How two groups of users experienced an educational web site

G.J. de Villiers
Telematic Learning and Education Innovation
University of Pretoria
+27 12 420 4301
devilliersg@postino.up.ac.za

ABSTRACT
This paper responds to the need for research into the usability of educational web sites for multicultural users. The study assesses the views of users from different cultures regarding the usability of an educational web site, its HCI and functionality, and users' level of satisfaction. Two groups of users were chosen to investigate the site, one group in an urban city context, the other in a rural context. The latter group comprised mainly disadvantaged users.

Keywords
Usability, Human-Computer Interaction, educational web sites

INTRODUCTION

> *The question needs to be asked: What personnel, power arrangements, and perspectives are needed to change the basic structure of schooling so that in the future the voices of the traditionally excluded become central to the definition of a quality education?* (Perry & Fraser, 1993).

The challenge facing the discipline of Human Computer Interaction (HCI) is to develop *educational* web sites that are usable for multicultures. Sites should be usable, intuitive, and should satisfy users' needs. Designers of educational web sites are faced with the challenge of satisfying both sophisticated and non-sophisticated users, and meeting users at their specific point of departure/experience. This is not an easy task, especially considering that the gap between the "urban rich" and "rural poor" is widening, and many users lack access to technology. However, schools have the potential of becoming "technological hubs" where learners can be given opportunity to access and explore educational web sites.

Although educational web sites may be sound in many respects, success can only be demonstrated once the material has been evaluated. However, Smith (1997) mentions that most evaluators of web-based material rely on subjective values of style and "coolness", instead of focusing on information content, currency, compatibility, authority, ease of use, connectivity, etc. Besides those who evaluate educational web sites on subjective values instead of relying on the criteria as mentioned above, to date, few researchers have developed questionnaires to conduct user-evaluations of educational web sites (Arnone and Small, 1999).

The researcher set out to answer the research questions listed in Table 1, in order to assess the site's ease of use, HCI and functionality, as well users' level of satisfaction/affective acceptance (Shneiderman, 2000). The web site evaluated in this study is *Plane Math* (http://www.planemath.com). It was chosen for evaluation over two other alternatives because it was visually attractive and appealing for a young target audience.

Table 1 Research questions and their respective Categories

Research questions	Category
Is *Plane Math* usable?	Ease of use
Does the HCI enhance or hinder functionality?	HCI and functionality
Did the users enjoy using *Plane Math*?	Level of satisfaction

The web site was generated as part of *InfoUse's* project entitled "An Internet-Based Curriculum on Math and Aeronautics for Children with Physical Disabilities" which was funded through a cooperative agreement with *NASA*. It was originally designed for children with special needs. Although the users who participated in this study had no physical disability, the users from the rural school were disadvantaged. The site is specifically not aimed at the mainstream, but was tested on such an audience as a form of control. The findings prove that the site can also be used

by mainstream learners, and not just for children with disabilities.

Before the findings are discussed, an outline will be given of the evaluational context (national and institutional), with specific reference to two schools in the New South Africa seeking ways to cope with change and development. This will be followed by information about *Plane Math*, the nature of the software, a literature review, the research methods used to conduct the research and the findings. Finally, the conclusions, implications for the field of HCI, and recommendations for further investigation will be given.

NATIONAL PROBLEMS AND SOLUTIONS

Internationally much has been made of the special role of Mathematics and Science education in promoting a skilled and technically sophisticated work force. Mathematics provides many of the fundamental thinking skills which underpin scientific/technical thought. Learners also need to be prepared for the technological challenges of the future, and to have well-developed critical thinking and problem-solving skills. This is slowly, but surely taking place, as evident in South Africa's improved position on the world scale, where its position has climbed six ranks (from being placed 44th in 1996 to 38th in 2000 out of 47 countries (IMD International, 1999).

Although South Africa's position on the world scale has improved, there remains an urgent need for a skilled and technically sophisticated work force to be developed in South Africa in order to continue to improve its position on the world competitiveness scale. Mathematical web sites have the potential to bring about major changes in the way education is delivered in South Africa. A serious problem however is a lack of skills and training resources. There is therefore an extensive area where the web can make a contribution, both in terms of teacher training and in the realms of using existing and developing new software in the classroom. If both the context and the usability aspects are of a high standard, South Africa has the potential to compete in the international market and to improve its position on the world scale.

State and private-sector initiatives can also play a significant role in developing a skilled and technically sophisticated work force. One such initiative is run by the Univeristy of Pretoria's *Telematic Learning and Education Innovation Department*, which develops innovative teaching programmes to help raise quality in neglected school systems, particularly in subjects such as maths, technology and the natural sciences, in which few black pupils qualify. The school programme targets poor, especially rural, schools that are short of teachers in maths and sciences (Macgregor, 2001). They invite school heads and teachers to discuss any problems they have and teachers are brought in to help design and film the daily programs. The programmes are broadcast between 14:00pm and 15:30pm via satellite television. The aim of these programmes, is according to Prof Hans Boon, the founder and head of the department, to "expand the pool of black school leavers who do well enough in final examinations to qualify for higher education" (Macgregor, 2001).

INSTITUTIONAL CONTEXT AND RESEARCH DESIGN

Educational web sites have a large variety of users. For this reason, two groups were chosen, one from an urban school and another from a rural school. The purpose of taking a sample from each of two schools in different cultural contexts is to assess whether users' experience of the site differered between the two groups. The schools associated with these groups are called School A and School B respectively.

School A is situated in the eastern suburbs of Pretoria, in the province of Gauteng. The medium of instruction is English. The learners of the school come from various population groups, with English, Afrikaans, Northern Sotho and Tswana as mother tongues. Most of the learners come from the affluent surrounding suburbs.

School B is situated in a small town, 25km from Tzaneen, and 100km from Pietersburg, in the Northern Province. The school is parallel medium and has been integrated since 1995. The learners of the school come from various population groups. Afrikaans and Sotho first-language speakers make up the largest numbers, but English and Shangaan speakers are also well represented. In addition there are a number of French-speaking learners, who come from Zaire and whose parents are working at the Ga-Kgapane hospital. Most of the learners come from rural areas and from farms.

A significant problem faced by schools is that Mathematics is a compulsory subject and is feared by many learners. The basic elements of fun, discovery and self-motivated mastery are absent for the majority of learners. To address this problem, both schools have embarked on major computerisation projects, each now having at least one computer laboratory. The objectives of the computer technology curriculum are similar for both schools, based on the primary schools' syllabi for Computer Skills.

One must distinguish between the use of computer technology in computer literacy courses, and the use of computers within subject teaching. *Plane Math* is an Internet-based learning environment that falls into the latter category.

PLANE MATH

As already stated, *Plane Math* was generated as part of *InfoUse's* project entitled "An Internet-Based Curriculum on Math and Aeronautics for Children with Physical Disabilities" which was funded through a cooperative agreement with *NASA*.

The genesis of this project is based around two issues (*InfoUse*, 1996).

1. The awareness that, around the 4th grade, current mathematics curricula require skilled manipulation of pen and pencil, calculators, or three-dimensional geometric models, placing learners with some/certain disabilities at a severe academic disadvantage.
2. The realisation that physically disabled children may not consider or be prepared for career possibilities in aeronautics or the importance of mathematics in pursuing these careers. The Internet, with its multimedia and communication capabilities, holds great potential for allowing these issues to be addressed.

The program has the goal of portraying learners and adults as bright, enthusiastic and able to both assist and work with others, regardless of ethnicity, background, disability, or gender (*InfoUse*, 1996). The stated mission of the project is "To stimulate and motivate students with physical disabilities in Grades 4-7 to pursue aeronautics-related careers via the development and delivery of accessible math education materials on the Internet".

With this goal, they developed four objectives, namely to:

1. Improve access to mathematics and aeronautics curricula materials for 4th – 7th graders with physical disabilities.
2. Improve mathematics proficiency outcomes among 4th - 7th grade students with physical disabilities.
3. Inspire and motivate learners with physical disabilities to pursue aeronautics-related careers.
4. Increase access to, and use of, digital communication and multimedia technology among learners with physical disabilities.

The researcher would have liked to evaluate this web site using a group of physically disabled users, but this was not possible. The site is, however, relevant to the broader range of users, and in this study, was evaluated in terms of users from different cultures. Many of the users in Group 2 came from a disadvantaged background and some worked through the medium of their second language. Others had specific problems in mathematics, although they were not physically disabled.

NATURE OF SOFTWARE

Plane Math primarily consists of lessons/instructional units which are of a tutorial nature. The web site offers nine lessons from which learners can choose. Within the tutorial, teaching segments alternate with question segments. It supports a behaviourist paradigm, and expects users to master a concept before a new one is introduced. The web site also partially supports a constructivist paradigm and encourages collaborative learning. This takes the form of group activities, a chat room (not yet functional), links to sites with related topics, an e-mail facility to the authors of the site and encouragement from live subject matter experts to pursue aeronautics-related careers.

The web site promotes discovery learning in that it has links to other organisations' web sites. Links are divided into three categories, namely: technology and disability, aeronautics, and mathematics. Within a lesson, if users answer a question incorrectly, they are encouraged by feedback which shows/tells them the result of their action, and encourages them to try again, but does not spell out the answers. Learners are returned to the original screen that presents the problem.

The web site operates effectively without the presence of a teacher or facilitator, and was demonstrated to be an effective source of remediation and extension. It is simple to move between levels, making it possible for weak users to drop a level or go back to previous, unmastered skills. It also facilitates the progress of users who are coping well, and decide to advance to more challenging interactive lessons.

LITERATURE REVIEW

According to ISO (2001), usability comprises the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use, where:

- **Effectiveness** measures the accuracy and completeness with which users achieve specified goals;
- **Efficiency** measures the resources expended in relation to the accuracy and completeness with which users achieve goals; and
- **Satisfaction** measures the freedom from discomfort, and positive attitudes towards the use of the product.

Few researchers have developed questionnaires to conduct learner-evaluations of educational web sites (Arnone and Small, 1999). For this reason, Arnone and Small (1999) have developed an instrument to address the effectiveness of children's web sites with a specific focus on motivational elements. They state that a child will be motivated to

remain at a web site if two essential motivational elements are present:

- The web site has value to him/her; and
- the child has the expectation that he/she can be successful within the web site environment.

Their affective (motivational) elements are based on the expectancy-value theory (Vroom, 1964) and Keller's ARCS model of motivation (Keller and Kopp, 1987). Expectancy-value theory argues that in order for individuals to devote effort to a task, value and expectancy for success must be present. Keller suggests that strategies designed to increase (A)ttention and (R)elevance contribute to value, while strategies to increase (C)onfidence and (S)atisfaction contribute to one's expectation of success (Arnone and Small, 1999).

Both value and the expectation of success must be present for a child to be positively engaged within a particular web site, and in order for him or her to be motivated to return to that same site later (Arnone and Small, 1999). Csikszentmihalyi's (1990) Flow Theory of Optimal Experience is based on users becoming engaged and absorbed by certain activities. Flow is defined as:

> *…. the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it* (Csikszentmihalyi, 1990).

When this is achieved, the learning experience is enriched. Malone's (1981) intrinsic motivators, such as: challenge, control, curiosity for learning and fantasy, also play a crucial role in childhood learning.

Arnone and Small (1999) list the motivational attributes that should be present in web sites for children. These can be related to the three attributes of usability as given by ISO (2001) – see previous page, and are listed against them in Table 2.

Table 2 Usability attributes and corresponding motivational attributes

Motivational attributes	Usability attributes
Useful and credible	Effectiveness
Organised and easy-to-use	Efficiency
Satisfying and effective	Satisfaction
Engaging and stimulating	Satisfaction

These attributes influence the child's tendency to revisit the web site and to motivate others to visit the site.

RESEARCH METHOD

This research falls under a non-experimental, descriptive research design. Such a design describes the nature of existing conditions, uses numbers to characterise groups and applies an instrument to obtain results and describe the situation (McMillan & Schumacher, 1993). The research is primarily qualitative, but quantitative measures were used to record the results of surveying/observing the users. Quantitative measures were taken in both the user questionnaire (where Likert scaling was used), and the expert review checklist.

The research methods were a user questionnaire, an expert review checklist and observation (Reeves, 1997). Multiple methods were used to validate the results generated from the user questionnaire, i.e. to apply triangulation. The user questionnaire was developed based on a variety of checklists from the literature. The questionnaire was administered to two groups - ten Grade 5 users from School A (urban) and ten Grade 5 users from School B (rural), i.e. n=20. Users completed the questionnaire after spending time using *Plane Math*. An expert review checklist was drawn up in collaboration with teachers from both schools, after they had explored the site. Observation entailed a researcher and a facilitator being present with the users while they worked in the web site, to record noteworthy incidents. The presence of two supervisors ensured validity. Informal discussions with the users were also held before and after using *Plane Math* to examine their response to the site.

In order to obtain further insights into the usability of the site, the researcher polled three instructional designers in the Department of *Telematic Learning and Education Innovation* of the University of Pretoria. They completed a questionnaire regarding their opinions as to how a culturally disadvantaged user would perceive the web site.

FINDINGS

The findings are grouped according to the three research questions, using all three methodologies, namely: questionnaire, expert review checklist and observation. The user questionnaire consisted of eighteen questions. Percentages were computed for all these questions on a 4 point Likert scale which ranged from (1) strongly agree, (2) agree, (3) disagree, to (4) strongly disagree. For the purposes of analysis however, categories one and two are combined, as are categories three and four. A table with sub-questions is given for each of the three research questions. Appendix 1 gives a list of the 18 sub-questions, with percentages for the two groups (Group 1 from School A and Group 2 from School B).

The final column (Δ) in these tables represents the difference between the two groups, that is:

Δ = Group 1 Value – Group 2 Value

When viewing these results it should be remembered that Group 1 consisted of users who were distinction candidates in mathematics, while a number of users in Group 2 come from a historically disadvantaged background, and work through the medium of their second language. Some users also had specific problems in mathematics.

Research Question 1: Is *Plane Math* usable?

In Group 1, 90% of the users responded that the web site gave them clear instructions on what to do. However, in Group 2, 50% of the users struggled to understand how to operate the system. In addition, 80% of the users from Group 2 did not realise that they could decide for themselves what to do. This was in direct contrast to users from Group 1, where all the users (100%) agreed that they could decide for themselves. This high percentage (Group 2: 80%) could indicate the influence of teaching methods reliant on passive rote learning, where users are told by the teacher what to do, or else it could result from a low exposure rate to computers (the majority of these users only had access to computers at school). In order to accommodate users from different cultures and who work through the medium of their second language, instructions on the available options should be made more explicit. Audio could possibly be used to solve this problem, with a human voice giving introductory explanations. This would optimise learner control.

Both groups of users agreed that they knew from the exercises what they were doing right or wrong (Group 1: 100%; Group 2: 70%). It is interesting that the percentage in Group 1 is 30% higher than that of Group 2. Users in Group 2 were also less confident in locating information on the screen quickly and easily, as only 60% of them agreed that they could, in contrast to 100% of the users in Group 1. This could be due to the material not being in their first language, resulting in difficulty in understanding it, or due to ineffective screen layout. Users found the web site engaging, as both groups of users responded that the web site kept their attention from beginning to end (Group 1: 70%; Group 2: 78%).

In both groups, 60% of the users felt that it did not help that all the pages looked alike. This could indicate that users would prefer exciting material, that is, web sites should motivate them with challenge, curiosity, control and fantasy (Malone, 1981). It emerged that these users, especially those in the urban school, found *Plane Math* too consistent and predictable, and might prefer novelty and variety, and a sophistication user interface.

Research Question 2: Does the HCI enhance or hinder functionality?

In this section the view of the users as well as the Instructional Designers at the University of Pretoria will be given, with regard to the HCI enhancing or hindering functionality.

Users viewpoint

Users responded very positively (especially Group 2) to each one of the sub-questions regarding the HCI and functionality. Users from both groups (Group 1: 70%; Group 2: 90%) were generally keen to explore all there was to see. The pictures also helped users from both groups understand the lesson (Group 1: 80%; Group 2: 90%). It was interesting to see that the pictures played a major role with the users in Group 2, helping them to comprehend the lesson. Eighty percent of the users in both groups indicated that the screens contained just the right amount of information, indicating that they did not experience sensory overload.

Surprisingly, users in both groups (78%) responded positively to the statement "it is easier to read from a computer screen, than from a book". If this is true in the general target population, then educational web sites and programs have a very valuable potential role in improving and enhancing perceptions of learning.

Instructional designers viewpoint

As stated previously, the researcher also polled two instructional designers from the Department of *Telematic Learning and Education Innovation* of the University of Pretoria, using a questionnaire to elicit their opinions regarding the likely perceptions of culturally disadvantaged users.

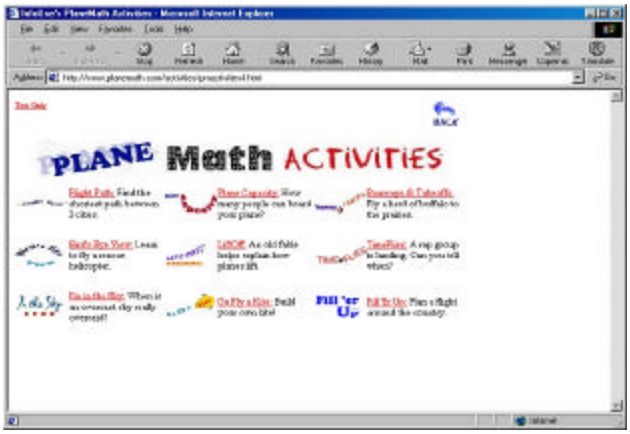
The instructional designers disagreed with the statement that “the instructional design of the web site is based on sound learning theory and principles” for the following reasons:

- The homepage is cluttered and it is not clear where students and teachers/parents should enter the site. The sponsors of the site should be made less prominent and the entry points of greater prominence.
- Optimal screen settings are not defined and screens will display differently for different users.
- The site needs more introductory explanations. The sites does not indicate clearly the objectives of each lesson nor which lessons are appropriate for whom, unless one views this information from the teacher/parent information within the site. Consequently, users can get lost.

- There is no indication as to the length of each lesson, nor where the user is within the lesson.
- A small font size is used and the font used is not easily legible. Both screen and text layout could be improved. Text layout could be improved by using bulleted lists for example.
- The transitions between screens are slow.
- The links in the site are not predictable in the sense that users do not always know what to expect when they click on objects/items in the web site.

On a positive note, colour was used appropriately (however, could have been used a bit more extravagantly to make the web site more exciting) and the screen displays were relatively easy to understand. The introductory menus stimulate interest, as the headings indicate what they do. Figure 1 sets out their real-world purpose.

Figure 1 Screen capture from *Plane Math*



Research Question 3: Did the users enjoy using *Plane Math*?
The attitudes of the children to the statement "*Plane Math* was fun and exciting!", were very positive. They responded as follows to open-ended questions:

- "I think this site is excellent".
- "I enjoyed myself".
- "I can only say this was very exciting".
- "It was fun and I learnt a lot".

Observation validates these results, as the users looked relaxed and discussed the problems amongst themselves. They did however, find the transitions between screens slow and, to a certain extent, this distracted their attention from the site for a while. This, however, was due to the limited bandwidth available in South Africa, and should the same study be replicated in another environment (e.g. United States or Australia), the same problems might not be experienced.

The day after the evaluation, Group 1's mathematics teacher asked those who took part in the evaluation if they had enjoyed the experience. In verbal response, 25% said that it was too easy, while the remaining 75% felt it was worthwhile. The teacher suggested that the responses depended on the level of maturity of the learner.

Users generally agreed that they enjoyed spending time in the web site (Group 1: 80%; Group 2: 67%). Users were asked in the open-ended questions, what they liked about this web site. Their responses were very positive, as indicated below:

- "It helps you in mathematics".
- "It is interesting and I learnt more about mathematics and flying".
- "The way it gave us information we really wanted to use".
- "Learning about topics that interest me, using the Internet".
- "It gives a lot of information and it makes learning easier".

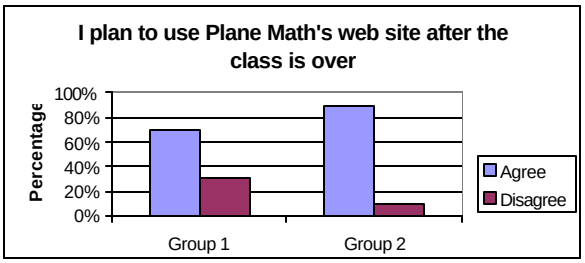
Users (Group 1: 90%; Group 2: 100%) agreed to the statement that "this was a nice way to learn". However, there were some things that they did not like about the site, where they responded as follows (the group is indicated in brackets, where it is applicable in this study):

- "Some lessons are boring". (Group 1)
- "The fact that it is a bit young". (Group 1)
- "Took too long for pages to load". (Group 1 and 2)
- "Too much white". (Group 1)
- "Sometimes I did not understand what was on the screen". (Group 2)
- "I liked everything". (Group 1 and Group 2)

It is interesting to note that one learner from Group 2 battled to understand what was portrayed on the screen. This learner was from a disadvantaged background, working through the medium of English as a second language.

Figure 2 depicts the users' response to the statement "I plan to use *Plane Math's* web site after the class is over". These results validate their responses from the open-ended questionnaire.

Figure 2 Users' attitude to using *Plane Math*



Users from Group 2 were more keen to refer this web site to their friends than users from Group 1. Some of the reasons users from Group 2 gave for referring this site to their friends were:

- "Because it is a better way to learn mathematics"
- "It will improve their mathematics".
- "Exploring the web site really helps you learn more about mathematics and flying".

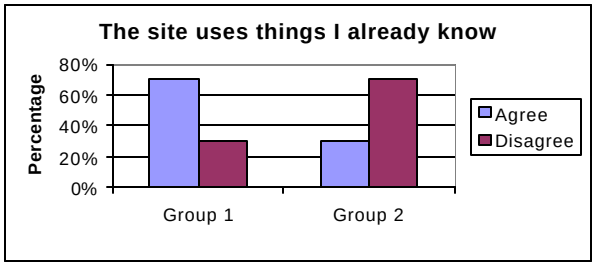
Users from School A were at a great advantage, as 80% of them had access to a computer at school and home, in contrast to School B, where only 20% had access to a computer at home. As a result, 70% of the users in Group 2 agreed to the statement that "using the *Plane Math* site helped me get better in using computers". It was also interesting to note that users who specified that they use the Internet "not a lot" (Group 1: 30%; Group 2: 50%), found the exercise far more enriching and valuable than users who use the Internet on a frequent basis. Users familiar with the Internet (Group 1: 60%), expected far more from the site (e.g. increased interactivity), than those who were less familiar (Group 2: 80%). Hence, the urgent need for users who are less advantaged to be exposed to such web sites, in order that they too might become critical thinkers and problem solvers. This would help in achieving educational equality.

A further notable point was that the majority of users (Group 1: 70%; Group 2: 56%) did not mind the American terminology, indicating their familiarity with American culture. Nevertheless, educational web sites that are specifically contextualised to the South African context and to different cultures, would provide users with a more appropriate point of contact.

In Group 1, 78% of the users responded that they could use their own ideas, in contrast to only 60% of the users in Group 2. This could indicate that the latter group explored the system to lesser degree than Group 1.

Figure 3 indicates that *Plane Math* did not use objects that users in Group 2 were familiar with, as 70% of the users disagreed to the statement "The site uses things I already know". From this one can see that the web site is predisposed towards users that are more advantaged.

Figure 3 How *Plane Math* uses prior learning



CONCLUSION

Both groups of users expressed positive responses to the site and experienced a high level of satisfisfaction while working within the site. The results clearly indicate that the basic elements of fun, discovery and self-motivated mastery were present in the web site. Satisfaction levels varied according to the maturity level of the users, their computer and Internet skills and their prior knowledge.

There were certain differences between the two groups, in that the urban school users found it more efficient and easy-to-use than did the rural school users. The techno-literate urban school users also had higher expectations of the site than the rural school users, who were less familiar with the Internet and many of whom only had computer access at school. Table 3 gives the most important differences between the two groups of users, with implications for design.

Table 3 Most important differences between the two groups of users

Group	Characteristics	Design implications
Urban school users	Were slightly more critical than the children from the rural school, due to their wider exposure to computer interfaces and their familiarity and confidence with computers. This resulted in their using the site as the designers had intended.	Increase sophistication in web sites, but at the same time, sites should remain simple and intuitive to understand throughout. This is a huge challenge, as not all users are computer literate.
Rural school users	▪ Struggled to understand how to operate the system. ▪ Did not know that they could decide for themselves what to do.	In order to accommodate users from different cultures, instructions on the available options should be made more explicit. This would optimise user control.
	The site did not use objects familiar to them.	Instruction should be adaptable to accommodate different cultural groups, i.e. different examples should be provided which are culturally appropriate for multicultural users.

The findings show that the site is predisposed to the more advantaged users. Nevertheless, both groups of users rated the site positively, and in all the categories investigated, namely: ease of use, HCI and functionality and level of satisfaction, it was found that the site met basic criteria. Although it was primarily intended for an audience of American users with physical disabilities, it proved highly useful for multicultural users who are mainstream learners.

IMPLICATIONS FOR THE FIELD OF HCI

South Africa poses a unique challenge to developers to meet the needs and aspirations of multicultural users, so as to achieve educational parity. Four guidelines follow for designers of user interfaces. These are not general usability guidelines, but rather pragmatic approaches geared towards multicultural utility.

1. Sites should include some degree of sophistication, yet remain simple and intuitive to understand throughout.
2. Sites should include explicit introductory explanations.
3. User-entry points should be prominent, and easily legible fonts should be used.
4. Directives, content and graphics should be appropriate and sensitive for multicultural users.

RECOMMENDATIONS FOR FURTHER INVESTIGATION

Recommendations for further investigation could include the following questions:

- Does the level of satisfaction experienced by users of educational web sites differ from one culture to the next?
- Why do users from an urban school have more confidence when working with computers? Is this due to high-tech computer games?
- How can the gap between different groups of users be bridged?

Suggestions for further development are:

- Design and development of user interfaces for disadvantaged adult learners.
- Follow-up evaluations of *Plane Math*, taking usability metrics.

BIBLIOGRAPHY

1. Arnone, M.P. & Small, R.V. 1999. Evaluating the Motivational Effectiveness of Children's Websites. *Educational Technology*, 39(2):51-55.
2. Csikszentmihalyi, M. 1990. *Flow: The psychology of optimal experience*. New York: Harper and Row.
3. IMD International 1999. *World Competitiveness Yearbook*. Lausanne: IMD.
4. InfoUse. 1996. *Plane Math*. Available at http://www.planemath.com
5. ISO. (2001). *USABILITY SA*. Available at http://www.usabilitysa.co.za/
6. Keller, J.M. and Kopp, T. 1987. Applications of the ARCS model of motivational design. In: Reigeluth, C.M. (Ed.), *Instructional theories in action: Lessons illustrating theories and models*. New Jersey: Lawrence Erlbaum.
7. Malone, T. 1981. Towards a theory of intrinsically motivating instruction. *Cognitive Science*, 5:333-369.
8. Macgregor, K. 2001. If you're this low, the only way is up. *The Times Higher Education Supplement*. August 3.
9. McMillan, J. & Schumacher, S. 1993. *Research in Education*. (3rd Edition). New York: HarperCollins College Publishers.
10. Perry, T. & Fraser, J.W. 1993. Freedom's plow: Teaching in the multicultural classroom. New York: Routledge.

11. Reeves, T. 1997. *Evaluation Tools*. Available at http://mime1.marc.gatech.edu/MM_Tools/evaluation.html
12. Shneiderman, B. 2000. Paper presented at the CHI SA 2000 Conference, Pretoria.
13. Smith, A.G. 1997. "Testing the Surf: Criteria for Evaluating Internet Information Resources." *The Public-Access Computer Systems Review*, 8(3). Available at http://info.lib.uh.edu/pr/v8/n3/smit8n3.html
14. Vroom, V.H. 1964. *Work and motivation*. New York: John Wiley & Sons.

APPENDIX 1

Results of the sub-questions, grouped according to ease of use, HCI and functionality and level of satisfaction - in relation to the two groups separately, and the difference in the last column.

A. Ease of use

Statement	Group	Agree	Disagree	D
This web site clearly explains what I must do.	Group 1	90%	10%	40%
	Group 2	50%	50%	
I can decide what to do.	Group 1	100%	-	80%
	Group 2	20%	80%	
It tells me what I do right or wrong.	Group 1	100%	-	30%
	Group 2	70%	30%	
I could find the information on the screen quickly and easily.	Group 1	100%	-	40%
	Group 1	60%	40%	
The web site kept my attention from beginning to end.	Group 1	70%	30%	-8%
	Group 1	78%	22%	
It helped that all the pages looked alike.	Group 1	40%	60%	0%
	Group 1	40%	60%	

B. HCI and functionality

Statement	Group	Agree	Disagree	D
I want to explore all there is to see.	Group 1	70%	30%	-20%
	Group 2	90%	10%	
The pictures helped me understand the lesson.	Group 1	80%	20%	-10%
	Group 2	90%	10%	
The screens contained just the right amount of information.	Group 1	80%	20%	0%
	Group 2	80%	20%	
It is easier to read from a computer screen, than from a book.	Group 1	78%	22%	0%
	Group 1	78%	22%	

C. Level of satisfaction

Statement	Group	Agree	Disagree	D
Plane Math was fun and exciting!	Group 1	80%	20%	-10%
	Group 2	90%	10%	
I enjoyed spending time in this web site.	Group 1	80%	20%	13%
	Group 2	67%	33%	
This was a nice way to learn.	Group 1	90%	10%	-10%
	Group 2	100%	-	
I plan to use *Plane Math's* web site after the class is over.	Group 1	70%	30%	-20%
	Group 1	90%	10%	
Using the *Plane Math* site helped me get better in using computers.	Group 1	56%	44%	-14%
	Group 2	70%	30%	
I don't know the American words (e.g. math and gas).	Group 1	30%	70%	-14%
	Group 2	44%	56%	
I could use my own ideas.	Group 1	78%	22%	18%
	Group 2	60%	40%	
The site uses things I already know.	Group 1	70%	30%	40%
	Group 2	30%	70%	