and my mum was trying to make my baby brother sleep or something like that."*

"Usually in the living room because I do my homework and I have more space in the living room for all my stuff. Yes I enjoy it. Like, I usually turn the laptop on and I went to take

a shower and I left the laptop in the living room and it was on YouTube and I heard the music in the shower."

We observed that students did not have designated homework of computer spaces, and moved the netbook around the house freely.

Portable = Fragile?
Outside of their personal space such as their room or at home, there was a real worry such as when taking it to friends, family and traveling. Many students expressed concern and worry about breaking the netbook; inhibiting usage as a portable device. In contrast, they expressed little to no concern about losing, dropping or even flushing a mobile phone down the toilet.

"I'm very distracted and I'm scared of breaking it. I don't know I just have like a feeling that if I take it anywhere it will fall."

In response to: "Would you like to take it to a friend's house?"

"Yes, we would take photos and look at Internet sites in my Grandma's house when I was with my cousins and I needed a camera and I was like oh if I had it with me we could take photos now."

Her fear of breaking it seemed justified: *"It sounds absurd, but mine* [mobile phone] *just fell in the toilet."*

This concern seemed to lessen when describing their hypothetical usage of a netbook device that they owned (as opposed to it belonging to the school).

"I will travel to New York; I think it will be fun to take because the hotel has the Wi-Fi."[If she owned one] *Because it's light and easy to take to places and it's cute. Then I would take it to various places because it's mine and if I break it I wouldn't worry so much."*

"If I traveled, I could take it. If the Internet's not working, I could do the webcam or start writing a diary as a Word document."

"That if I had it to go traveling like to another country, it's little and then I could take it when I have so much weight in my bag."

Device proximity influences social closeness
In addition to walking around with the netbook, the video footage shows how easy it is to share the screen of a netbook with a friend by turning or swiveling it around. This screen sharing is not restrained by netbooks being tethered by power or LAN cables. We noticed in Shanghai that, in contrast to the more fixed computer labs, students were sitting closer to each other and angling their screens to share a common viewpoint as well as reaching over to type on a friend's computer. The students also used screen sharing when part of the assigned project involved working with class mates. The common denominator of this behavior was that students were able to help each other and to help the teachers by acting as learning mentors.
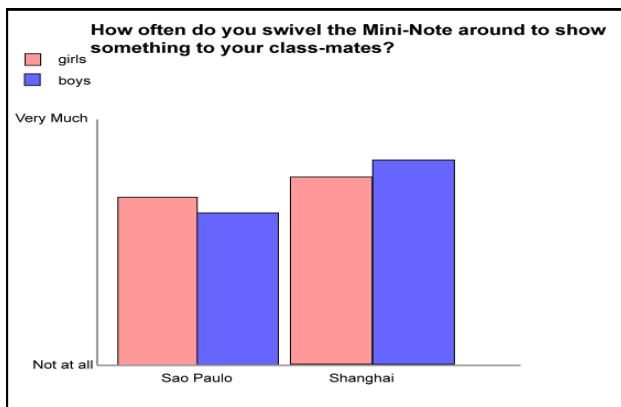
Figure 1: Ease of movement

Figure 2: Ergonomics vs. a standard laptop

"Yes we help each other, me and my friends are always like 'how do you do this?' and 'you do it like this' so we help each other. If I don't know something she helps me or I help her. We sit at big tables that fit three people on it so I have two partners next to me so we talk but we also talk to people on the other tables."

The Mini-Note 2133 has rubber feet on the bottom which prevent it from sliding easily across the table. Some students found an easy solution to this resistance:

"Well we have a piece of paper underneath it and we just slide it because it's easy."

In Shanghai, we found this kind of closeness even more pronounced. Regularly students would crowd around a screen.

"Yes well we're like best friends, she's one of my best friends; I think other people around me we talk about the stuff that we're typing and stuff like that and so I wouldn't know the person next to me if we didn't have these probably."

Emotional connections to the devices
What we noticed is how social learning is and how often the netbook is part of the fun; the netbook goes with the social and emotional flow.

The observational video footage shows students working on their netbooks including: girls sharing a laugh, a boy letting out a roar, a girl waving her arms in the air, a boy pointing to himself on his screen, and girls sharing high fives. In Shanghai, there was often a sense of cheerful anarchy amongst the students. They regularly resembled a nest of puppies as they crowded around the netbook screens, or used their desks as a pillow.

Students seem to have an emotional connection with the netbook and describe it as "cute", "adorable" and "cool". The netbook provided a constant source for tactile interactions. We noticed students fiddling with it during idle (dreamy) time, opening and closing it without purpose; they stroked the round edges and the keys of the keyboard.
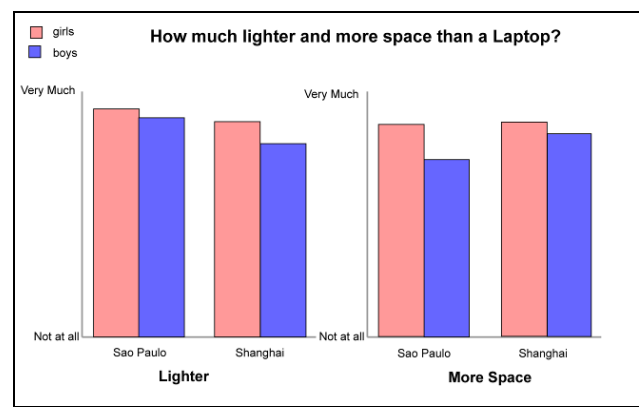
Personalization and screen-size
In addition, students were keen to personalize the netbook "wallpaper", even if they were going to use it for one hour only. In addition and a related identity discovering activity, all students were avid social net-workers. In Fresno students exclusively used MySpace, which was a bit surprising given the pervasiveness of Facebook at the time. The Sao Paulo students used Orkut, one of the earlier social networking sites. In Shanghai, students subscribed to "QQ" for social net-working. QQ is also a site for gaming, music and (a variety of) application downloads. For completeness we should mention that the search engine of choice in Fresno and Sao Paulo was Google and in Shanghai there were So Gou (search dog), So-So and Baidu.

However, for longer duration (sitting down) tasks requiring a larger screen the netbook's screen proved to be less satisfactory. Some just attribute it to being used to larger screens:

"I like the bigger ones. A bigger screen and a bigger keyboard but that's just me. Yes and I'm used to it because I have one at home."

In Shanghai during an animation class (Flash) the screen did not provide enough space, when it came down to students having to navigate all the different aspects of a Flash authoring screen.

Students' Perspectives
The survey data yielded many results of which we can only report some. We obtained 192 responses for Fresno which allowed us to compare (and contrast) the results for grade 7 and 8. We present the results for Sao Paulo and Shanghai in a separate analysis, due to the much lower numbers of participants (19 from Sao Paulo and 20 from Shanghai).

Ease of Movement and Ergonomics
Confirming our classroom observations, students in Sao Paulo and Shanghai rated that very often they swivel the netbook around to share with their class-mates (**Error! Reference source not found.**). In Sao Paulo and Shanghai, we asked students to compare the netbook with the standard laptop computer for weight and desk space. The ratings for
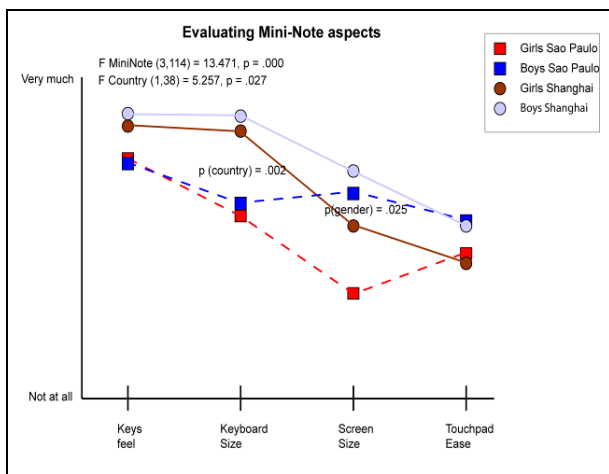
Figure 2. Ergonomic aspects

both questions were very high in favor of the netbook and there were no differences between the 2 schools, although the means for the girls were slightly higher (**Error! Reference source not found.**).

We also asked about other ergonomic aspects: keyboard, screen-size, feel of the keys, and ease of using the touchpad (Figure 2).

Carrying out a three way ANOVA (Mini-Note aspects * Country * Gender), we found a significant effect for Mini-Note aspect, p = .000 as well as an effect for country, p = .027.

Thus different aspects of the netbook are rated differently in the different countries. The highest ratings were for the feel of the keys and the lowest for the ease of using the touchpad.

Overall the Shanghai pupils gave the netbook higher ratings than the Sao Paulo children. Interestingly, independent of country, girls, in Shanghai and (particularly) in Sao Paulo, state that the size of the screen is not big enough and the girls' ratings are significantly lower than the boys (LSD, follow up analysis, p = .025).

Homework and Socializing
USB sticks were essential for doing homework for the students in all three countries. In Fresno, 92% of the respondents have one and they use it very often. Students in Grade 8 rate the use of the memory stick significantly higher (p = .005) than grade 7. In Sao Paulo, 16 (out of 19) students and in Shanghai 19 (out of 23) students have one and use it intensively.

For all three schools, when asking about home computing, we found that few children report doing last minute homework *before* they go to school leading us to believe the action is more deliberate and planned rather than ad-hoc.

In Fresno the home computer was intensively used by both grades *after* school, with grade 8 using it significantly more
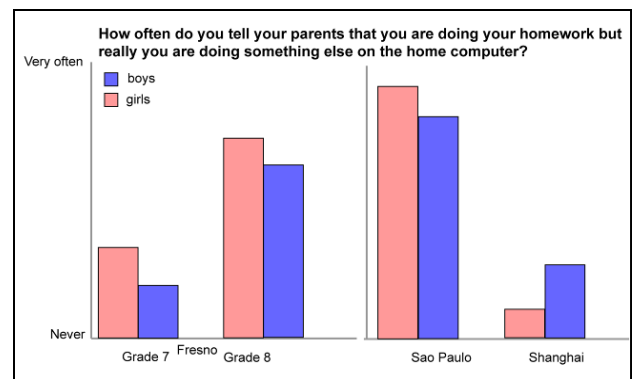

Figure 3. Homework falsities

than grade 7 (p = .000), probably reflecting the increased workload for the higher grade. In Sao Paulo there was ample availability of home computers (usually in excess of three computers per household), whereas in Shanghai only 74% of students had one at home. We found that the students in Sao Paulo do significantly more homework on the home computer than their Shanghai counterparts (p = .023).

Searching the internet at home was rated significantly higher than doing homework (p = .000) in Fresno. In Sao Paulo and Shanghai there was a similar difference (p = .007). Although there was no gender effect for doing homework on the home computer, girls in both countries report that they look things up on the internet significantly more than boys (p = .031).

We asked students to rate: "How often do you tell your parents that you are doing your homework but really you are doing something else on the home computer?" We refer to this here as "fibbing" (Figure 3). In Fresno, this question resulted in highly significant grade (p = .000) and gender effects (p = .021). The lower grade yielded low scores but with the girls "fibbing" more. Grade 8 ratings (and this seems to be the biggest difference between the two grades across the whole questionnaire) however are well above the central mark and again the girls outweigh the boys. The Sao Paulo children were the biggest fibbers and this contrasted strongly with the low scores in Shanghai, most likely, as a consequence of a highly supervised use of the only PC in the household.

Related to fibbing, we evaluated chatting and email use. In Fresno, girls send emails significantly more often (p = .032) than boys, regardless of grade. However, chatting is done significantly more than sending emails (p = .000) in both grades and with girls being significantly more active than boys (p = .001).

In addition grade 8 chatted significantly more (p = .001). Repeating this exercise for the Sao Paulo and Shanghai data, we found that chatting is done significantly more than sending emails (p = .01). The Sao Paulo students chat significantly more than their Shanghai counterparts (p = .022) and girls in both countries chat significantly more (p
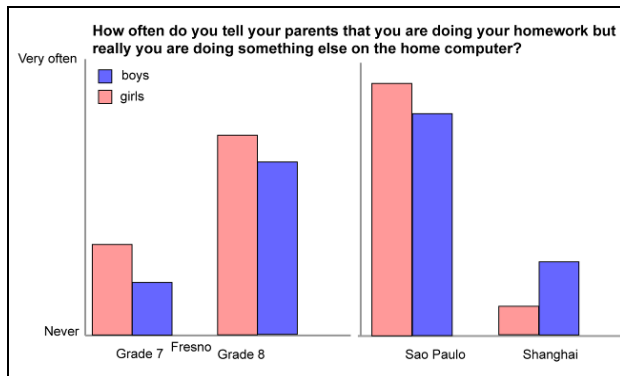
Figure 4. Homework falsities

Figure 4. Use of chatting software

= .023) than boys. Figure 5 shows the mean ratings for "chatting" for all three countries.

Emotional connections and personalization
The Sao Paulo pupils rated their enjoyment of taking the netbook home high. The girls mean was close to the "Very Much" extreme (the 100% mark) which proved to be significantly, p = .002, higher than the boys, even though their ratings were also high.

The students assigned both an emotional and an identity value to the netbooks. They expressed a strong desire to personalize the netbook and put skins on the outside. The questionnaire resulted in very high scores in both countries and for both genders regarding personalization.
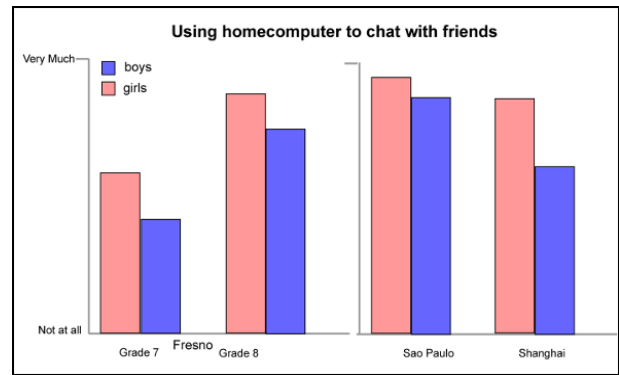
Mobile phone use
Although there is a big difference between Sao Paulo and Shanghai in home computer use, for mobile phones we barely see any differences, even though, 18 out of the 19 (95%) Brazilian respondents own a mobile phone, whereas only 15 out 23 (65%) Chinese respondents owned one.

We asked whether the students thought mobile phones could be used for school assignments but, the ratings were only around the halfway mark; given the general endorsement of mobile phones by the 21st Century youth, this is not very promising.

Use of media is of interest however, thus girls take almost significantly (p = .055) more photos than boys and the Shanghai pupils tend to capture video more than the Sao
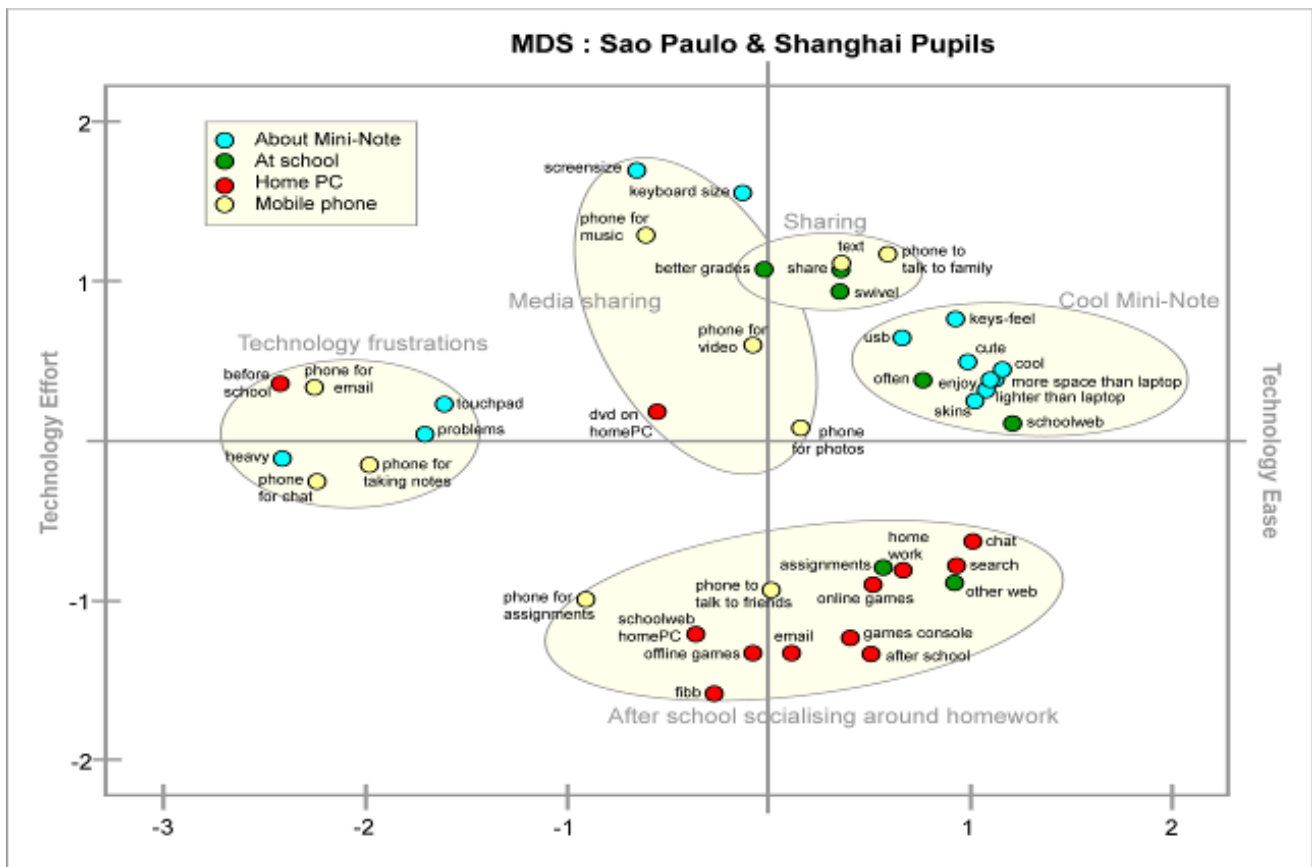

Figure 6. MDS plot for the Sao Paulo and Shanghai survey

Paulo ones, although this did not reach significance (p = .076). Surprisingly, given the importance of music for teenagers, downloading music received medium ratings for both countries. The only high use of mobile phones was for "texting". Talking to family or friends only received medium ratings.

Cluster Analysis
Cluster analyses (MDS) on all the questions confirmed (for Fresno) how much more social grade 8 is as well as how much less separated home and school activities are. The MDS analysis for Sao Paulo and Shanghai (Figure) is perhaps more illustrative as it defines the X-axis running between "Technology Effort" and "Technology Ease" and the Y-axis, although less pronounced between social focus and device focus.

Thus towards the bottom of the plot there is a cluster relating to socializing around homework with mostly "home" related activities (in red), to the right there is a cluster with items (in blue) relating to the things that are easy and cool about the netbook. Towards the top there are two clusters named sharing and media sharing. To the left there are all the things that are frustrating or difficult to do with technology.

Teachers' and School Administrators' Perspectives
In each school we interviewed at least two teachers and two administrators. The teachers were responsible for the students that we interviewed and observed in this study. The roles and responsibilities of the administrators that we interviewed were as follows: a) Head of logistic/general affairs. They are responsible for gathering requirements, collecting quotations, preparing proposal, leading decision progress, and conducting major maintenance twice a year of the school related IT materials. They are not responsible for setup and technical issues; b) CIO. They are responsible for identify requirements, preparing proposals, and the setup, repair, and management of technical issues. Each interview session lasted for about 1 hour, after which we took a tour of the school.

We found that most teachers are idealistic, realistic, driven, dedicated and experienced, and had strong links with parents.

"*I will see three groups of students, two periods at a time. I did over twenty years in Elementary School before I came to Middle School so my background is rather broad. --- We talked a great deal with the parents --- There was an educational side to this to the parents too*"

Collaboration vs. anywhere learning
There are a number of models in which netbooks can be used in schools. Primarily there are three dimensions:
a) ratio of netbooks per student (i.e. 1-to-1, 1-to-2, 1-to-many);
b) owned vs. borrowed

c) locations of use (only in school vs. school and home). We evaluated a few models of netbook usage in schools to try to determine which one would be most suitable.

In Fresno, where students were not allowed to take the netbook home, used a 1-to-2 model, and we observed that sharing notebooks fosters collaboration; the kids help each other with technology. In Sao Paulo, 1-to-1 model was used, and we observed that this promoted anywhere and anytime learning. In China, teachers questioned the value of providing PCs for every student in class since they think that students are too young, might get distracted easily. We observed plenty of collaboration in China.

Teachers need more content, not more tools
We observed that teaching follows state-mandated curriculum standards, and found that while there is a plethora of tools [6, 7, 8, 9, 10, 11, 12] content generated by the teachers and students needs to be better aligned with the curriculum standards. The tools that are being currently used at schools (the ones that we observed in our research) failed to address this alignment.

"*Don't give us more tools, we need real-time content, evaluation and feedback*"

As the content is being generated increases, we find that there is a lack of tools that help teachers with the grading of the content (such as HP's eduPal [5]). Better methods and technology is required for integrating annotations into digital information such that teachers can grade assignments that are no longer just text-based.

Technology is tool not end
"*The kids couldn't get care less, the machine was so incidental to what they were doing, ---- it was a pencil on steroids, --- It is what they were doing that mattered more.*"
Computers make it easier to teach in some ways. We found that using netbooks, teachers no longer had to plan as much in advance. They could tweak lesson plans on the fly depending on the response received by the students

"*I don't teach the same way every year, I try to innovate, so having a computer to document is useful. Then I can refer to it next year and innovate - teach it in a new way.*"

Teachers need a support system
Teachers themselves aren't taught utilizing technology. Only one school in our study provided teacher technology training, on-site curriculum/technology specialists and had student aids assigned to IT staff.

Mini Notes in the curriculum increases engagement but slows class progress
Teachers certainly value the quality of the learning but are concerned about the pace. In Shanghai, teachers believe that searching for information is inefficient. In Fresno, some teachers are more skilled at using computers in class whereas others in Shanghai and Fresno are just starting. One of the main reasons is because the services and tools

don't align well with the state-mandated curriculum standards.

Computer-based education makes teaching more difficult in other ways. We find that the subjects such as English, history and social studies classes more adaptable to Mini Note use, as compared to more hands on subjects as such Math and Science.

Parents and teachers are concerned about concerned about long term affect of the screen and font size on student's eye sight. While the netbook screen size was ideal for students for certain assignments and classes, it may not be the right size for teachers.

Value of using computers and technology

Teachers reported that repeated use of netbooks increased the focus of students, and they followed instructions more accurately. This is opposite from expected. Teachers hypothesize that *"Students are used to using computer so they are more attentive"*.

Computers enable very effective ability to collect and synthesize information from various sources.
"Students are looking at letters written by soldiers during the Civil War. They are having to determine what articles are going into [their reports], what would go on the cover, so you got graphic design, you got elements of language arts, you got elements of social studies, all criss-crossing, and the technology is just the thing that is bringing it all together. And they are going to use the little notebook computers. At the same time we are having the kids do a pod-cast of the Gettysburg address, recording on a computer for that."

Based on the current study, while it is certainly hard to pin-point the exact reason for performance, the fact that *"technology and multimedia makes students more interested in curriculum"*, and the fact that *"technology helps kids concentrate"* can validate the increased engagement level.

Teaching is changing based on computing in the classroom. Teachers are morphing into mentors on how to find the answers, and there is more learning through collaboration. Mini Notes save space in science classroom, and takes the pain out of having to book time in computer labs, and planning the class ahead of time, thus allowing teachers the flexibility to change the teaching plans.

Finally, technology can be used to keep students in school since students dropouts was a problem in the areas that we studied. One of the main concerns that teachers face is the limited amount of time and attention that they can provide to each student. Using technology, learning can be customized such that students can learn at own pace, and teachers can easily adjust to learning styles.

"Technology can be used to bring kids to grade level"

"We were losing some of our students and so we wanted to encourage them."

Parents' Perspectives

We were able to interview several students while at home with their families. In regards to home computer usage, the parents described how usually the computer was placed in a community area so that it could be shared by all family members. The parent's described that in terms of priority for their children it was often TV first, cell phone second, and the computer third. They did describe monitoring their child's computer usage somewhat but a general trust and only minimal oversight providing advice more often than enforcing restrictions. In several cases, the parents of the students acknowledged that their children knew more about computers than they did. Some parents described using online social networks in order to stay in touch with their kids and the rest of their family. They also described computing as a way to bring the family together – such as through shared activities like video chatting, gaming, and activities like editing family photos.

There were some concerns about their children balancing doing their school work with social interactions on the computer. Several parents describing controlling the amount of time their child spent "playing" versus "working" as well as balancing time on the computer with spending time being active such as in sports or playing outside. Some parent's did express stronger concerns about their child's usage of the computer. Some felt that the students were too young for the responsibility of owning their own computer. In China specifically, some parents worried that computer usage could put academics at risk. This was credited to the portrayal of the Internet as an addiction risk based on dropout rates credited to the use of Internet cafes. In an interview with one of the chief information officers at the school, he expressed the general negative attitude by parents toward computer usage in general.

Regarding the ergonomics of a netbook specifically, some parents expressed concerns over the small screen size and its effects on eye site and posture. Some described it as perfect for a student but not appropriate for use by them since the screen was so small.

In general, most parents were supportive of the netbook usage in the classroom as long as standards were taught. They felt that computer usage helped prepare their children for the real world and helped to bridge the digital divide. There was also a general trust in the teacher's ability to incorporate the use of technology into the curriculum. Several parents described their children as being more engaged in school once netbooks were introduced. They also wanted more progress updates on their children and saw technology as an enabler that would allow them to actively engage in their child's education.
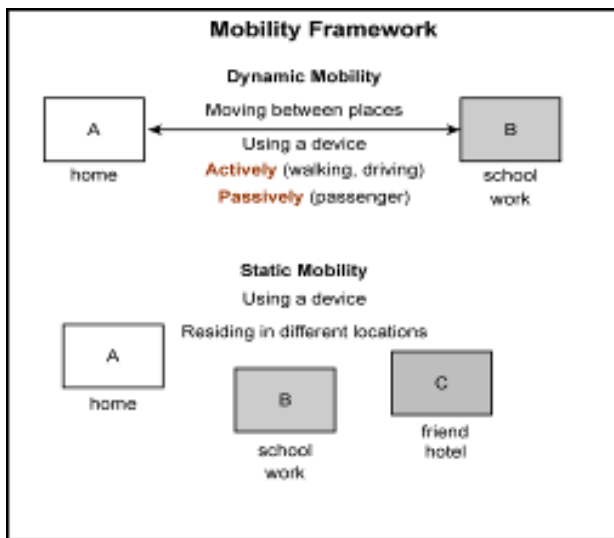
Figure 7. Mobility Framework

DISCUSSION

We carried out research in three schools in three different geographical locations (California, Brazil, and China) on the use of the HP netbook Mini-Note 2133 during a typical school week. In spite of considerable geographical and socio-economic differences, we did not find many differences in attitudes and usage at these schools, although the affluence of the Sao Paulo students meant easier access to home computers. We did, however, find gender and age differences, mainly around social networking.

Thus in Fresno, as there was a good opportunity to compare age 11, 12 with age 13, 14 students, we noticed in the older group a major departure from being still playful, parent-obeying where home and school seemed to be firmly separated to a highly social peer oriented, more secretive age where socializing around homework was of the essence. Our survey data show that by and large girls of 13,14 years old are veritable champions of social networking, lending support to the notion of Blakemore's neuronal basis of the social brain and highlighting that this age group *is* a good exemplar for future studies.

To summarize our findings: The netbook is a departure from traditional laptops as it is a more mobile and more personal class of device; it enhances local mobility, sharing and collaboration and fits well with social and emotional flow in the classroom. In addition it stimulates visual creativity.

Mobility has different connotations and in this paper we propose the following mobility framework (Figure 7). Consider, for instance, mobile phones and laptops which are both mobile devices but have different use patterns and affordances with relevancies for design. We distinguish between "dynamic" mobility, referring to using a mobile device whilst *moving between locations* and "static" mobility which refers to using a mobile device whilst *residing in different locations*. Furthermore, within dynamic mobility we make a further distinction of actively using a mobile device or passively. Thus using a mobile phone whilst walking between home and work or school classifies as being actively and dynamically mobile, being a passenger on a train allows a user to be passively and dynamically mobile which caters for both phone and laptop use. Using a laptop at home and then traveling with the laptop to work where it is used in an office fits with static mobility.

However, observing netbook use on campus and hearing how the device is used at home, we find that compared to traditional laptops netbooks enhance, *within* a location, i.e. a static mobility paradigm, local mobility as netbooks allow students to take the netbook *to* the teacher and at home they are regularly moved from room to room, thereby taking up a position in the design space, somewhat between a laptop and a mobile phone.

With regards to mobile phones as a learning aid, although phones play an important role in socializing around homework, our survey casts some doubt on the capability of mobile phones to be used as a general tool in education, e.g. taking notes, using the phone to email are still experienced as being painful. There might be "niche" uses, i.e. taking photographs and record video. On the other hand as high end mobile phones have powerful mobile computing (internet) capabilities, there is a chance, as prices will come down, that the mobile computing aspects will be conducive to them being used in the classroom. However, it is good to bear in mind that the teachers in the study are not keen on mobile phone use in the classroom, young students such as the ones we studied, may not always look after their phones and therefore parents might be reluctant to pay for expensive phones with mobile computing capabilities.

Although teachers and students alike value the smaller footprint as well as the reduced height of the netbooks, enabling a more social interaction this reduced height also reduces suitability for certain computer tasks requiring a higher screen, e.g. teaching Flash authoring in Shanghai. In addition there is a concern (by adults) about eyesight, in particular for longer duration tasks.

PRACTITIONER TAKE-AWAY

• The form-factor of netbooks is ideal for educational environments (devices take less desk space; low price point; small screen size does not hinder collaboration between students and teachers etc.). But the successful adoption of netbooks is dependent on tight integration of software applications with curriculum standards and tools for content management.

• Students have a very tactile (touchy-feely) relationship with the Mini-Note, e.g. stroking the round edges of the screen, which goes beyond simple "cosmetic niceties" but rather adds to their sense of identity / ownership. Future designs could extend this using appropriate materials or even providing haptic feedback.

- Collaboration is very important in an educational environment. While the light weight and small size of the netbook devices provide agile mobility, there is a lack of user-friendly solutions for sharing multimedia files across devices.

- The processor speed and memory of the netbooks are comparable to standard laptops, but due to the small screens (8-10 inches) user interfaces of applications needs to be adapted to smaller screen dimensions.

- Students were very adept at utilizing the web-cam and enjoyed creating videos for homework assignments. They also were very skilful in using image manipulations. But user interfaces of these applications today are not optimized for the small screen. These limitations get magnified as the animations and graphics become complicated in nature.

- Parents saw technology as an enabler that would allow them to be actively engaged in their child's education, but there is a lack of applications that provide synchronous progress updates (beyond reports on grades) on their children' performance at school.

- As reported by teachers and parents, the repeated use of netbooks resulted in increased focus and engagement in school, but a controlled longitudinal user study and suitable metrics are required to validate the value.

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