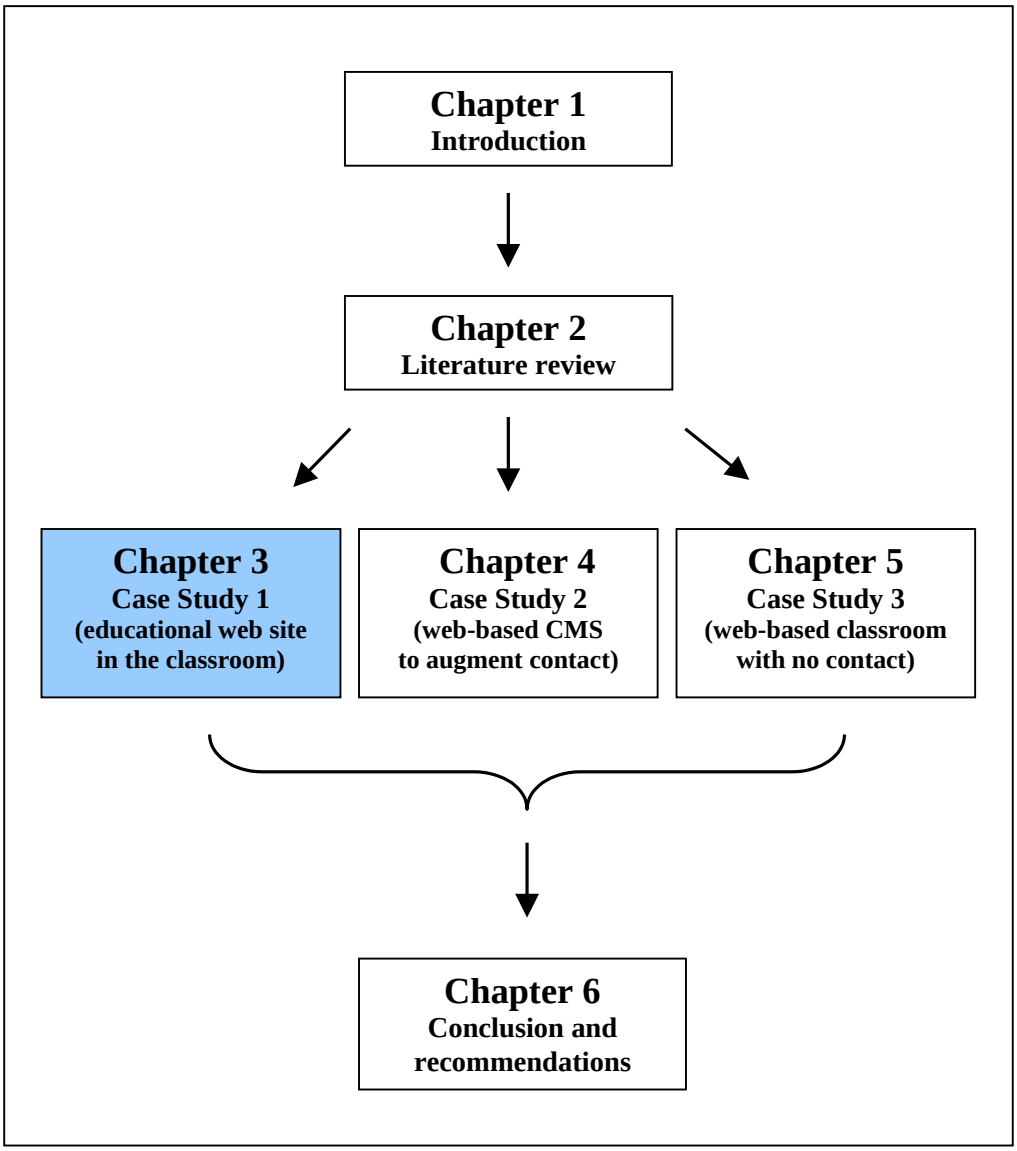
Chapter 3

Case Study 1 – Investigation of an educational web site



3.1 Introduction

This chapter reports on the first case study, namely, the investigation of an educational web site, *Plane Math* (a web-based tutorial and practice environment - http://www.planemath.com), and its usefulness in a Grade 5 classroom. The investigation took place in 1999. The goal of the chapter is to investigate the effectiveness of *Plane Math* and to compare the responses of children in an urban school and children in a rural school.

The case study is a response to the urgent need to conduct research on children's response to educational web sites. The domain of educational web sites is a rapidly growing and dynamic field that is making significant demands on evaluators to keep pace. Due to their currency, few have been evaluated thus far.

To determine the instructional and motivational effectiveness of educational web sites, the following aspects are investigated: pedagogical, affective/emotional, communicative and technological aspects. These aspects incorporate sub-aspects, including: children's response to educational web sites and their motivational effectiveness, and their instructional, curriculum and cosmetic adequacy (Hannafin and Peck, 1988:303-321).

If the feedback generated by such an evaluation is positive, it would be worthwhile to introduce the relevant web site as a supportive tool in the appropriate educational curricula.

The study commences by listing the relevant research questions, followed by a literature review and an outline of the context (international, national and institutional) of the study, with reference to two schools in the New South Africa seeking ways to cope with change and development. This is followed by the research methods used to conduct the research, the specifics of *Plane Math* and the results. Finally, a summary is given, and conclusions and recommendations are proposed.

3.2 Research questions

The researcher set out to answer the research questions indicated in Table 3.1, and assess whether there was a difference between the responses of children from an urban school and those in a rural school. These questions are asked and responses measured under the four main aspects covered in this dissertation, namely: andragogical, affective/emotional, communicative and technological. Some of these, in turn, have sub-aspects, which are shown in Table 3.1 in their respective categories.

Table 3.1 Research questions and their respective categories

	Aspects	Sub-aspect	Research subquestions
Case Study 1	Pedagogical	Children's response	▪ What was the response of the children with regard to their own learning?
		Curriculum adequacy	▪ How relevant is *Plane Math* to the school curriculum?
	Affective/emotional	Motivational effectiveness	▪ Did the children enjoy their learning experience?
	Communicative	Instructional adequacy	▪ To what extent does the site employ adequate Instructional Design (ID) principles?
		Cosmetic adequacy	▪ To what extent does the Human-Computer Interaction (HCI) promote learning or hinder it?
	Technological		▪ To what extent does the technology support effective use?

The researcher will not be measuring learning gain through pre-tests and post tests alike, because she accepts Clark's contention that media do not influence learning (Clark, 1994), and Russel's conclusion that there are no significant differences in performance between individual delivery media (Russell, 1999).

3.3 Literature review

In this section the motivational aspects of children's web sites are discussed, as well as the evaluation of such sites.

3.3.1 Motivational aspects of children's web sites

Although educational web sites may be sound in many respects, success can only be demonstrated once the material has been evaluated. However, Bantjes and Cronjé (2000) mention that most evaluators of web-based material rely on subjective values of style and "coolness", instead of focusing on information content, currency, compatibility, authority, easy 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 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, that is:

- 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 motivational elements are based on the expectancy-value theory (Vroom, 1964) and Keller 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 on another occasion (Arnone and Small, 1999). They state that motivation explains the "why" of behaviour, i.e. why one chooses to expend effort on certain tasks or activities as opposed to others. Malone's (1981) intrinsic motivators, such as: challenge, control, curiousity for learning and fantasy, also play a crucial role.

Arnone and Small (1999) list the motivational attributes that should be present in web sites designed for children. They should be:

- Engaging and stimulating;
- useful and credible;
- organised and easy-to-use; and
- satisfying and effective.

These attributes influence the child's tendency to revisit the web site and to motivate others to visit the site. The motivational elements, the attributes as specified above and a description of each of these attributes are given in Table 3.2.

Table 3.2 Motivational elements within web sites for children

Motivational elements	Attributes	Description
Value	Engaging and stimulating	Includes features that both capture and maintain interest and curiosity.
	Useful and credible	Includes elements that add value and promote relevance, e.g. the appropriateness of the site for the target population, as well as quick and easy links to other relevant web sites.
Expectation for success	Organised and easy-to-use	Features such as ease of navigation, user control, and help mechanisms translate to an organised and easy-to-use web site. This helps to build confidence in a child's abilities, so that they have a successful experience with the web site.
	Satisfying and effective	Opportunities for interaction, exploration, having fun and feeling competent translate to a satisfying experience and an effective web site.

(summarised from Arnone and Small, 1999)

Arnone and Small (1999) emphasise that motivational effectiveness enhances the learning process and is especially critical if a child chooses to visit a particular web site as opposed to having it assigned by a teacher.

3.3.2 Evaluation of educational web sites

Trochim (1999) describes evaluation as the systematic acquisition and assessment of information to provide useful feedback about some object. For the purposes of this research, a summative evaluation was conducted. A summative evaluation examines the effects or outcomes of programs, determining the overall impact (Trochim, 1999). Most often, feedback is perceived as "useful" if it aids in decision-making. Thus, the major goal of evaluation should be to influence decision-making or policy formulation through the provision of empirically-driven feedback (Trochim, 1999).

When evaluating educational programs and web sites, it is important also to look at the underlying learning theory, as this can have a significant influence on learning. Reeves (in: de Lisle, 1997) describes the objectivist basis of much educational software. Grounded in Behavioural Psychology, this kind of software has a limited ability to develop higher-order skills and ignores and/or represses human potential, as is evident in Chapter 2, Table 2.3.

An alternative model is based on cognitive science, commonly known as constructivism. Constructivism is an implementation of cognitive learning theory, just as mastery learning is related to objectivism. It is based upon the tenets of children constructing their own knowledge, i.e. the learner co-constructs meaning by exploring an environment, solving a problem, or applying information to a new situation that he/she helps to define (Campbell, 1999). The NCTM (National Council of Teachers of Mathematics) of the USA expresses a constructivist stance:

> *Learning mathematics is enhanced when content is placed in context and is connected to other subject areas and when students are given multiple opportunities to apply mathematics in meaningful ways as part of the learning process* (NCTM, in: Marsh, 2000b).

3.4 Context and research design

In this section the international and national context of the research will be discussed, as well as the institutional context and research design.

3.4.1 International and national context

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. Children 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 is evident in South Africa's improved position on the world competitiveness 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. There is hope, however, in *Curriculum 21* (a new revised and streamlined curriculum), which is to replace *Curriculum 2005* (Pretorius, 2000). *Curriculum 2005* is a curriculum based on the ideal of lifelong learning for all South Africans. It is aimed at equipping learners with the knowledge, competencies and orientations needed for success after they leave school or complete their training. Its guiding vision is to produce future citizens who are competent and think critically (South Africa, 1997a).

However, according to Chisholm (2000), although *Curriculum 2005* inaugurated a new dispensation in education in South Arica, its implementation occurred in conditions that did not enable it to meet either social or personal educational goals. The curriculum was said to be complex, insufficiently balanced and stymied by a lack of resources and capacity to implement them. In June 2000, a decision was made that *Curriculum 2005* could not continue in its present form, and an improved curriculum was envisaged - *Curriculum 21* (Pretorius, 2000). However, the key elements of *Curriculum 2005* will remain (Pretorius, 2000). This embraces the principle of Outcomes-Based Education (OBE) – an approach to

teaching where the learner is the most important consideration and learning happens through activities.

According to Chisholm (2000), the development of creative, critical and problem-solving individuals lies at the heart of *Curriculum 21*, in order to achieve the values of a society striving towards social justice, equity and development. The curriculum places a strong focus on the teaching of mathematics and science, with 50% of classroom time to be spent on mathematics and language teaching in Grade 4 and onwards (Pretorius, 2000). The curriculum consists of six learning areas for Grades 4 to 9, namely: language, mathematics, natural sciences, social sciences, arts and culture, and life orientation. In each of these areas, children should be afforded opportunities to apply what is learnt to "authentic" problem situations and so make their learning relevant and applicable to their lives (Chisholm, 2000).

If implemented successfully, this program has 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 could make a contribution, both in terms of teacher training and in the realms of using existing and developing new software in the classroom. If the latter is taken seriously, South Africa has the potential to compete in the international market and to improve its position on the world scale.

3.4.2 Institutional context and research design

Educational programs and web sites are used by people with unique needs in a real world. For this reason, two groups were chosen to participate in the investigation, one school in an urban city context (referred to as urban school), the other in a rural town context (referred to as rural school). The urban school, Lynnwood Ridge Primary School, is situated in an upper middle class suburb in the industrial province of Gauteng, while the rural school, Duiwelskloof Primary School, is in a small rural town in a mountainous area, in the remote Northern Province. The latter school is 25km from Tzaneen and 100km from Pietersburg. Figure 3.1 is a map of South Africa, showing the location of the two schools in their respective provinces.

Figure 3.1 Location of the two schools within South Africa

The medium of instruction at Lynnwood Ridge Primary School is English. The children come from various population groups, with English, Afrikaans, Northern Sotho and Tswana as mother tongues. Most of the children come from the affluent surrounding suburbs.

Duiwelskloof Primary School is parallel medium (English and Afrikaans) and has been racially integrated since 1995. The children 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 black French-speaking children from Zaire, whose parents work at the Ga-Kgapane hospital. Most of the children come from rural areas and from farms. A more detailed description of the children who participated in the actual survey is given in Table 3.3.

The purpose of taking a group from each of the two schools in their different contexts is to see whether children's response to *Plane Math* varied, and to evaluate whether or not educational equality among diverse populations of children was achieved.

A significant problem faced by schools is that Mathematics is a compulsory subject, feared by many children. The basic elements of fun, discovery and self-motivated mastery are absent for the majority of children. 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 (Frielick, 1999:4):

- To enable children to feel the empowerment that is brought about by competence in computer technology.
- To prepare children for the technological challenges for the future, challenges which incorporate marketable skills, economic empowerment and critical thought processes.
- To produce school-leavers who are critical thinkers, problem solvers and information seekers.
- To make computer lessons fun, interesting and worthwhile for the children to maintain an interest, and engender an enthusiasm for working with computers.
- To integrate essential learning and thinking skills alongside teaching basic computer skills, meaning that lessons are task-based activities.

3.5 Method

This research falls under a non-experimental survey design. The research is primarily a quantitative study, but qualitative measures were used to record the results of surveying/observing the learners. Quantitative measures were taken in both the questionnaire (where Likert scaling was used), and the expert review checklist. The questionnaire appears as Appendix A and the expert review checklist as Appendix B.

Multiple methods were used to validate the results generated from the questionnaire, i.e. to apply triangulation. The questionnaire was based on a variety of checklists available in literature. It was administered to two groups - ten Grade 5 children from Lynnwood Ridge Primary School (an urban school) and ten Grade 5 children from Duiwelskloof Primary School (a rural school). The children from Lynnwood Ridge Primary School were a sample of volunteers, while the children from Duiwelskloof Primary School comprised an entire class. The children completed the questionnaire after spending time using *Plane Math*. *Plane Math* offers nine lessons from which learners can choose which lesson/s to complete. Each lesson has its own NCTM standards, outcomes, list of supplementary material and activities. The *Plane Math* web site was chosen above two other alternatives because it was visually attractive and appealing for a young target audience.

An expert review checklist was drawn up in collaboration with the teachers from both schools, after they had spent time working on the web site. Observation entailed a researcher and a facilitator being present with the children while they used the web site, to record noteworthy incidents. The presence of two supervisors promoted validity. Informal discussions with the children were also held before and after using *Plane Math* to examine their response to the site.

3.6 Specifics of *Plane Math*

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 children 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, and may not realise the personal relevance 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 children and adults as bright, enthusiastic and able to both assist and work with others, regardless of ethnicity, background, disability, or gender (*InfoUse*, 1996). As such, it may be regarded as a radical humanist web site, since it views the individual and his/her well-being and development as the main point of departure (Roode, 1999:5). This approach moves the focus from technology to aspects such as the individual and their productivity. The primary research questions the radical humanist sets out to answer are "how does?" and "what is?". Such questions help to focus the evaluation on the individual and the overthrow of existing social structures (Roode, 1999:5-6).

According to *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.*

Based on this mission statement, the developers pursued four goals, these being to:

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

The second and fourth goals above appear to correspond well to the objectives of the two schools computer technology curriculum listed in Section 3.4.2. The researcher would have liked to evaluate this web site in terms of a group of physically disabled children, but this was not possible. The site is, however, relevant to the broader range of children, and in this study was evaluated in terms of children from various population groups, some of whom work through the medium of their second language, and others who had specific problems in mathematics, although they were not physically disabled.

3.6.1 Nature of tutorial

Plane Math consists primarily of lessons/instructional units of a tutorial nature. Within the tutorial, teaching segments alternate with question segments. It supports a behaviourist paradigm, and expects children to master a concept before a new one is introduced. The web site also partially supports a constructivist paradigm in that it encourages collaborative learning. This takes the form of group activities, a chat room (not yet functional at the time of writing), links to sites with related topics, an e-mail facility to the authors of the site and contact with live subject matter experts.

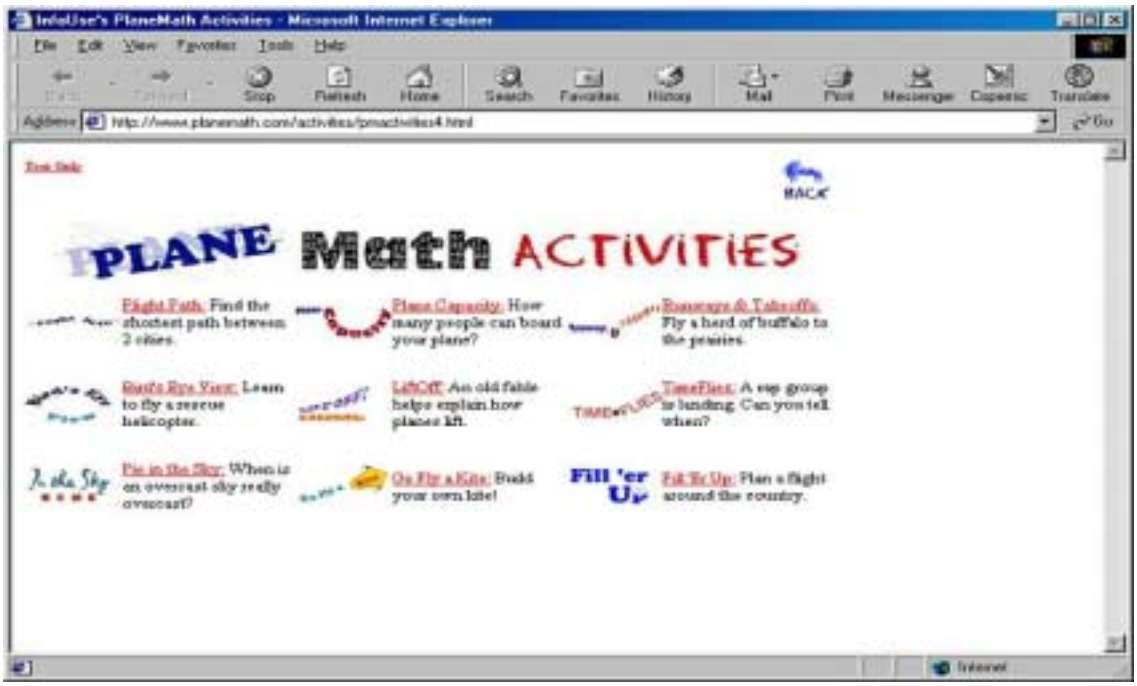
The web site promotes discovery learning in that it has links to other organisations' web sites. Links are divided into three categories, namely: technology and disability, aeronautics, and mathematics.

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, thus making it possible for weak children to drop a level or go back to previous, unmastered skills. It also facilitates the progress of children who are coping well, and decide to advance to more challenging interactive lessons (if they have the necessary technology).

The Human-Computer Interaction (HCI) is commendable in its use of sound principles of screen design - 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 easy to understand. In the expert review checklist, all four teachers who served as respondents gave a rating of 1 ("strongly agree") for the statement that "the screen design of this web site follows sound HCI principles".

The introductory menus stimulate interest, because the headings are semantically clear. Figure 3.2 sets out their real-world purpose.

Figure 3.2 Screen capture from *Plane Math*



Plane Math does not indicate clearly which lessons are appropriate for whom, and what the objective of each lesson is, unless one views this information from the "teacher/parent information" within the site. Consequently, children can get lost, unless given clear guidance from a mathematics teacher as to how best to navigate the site. In general, however, all four teachers agreed that the instructional design of the web site was based on sound learning theories and principles.

Feedback does not spell out the answers. This is in keeping with the goal of portraying children and adults as bright and enthusiastic. If a child answers a question incorrectly, they are assisted by feedback which shows/tells them the result of their action, and encourages them to try again. They are returned to the original screen that presents the problem.

3.7 Results

The results are grouped according to the six research subquestions, using all three methodologies, namely questionnaire, expert review checklist and observation. Percentages were computed for 22 questions on a four 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 under the label "agree", as are categories three and four under the label "disagree". Results of the subquestions are given, grouped according to their aspects with their respective sub-aspects. There are twenty-two subquestions, with percentages for the two groups, namely the urban and rural school respectively. The final column (Δ) in these tables represents the difference between the two groups, that is:

Δ = urban school value – rural school value.

The difference between the responses of the two groups is also depicted in corresponding figures below each table.

The questionnaire was completed by ten children from the urban school and ten children from the rural school. Seeing that a small sample size was used, these results are tentative.

Table 3.3 gives a description of the two groups of children under investigation.

Table 3.3 Description of the target population

Characteristics		Urban school	Rural school
Gender	Boys	8	8
	Girls	2	2
Home language	English	70%	30%
	Afrikaans	20%	0%
	Black language	0%	60%
	Other	10%	10%
Computer use	Home and at school	70%	20%
	At school only	30%	80%
Use to which computer is put.	Exploring and searching; and playing games	50%	50%
	School projects	40%	30%
	Exploring and searching	0%	20%
	Programming	10%	0%
Internet use	Frequently use it	30%	0%
	Occasionally use it	30%	20%
	Hardly use it	30%	50%
	Never use it	10%	30%
Age range		10-12 years old	11-12 years old
Location of learners		Traditional contact teaching	

When viewing the results it should be remembered that the urban school children were volunteers who were distinction candidates in mathematics, working mainly in their first language, while in the rural school, 70% of the children worked through the medium of their second language and some had specific problems in mathematics. Certain children from the rural school also come from a historically disadvantaged background.

In addition, only 20% of the rural school children used computers at home, in contrast to 70% of the urban school children who used computers both at home and at school. The urban school children also used the Internet on a more frequent basis than did the rural school children. It was interesting to see that both groups of children used computers for a combination of school work and playing games, and not one in isolation.

3.7.1 Pedagogical aspects

In this section children's response to their own learning is discussed, as well as the relevance of the web site to their school curriculum.

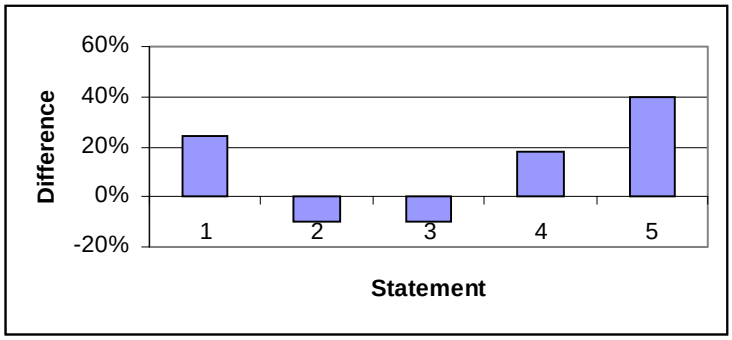
3.7.1.1 What was the response of the children with regard to their own learning?

Table 3.4 and Figure 3.3 depict the differences and similarities in children's response to various statements regarding their own learning. Figure 3.3 indicates that the most notable difference was the difference in the response of children to the site using things they already knew. Otherwise, the responses of the two schools were quite similar.

Table 3.4 Children's response to their own learning

Statement		Group	Agree	Disagree	Δ
1.	I learnt a lot about mathematics.	Urban school	80%	20%	20%
		Rural school	60%	40%	
2.	I am more confident in mathematics now.	Urban school	70%	30%	-10%
		Rural school	80%	20%	
3.	The site made me do a lot of thinking.	Urban school	70%	30%	-10%
		Rural school	80%	20%	
4.	I could use my own ideas.	Urban school	78%	22%	18%
		Rural school	60%	40%	
5.	The site uses things I already know.	Urban school	70%	30%	40%
		Rural school	30%	70%	

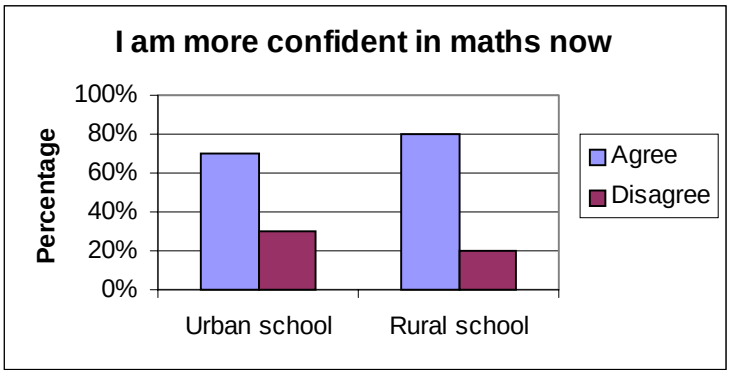
Figure 3.3 Areas of difference between the two groups, with regard to pedagogical aspects



In both groups (urban school: 80%; rural school: 60%) children responded that they learnt a lot about mathematics, especially the children in the urban school.

Figure 3.4 shows the positive effect the web site had on both groups of children (urban school: 70%; rural school: 80%) in terms of their confidence levels in that section of mathematics.

Figure 3.4 Children's confidence levels

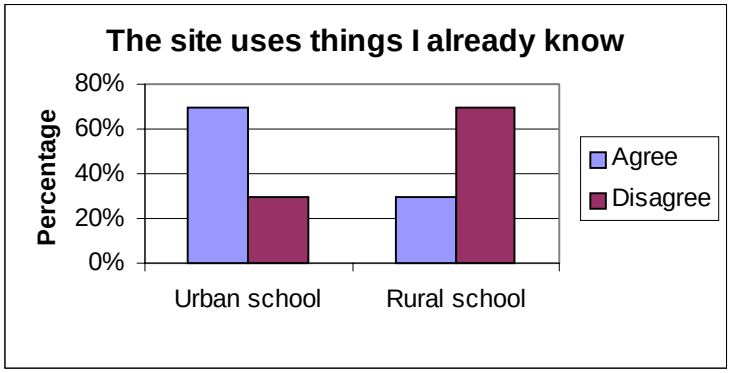


Children responded very similarly to the statement "The site made me do a lot of thinking", in that both groups agreed to this statement (urban school: 70%; rural school: 80%). This was confirmed by the observation in which there were periods of silence while they worked through a particular problem. It was also rewarding to see them working together and pointing to certain objects on the screen to highlight what appealed to them.

In the urban school, 78% of the children responded that they could use their own ideas, in contrast to only 60% of the children in the rural school. This could indicate that the latter group explored the system to a lesser degree than the urban school.

Figure 3.5 indicates that *Plane Math* did not use objects familiar to the children in the rural school, as 70% of these children disagreed with the statement "The site uses things I already know". This demonstrates that the web site is predisposed towards the more advantaged children.

Figure 3.5 How *Plane Math* uses prior learning



3.7.1.2 How relevant is *Plane Math* to the school curriculum?

Table 3.5 indicates that children responded favourably to the statement that the lessons could help them with their school work (urban school: 80%; rural school: 100%).

Table 3.5 Curriculum adequacy

Statement	Group	Agree	Disagree	Δ
The lessons can help me with my school work.	Urban school	80%	20%	-20%
	Rural school	100%	0%	

In the expert review checklist, the teachers agreed that the web site relates to the Grade 5 school curriculum, and plan to use it as a supportive tool in their curriculum in future years. Generally, teachers found *Plane Math* to be a valuable learning tool, as indicated by the following quote:

> *Thanks very much for showing us this very useful site, the children enjoyed it and we the teachers learnt something.*

3.7.2 Affective/emotional aspects

This section examines the motivational effectiveness of *Plane Math*.

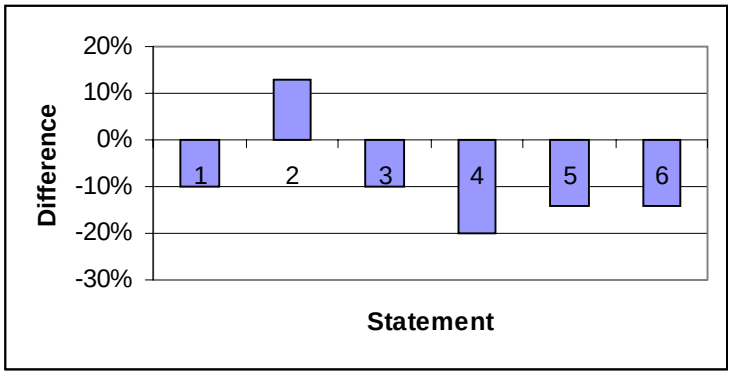
3.7.2.1 Did the children enjoy their learning experience?

Table 3.6 and Figure 3.6 depict the differences and similarities in children's response to various statements surrounding their experience of *Plane Math*. Their responses to the various statements were similar in nature. The most significant difference in this section was their response to using *Plane Math's* web site after the class was over.

Table 3.6 Motivational effectiveness

	Statement	Group	Agree	Disagree	Δ
1.	*Plane Math* was fun and exciting!	Urban school	80%	20%	-10%
		Rural school	90%	10%	
2.	I enjoyed spending time in this web site.	Urban school	80%	20%	13%
		Rural school	67%	33%	
3.	This was a nice way to learn.	Urban school	90%	10%	-10%
		Rural school	100%	0%	
4.	I plan to use *Plane Math's* web site after the class is over.	Urban school	70%	30%	-20%
		Rural school	90%	10%	
5.	Using the *Plane Math* site helped me get better in using computers.	Urban school	56%	44%	-14%
		Rural school	70%	30%	
6.	I don't know the American words (e.g. math and gas).	Urban school	30%	70%	-14%
		Rural school	44%	56%	

Figure 3.6 Areas of difference between the two groups, with regard to affective/emotional aspects



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.*
- *It's great.*

Observation validates these results, as the children in both groups looked relaxed and discussed the problems amongst themselves. The day after the evaluation, the mathematics teacher from the urban school asked the children who took part in the evaluation if they enjoyed the learning experience. In verbal response, 25% said that it was too easy, while the remaining 75% commented that "it was fun". The teacher felt that these responses depended on the level of maturity of the child.

The children generally agreed that they enjoyed spending time in the web site (urban school: 80%; rural school: 67%). They were asked in the open-ended questions what they liked about the 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.*
- *The questions they asked us.*
- *Learning about topics that interest me, using the Internet.*
- *It gives a lot of information and it makes learning easier.*

Both groups of children (urban school: 90% ; rural school: 100%) agreed with the statement that "this was a nice way to learn". However, there were certain aspects that the children disliked about the site, evidenced by the following responses:

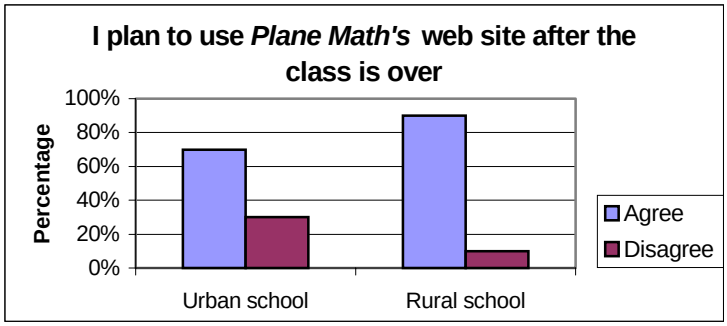
- *Some lessons are boring* (urban school).
- *The fact that it is a bit young* (urban school).
- *Too much white* (urban school).
- *Sometimes I did not understand what was on the screen* (rural school).

- *Took too long for pages to load* (urban school and rural school).
- *I liked everything* (urban school and rural school).

It was interesting to note that a learner from the rural school battled to understand what was portrayed on the screen. This is a learner who works through the medium of English as a second language.

Figure 3.7 depicts the children's response to the statement "I plan to use *Plane Math's* web site after the class is over".

Figure 3.7 Children's attitude to using *Plane Math*



Children from the rural school (90%) were keener to refer the web site to their friends than those from the urban school (70%). These results validate their responses in the open-ended questionnaire, where some of the reasons children from the rural school 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.*

Children from the urban school were at a greater advantage, since 70% of them had access to a computer both at school and at home, in contrast to the rural school, where only 20% had access to a computer at home (see Table 3.3). As a result, 70% of the children in the rural school agreed with the statement that "using the *Plane Math* site helped me get better in using computers". It was also interesting to note that children who specified that they use the Internet "not a lot" (urban school: 30%; rural school: 50%), found the exercise far more

enriching and valuable than children who already use the Internet on a frequent basis. Children familiar with the Internet (urban school: 60%) expected far more from the site (e.g. increased interactivity), than those who were less familiar with the Internet (rural school: 80%). Hence there is an urgent need for children who are less advantaged to be exposed to such web sites, so that they too can become critical thinkers and problem solvers. This would help in achieving educational equality.

A further notable point was that the majority of children (urban school: 70%; rural school: 56%) stated that they did not mind the American terminology, thus indicating their familiarity with American vocabulary, possibly due to movies and TV. Although the children did not object, educational web sites that are specifically contextualised to the South African context would provide them with a more appropriate point of contact.

3.7.3 Communicative aspects

In this section the extent to which *Plane Math* employed adequate ID principles is discussed, as well as the extent to which the Human-Computer Interaction (HCI) promoted learning or hindered it.

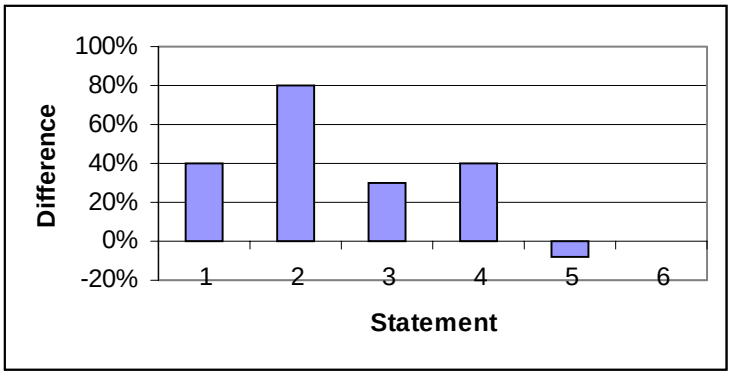
3.7.3.1 To what extent does the site employ adequate Instructional Design (ID) principles?

Table 3.7 and Figure 3.8 depict the differences and similarities in children's response to the instructional value of *Plane Math*. Notable differences in the response of the two groups are depicted in Figure 3.8, the most notable being whether or not they could decide for themselves what to do.

Table 3.7 Instructional adequacy

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

Figure 3.8 Areas of difference between the two groups, with regard to instructional adequacy



In the urban school, 90% of the children responded that the web site gave them clear instructions on what to do. However, in the rural school, 50% of the children struggled to understand how to operate the system. In addition, 80% of the children from the rural school did not realise that they could decide for themselves what to do. This was in direct contrast to the children from the urban school, where all the children (100%) agreed that they could decide for themselves. The high percentage among the learners in the rural school (80%) could indicate the influence of teaching methods based on passive rote learning, where the learner is told by the teacher what to do, or else it could result from a low rate of exposure to computers (the majority of these children only had access to computers at school). In order to accommodate children from diverse populations and who work through the medium of

their second language, instructions on the available options should be made more explicit. This would optimise learner control.

Both groups of children agreed that they knew from the exercises what they were doing right or wrong (urban school: 100%; rural school: 70%). It is interesting that the percentage in the urban school is 30% higher than that of the rural school. Children in the rural school 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 children in the urban school. This could be due to the material not being in their first language, resulting in difficulty in understanding it.

Children found the web site engaging, indicated by the fact that both groups of children responded that the web site kept their attention from beginning to end (urban school: 70%; rural school: 78%).

In both groups, 60% of the children felt that it did not help that all the pages looked alike. This could indicate that children would prefer exciting material, that is, web sites should motivate them and provide them with challenge, curiosity, control and fantasy (Malone, 1981). This would gain their attention and provide a high level of satisfaction (Keller and Kopp, 1987).

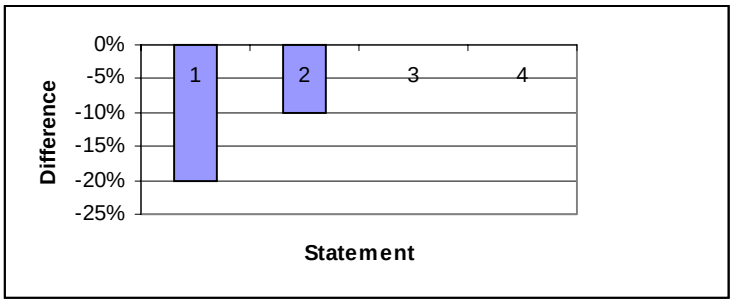
3.7.3.2 To what extent does the Human-Computer Interaction (HCI) promote learning or hinder it?

Table 3.8 and Figure 3.9 depict similarities in children's rating of the cosmetic adequacy of *Plane Math*. Their responses to the various statements were very similar, with no notable differences.

Table 3.8 Cosmetic adequacy

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

Figure 3.9 Areas of difference between the two groups, with regard to cosmetic adequacy



Children responded positively to each one of the subquestions regarding cosmetic adequacy, especially the children in the rural school, as evidenced in Table 3.8. Children from both groups (urban school: 70%; rural school: 90%) were generally keen to explore all there was to see. The pictures also helped children from both groups understand the lesson (urban school: 80%; rural school: 90%). It was interesting to see that the pictures played a major role with the children in the rural school, helping them comprehend the lesson. Eighty per cent of the children in both groups stated that the screens contained just the right amount of information, indicating that they did not experience sensory overload.

Suprisingly, children in both groups (78%) reacted 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.

3.7.4 Technological aspects

In this section the extent to which the technology supports effective use is discussed.

3.7.4.1 To what extent does the technology support effective use?

The children found screen transitions slow and, to a certain extent, this temporarily distracted their attention from the site. This, however, was due to the limited bandwidth available in South Africa, and should the same study be replicated in another environment (e.g. the United States or Australia), the problem might not be experienced.

3.8 Summary

In general, the children from the two groups responded similarly to the web site. Both groups expressed positive responses to the site and its value in their mathematical learning. The results clearly indicate that the basic elements of fun, discovery and self-motivated mastery were present in the web site, and that value and the expectation of success, as suggested by Arnone and Small (1999) were present. However, there were certain differences between the two groups, of which the most important are given in Table 3.9.

Table 3.9 Most important differences betweent the two groups of children

Groups	Differences
Urban school	▪ Responded more positively to the statements on instructional adequacy, due to their familiarity and confidence with computers. This resulted in their using the site as the designers had intended. ▪ Were slightly more critical than the children from the rural school, due to their wider exposure to computer interfaces and learning resources in general.
Rural school	▪ Did not know that they could decide for themselves what to do. ▪ The site did not use objects familiar to them.

3.9 Recommendations

This investigation has demonstrated that the overall effect/outcome of the evaluation was positive. Based on the children's and teachers' feedback, a decision could be made to implement educational web sites as a supportive tool in the appropriate educational curricula. Furthermore, the researcher recommends that the site be used in a South African context, but that many of the lessons should be enriched by having children adapt their responses to South African conditions. The researcher also makes certain recommendations concerning improvements to the site itself, suggestions that may well be useful to people wishing to develop similar sites. The recommendations are divided into the aspects investigated in the study.

Pedagogical aspects

- The web site should provide children with a clear knowledge of who the various lessons are for and should provide clear aims and objectives.
- The same concept should be applied to applications other than those in the aeronautical industry. Also, the curriculum should be made broader, and not just in mathematics.
- Instruction should be adaptable to accommodate different cultural groups, i.e. different examples should be provided which are culturally appropriate for the varied groups of learners.

Affective/emotional aspects

- The site could be enriched in line with current web developments.
- It should be made more interactive and exciting on the Grades 4 and 5 levels, for example, allowing children to control the plane.

Communicative aspects

- More hyperlinks and facts should be given.
- Learners should be exposed to computers from early grades; this applies particularly to children in rural schools.
- Children should be given clearer instructions regarding the options offered by the system.

Technological aspects

- Reducing the size of graphics could increase transition speed between screens.
- Bandwidth needs to be improved. This situation will improve, however, as South Africa's bandwidth capacity is increased.