ESTABLISHING FUNDAMENTAL THEORIES FOR INTERNET ATLAS REALISATION WITH APPLICATION IN THE BRAZILIAN PRIMARY EDUCATION SYSTEM

A thesis submitted in fulfillment of the requirements for
the degree of Doctor of Philosophy

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DECLARATION

This thesis contains no material that has been accepted for the award of any other higher degree or graduate diploma in any tertiary institution. This thesis contains work of mine alone and the best of my knowledge and belief contains no material previously published or written by another person, except where due reference is made in the text. Furthermore, the work presented has been carried out since the official starting date of the program.

Cristhiane da Silva Ramos
March 2006

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Glossary

GML – Geographic Markup Language – Markup language based in XML designed to describe and exchange geographical data over the Internet.

JavaScript – Scripting language that can be embedded into HTML pages. It allows the manipulation of SVG objects, enhancing interactivity.

PDA – Personal Digital Assistant – Digital portable device that can combine multiple functionalities: a computer, a mobile phone, a camera, a navigation system and music player.

SMIL – Synchronised Multimedia Integration Language – Language used to describe multimedia presentations also based in XML. SMIL statements can be used to control animations in SVG files.

SVG – Scalable Vector Graphics – Markup Language based in XML. SVG aims to provide guidelines for rendering 2D vector graphics. SVG files can be either static of animated.

Visualisation and Geovisualisation – In this document the British spelling with *s* was adopted, unless when the words are part of quotes.

VRML – Virtual Reality Modelling Language – A modelling language used to describe 3D interactive vector graphics.

W3C – World Wide Web Consortium <http://www.w3c.org> - International organization dedicated to develop and validate standards for the World Wide Web.

XML – Extensible Markup Language – A language validated by the W3C that aims to provide guidelines for exchanging data over the Internet. XML is also used for creating additional markup languages with specific purposes.

Prologue

I believe that some clarification is necessary to justify the topic chosen in this research programme. As a Brazilian citizen, sponsored by the Brazilian government, it would be natural to choose a research topic applied to my country.

However, I have a personal experience related to the field of research described in this thesis. Although I had never worked with cartography for school children in Brazil, I am a qualified primary and secondary school teacher. I worked as a teacher, in public and private schools in Brazil, for three years, from 1992 to 1995.

In 1997, however, I was hired by the company *Serviço Nacional de Aprendizagem Comercial* (SENAC). SENAC offers vocational education and training courses in various areas, from hospitality to hair dressing, including computer training. SENAC is similar in structure to TAFE in Australia.

I was hired to deliver training in Microsoft Office applications to public school teachers. I worked in 1997 and 1998 training teachers in two different cities in São Paulo State: Limeira and Araras. As an employee I understood that SENAC had been engaged by the State government to offer computer training to all public school teachers in the State. That was a massive task in a State with a population of about 37 million people.

The courses were very intensive, with four hours per day contact. I believe the experience was really rewarding for both presenter and class. I could see the difficulties the teachers had using computers. Many of them had never used a computer before. Many told me the problems they had trying to use educational packages provided by the State government, but delivered in a foreign language. I was invited by some school principals to visit some of the computer laboratories provided by the State government. Here I saw the facilities first-hand and I could analyse the resources available.

Therefore, when the opportunity came to propose a research project for my PhD I thought “wouldn’t it be nice if I could use both my experience as a teacher and teacher training with computers for education as a focus to my PhD research?”.

I believe that most of Brazilian undergraduate candidates that undertook their studies in public universities in the States of São Paulo, Minas Gerais, Rio de Janeiro and Paraná, were in contact at some stage with an important Brazilian researcher in the field of cartography for children. It was no different in my case. This person is Profa. Dra. Rosângela Doin de Almeida, the organiser of the *School Atlas of Rio Claro*, who taught me the subject “Teaching Practice in Geography”.

Research in cartography for children in Brazil is so profuse that it would be natural for me to follow that path. I had had previous contact with the *School Atlas of Rio Claro* before coming to Australia in 2002. Although I was not part of the original development team, the Atlas was developed in the same university that I undertook my undergraduate study and my Masters degree.

I considered that I could build-on my experience I had acquired during my Masters degree, completed in 2001, when I developed a small, discrete and GIS-based atlas to a major project where I could propose a methodology for publishing Brazilian local school atlases on the Internet.

Both of my supervisors, Prof. William Cartwright and Profa. Dra. Rosângela Doin de Almeida, embraced this challenge and now I present the results of three years of research. During this period I had to make many choices, but the main constraint was to propose something feasible for the Brazilian context considering budget and human resource restrictions. I hope that the main outcome of this research would be to foster the implementation of additional quality Brazilian educational products, particularly atlases delivered on the Internet.

1 Introduction

1.1 Research Background

The use of maps by children and its cognitive aspects have been the focus of much research over the last two decades (Bonin 1982; Anderson 1985; Castner 1993). This international phenomenon has also been seen in Brazil (Santos and Sann 1985; Almeida and Passini 1992; Almeida 2001b) where much research effort has focused on the development of local school atlases for early grades of primary school.

In 1997 the Brazilian Federal government published new guidelines for education at primary and secondary levels (*Parâmetros Curriculares Nacionais – PCNs*), where the role and importance of cartography in schools was recognised. In this document cartography was seen as an important tool for learning different geographical concepts. The idea was to use cartography to educate citizens about geography, by using maps not just for location purposes, but as tool for understanding the world.

Much current research related to cartography for children in Brazil has focussed on the development of municipal atlases for dissemination on paper, providing school children geographical knowledge about their own space. For example, a city can be used as a metaphor for the real world, where historical and geographical processes can be seen and analysed. These atlases were usually developed as partnerships between local government and public universities. They were created by academics, undergraduate and graduate students, and primary school teachers. Generally funded by research grants, these products are unlikely to be re-printed once stocks are depleted. At the time of writing 14 Brazilian local school atlases have been published. More are under development, such as the School Atlas of Sumaré and the School Atlas of São Bernardo do Campo.

The main focus of this research was to propose develop and evaluate a methodology that would empower Brazilian local school atlas developers with the means to publish their products directly using the World Wide Web (Web), and thus eliminating paper publishing constraints. The *Atlas Municipal e Escolar of Rio Claro*, Brazil (that will be referred in this document as *School Atlas of Rio Claro*) was used to provide data for producing a proof-of-concept prototype for testing the methodology developed.

It is believed that, once implemented, the methodology will lead to the publication of an increased number of local school Web atlases for Brazil that will provide the condition to reach a much wider student audience, thus enhancing the teaching of Geography in Brazilian primary education.

1.2 Aim and Scope

The aim of this research was to provide a methodology for publishing Brazilian school atlases on the Web that would be both easy-to-implement and relatively inexpensive. The methodology was developed considering the following presumptions:

- There will be a growing demand for Brazilian digital educational applications due to the creation of computer laboratories for didactic purposes in Brazilian public primary schools. (since the 1997, the Brazilian Federal Government has provided 53 thousand computers to 4,640 schools (Serpro 2004); top-up investments from State and Local governments as well as the industry are believed to vary throughout the country);
- Primary school teachers will be able to use digital atlases as they have been trained in computer use within education; and
- Local atlas developers will be able to publish their atlases on the Internet with no increased production costs.

Therefore, the bottom line for exploring the appropriateness of an alternative methodology was that it should be easy to use, be inexpensive and provide the means for publishing school atlases on the Web. Acknowledging this constraint, amongst numerous technologies that could be used to publish Web Maps (including Web GIS), the use of the Open Standard technology SVG (Scalable Vector Graphics) and JavaScript were the core components of the methodology developed. To make these technologies user-friendly for unexperienced Web developers, a set of SVG-based Web atlas templates was developed. These templates aimed to cover a range of interactive atlas use situations that, combined with the content to be provided by developers, would lead to the publication of the final product. In this way, the templates proposed would be part of a 'Web atlas publishing cook book' for local Brazilian atlas developers. As part of the research, a prototype of the *School Atlas of Rio Claro* was developed using the proposed templates. This prototype, as well as the templates themselves, was tested in Brazil with primary school teachers (testing the prototype) and a group of atlas developers (testing the templates).

1.3 Overview of the study

This thesis comprises seven chapters. Following this introductory chapter, the second chapter focuses on defining digital atlases. It is believed that a better understanding of what a digital atlas actually is was necessary, considering that the culture of publishing atlases on the Internet is not yet well established amongst Brazilian academics (this is analysed in chapter four). Therefore, this knowledge will allow Brazilian developers to better understand the types of digital atlases possible, helping to demystify the topic area. The main idea is to show Brazilian developers what a digital atlas could be so that they might more readily adopt a digital medium for geographical application development. This second chapter also presents elements for developing a methodology for publishing school atlases on the Internet. In this chapter definitions provided by several authors are presented. Additionally different types of digital atlases are identified. The lingering question about the difference between GIS (Geographical Information Systems) and digital atlases is also addressed in the chapter. As can be seen in the chapter, digital atlases do not necessarily employ GIS-based tools and this information indicated the path to follow in the methodology to be developed, because Brazilian local atlas developers, generally, do not use GIS-based tools when producing their maps.

Chapter three reviews multimedia and interactive functionalities that could be implemented in digital atlases. The concepts of geovisualisation, hypermaps, interface and multimedia map metaphors and animations are analysed. Additionally, the chapter focuses on analysing discrete media used to convey interactive mapping applications.

Chapter four focuses specifically on Internet maps. Different technologies that could be used for publishing Web atlases are analysed. Although the universe of Web publishing technologies is quite broad and ever-changing, some Open Standard technologies are analysed, related to the aim and scope of this research. Additionally, Internet figures are analysed as are the proceedings of International and Brazilian cartographic conferences. The analysis of the proceedings of Brazilian Cartographic Conferences found strong research interest in using digital technology for producing teaching materials. This information corroborates the need of developing a methodology that could be used by Brazilian researchers to publish their educational products directly via the Web.

Chapter five initially aims at informing readers about aspects of the Brazilian educational system. It also presents an overview of research in cartography for children in Brazil. It then focuses on the *School Atlas of Rio Claro*, the primary source of information used to build a prototype for this research. The Brazilian educational system is also briefly outlined. The Chapter then moves to the analysis of advantages and disadvantages related to publishing digital education materials. Additionally, difficulties for producing digital atlases for education in Brazil are identified and possible solutions suggested.

Chapter five presents the structure of the proposed methodology for publishing school atlases on the Internet. The focii in this section are three topics: layout and interface design; coding; and interactive functionalities. In this section templates are presented and the code use explained.

Chapter six is dedicated to describing user testing. Two tests are outlined and the results of the analysis provided. The first test was carried out with a group of test candidates who were voluntary teachers working in Brazilian public primary schools. The purpose of this test was to assess potential problems that teachers might have when using an Internet atlas based on templates developed as part of the research. To achieve this goal part of the *School Atlas of Rio Claro* was published as a test Web atlas. The second test was conducted with a group of Brazilian atlas developers to assess whether the proposed templates would be a valuable resource for Brazilian atlas developers and to identify the limitations of the methodology proposed.

The results from the two tests outlined in chapter six, together with remarks from the development of the methodology itself, described in chapter five, led to the conclusions and recommendations that are drawn in chapter seven. The main conclusions are:

- The methodology proved to be a valuable tool for developing Internet-based local school atlases;

- There is a demand for such products, and primary school teachers are likely to apply them to their educational practice;
- The use of combined media - digital and paper - encourages teachers to not only use the atlas but to also propose paper-based activities for the classroom; and
- Brazilian primary school teachers still lack familiarity with interactive cartography.

It is recommended that further research could identify different atlas use methods for teachers who had not had contact with previously-published paper products. Additional research could also identify what types of atlas use could be established with teachers who are familiar with interactive maps. Additionally, the use of educational games as part of a digital atlas is another topic that requires future investigation.

1.4 Chapter Summary

This chapter has provided an overall description of the thesis content. The purpose here was to provide the research background, which emphasises the need for developing interactive geographic educational resources in Brazil. The aim and scope of this research were also presented in this chapter. Additionally, the following chapters that comprise this document were briefly outlined.

In the following chapter key concepts related to digital atlases are analysed.

2 Atlases from paper to digital medium

2.1 Chapter Overview

The main purpose of this chapter is to define atlases in general, and particularly digital atlases. Additionally, the chapter focuses on better understanding what constitutes digital atlases: defining their characteristics, classification and delivery medium. It is important to better understand atlases in this contemporary context, as atlases are no longer restricted to just paper and, as well, they are not necessarily comprised of 'just' maps.

Many researchers have reviewed the definition atlas and digital atlas (refer to sections 2.3 and 2.4). However, although many definitions of digital atlases have been made, digital atlases encompass such a wide range of features and technologies that it is necessary to extend these by defining their characteristics and different atlas types. Also, the recent advances in atlases production can raise the question: "Are digital atlases a kind of GIS?" This question is inevitable as, in some ways, digital atlases cannot just be comprised of functions for spatial analysis, but also GIS objects as well. If there was a dividing line separating the definitions of GIS and digital atlases, one could say that it is becoming fuzzier.

Atlases are, probably, the best known and the most flexible of popular cartographic products. Atlases can be used to address different issues and to target different audiences. Historically, atlases have played different roles - from instruments of power in the renaissance, to current decision and planning support tools. Atlases can be used for general reference, education and business. As they evolved, atlases were produced in different ways, from the initial manual production to current computer-generated applications. Atlases have experienced many changes in the way they are conceived, produced, disseminated and used.

2.2 Technology and Cartography

According to Kraak and Ormeling (1996, p. 40), maps can be understood as being a "model which enables one to perceive the structure of the phenomenon represented" therefore they claimed that a map is not only about representing data but also about understanding the information mapped.

Cartography, according to Kraak and Ormeling (1996, p. 40) is the science of "representing a phenomenon or an area in such a way that its spatial structure will be visualized and this will usually take some experimenting". Technology can be considered as an underlying concept for understanding the development of cartography. Traditionally, cartography has been quick to adopt technological advances from other fields. However, as stated by Robinson *et al.* (1995), it seems that every new technology that has been introduced has caused greater changes in cartography than the previous one, and, as well, it can be argued, the time between technological changes seems to be diminishing.

These advances changed the way cartographic products were produced and distributed. As humanity evolved technologically, these advances were adopted by cartography. Initially, mediums such as clay tablets, leather and papyrus were used to convey maps. Each of these maps was unique, just like the first map drawn in the sand. Maps had to be reproduced one by one in a painstaking process mostly done by high-skilled workers. Therefore, even after the use of durable media, maps were still not widely available.

During the 20^{th} century many other advances were introduced to cartography from field equipment to the use of satellite images. The introduction of computers represented a significant revolution to the cartographic process, because they not only changed the way that cartography is produced, but they became a medium for cartography.

Considering changing technologies as a guiding concept to understand cartography, Robsinson *et al.* (1995) emphasised the technological periods in cartography. This is summarised in table 2-1.

Technology	**Beginning**	**Effects on Cartography**
Manual	Pre-history	The beginning of cartography. Maps were result of field observations and were made by skilled hand-workers, one by one. The authors highlight that the techniques developed during this period remained in use in the following periods.
Magnetic	12^{th} Century	The introduction of the magnetic compass, brought from China, represented a major change to cartography. After this technology, angles could be measured.
Mechanical	12^{th} Century	The introduction of the printing process, first in China during the 12^{th} Century and later in the Western culture, by Johannes Gutenberg in Germany during the 15^{th} Century, made possible to reproduce maps more rapidly and efficiently
Optical	17^{th} Century	The introduction of the telescopic and magnifying lenses enhanced the human sight. Other important optical technologies such as the stereoscope and CD-ROMs for data storage were also introduced in the following centuries.

Photo-chemical	18th Century	Lithography, which is a chemical printing process created in the late 17th Century, make it easier and cheaper to reproduce maps. Another remarkable advance in this period was the introduction of photography, first for field observation and later the use of aerial photographs made possible perpendicular view of geographical space.
Electronic/Digital	20th Century	Electronic technology changed cartography as a whole. Electronic devices, mainly computers, are used to collect data, to produce and print maps and even as the medium in which the map is to be used. Digital technology is used to store data, and millions of maps as digital files are exchanged daily over the Internet.

Table 2-1. The six major technological revolutions that affected cartography, after Robinson *et al*. (1995).

Due to the advances summarised above, maps became increasingly present in everyday life, not only for decision makers, but also for ordinary people. In the news, in weather forecasts, in multimedia kiosks in shopping centres, in street directories, in tourist brochures, schoolbooks, maps are omnipresent.

2.3 Atlases: a definition

Atlases are probably one of the first cartographic products that people use, because they are introduced to students early at school. Atlases can be considered the most widely known cartographic products (Kraak 2001b) and a high point for cartography (Kraak and Ormeling 1996; Kraak 2001b).

The original meaning of the word atlas refers to ancient Greek mythology. Atlas was one of the twelve Titans, sun of Uranus (God of the sky) and Gaea (Goddess of the earth), brother of Zeus, the supreme governor of the universe, and father of Pleiades and Hesperides. According to the ancient Greek beliefs, Atlas was the God who was condemned to hold the vault of the sky, represented by a globe, on his shoulders. (Aghion *et al.* 1996).

According to Thrower (1972), the use of the word atlas to describe a collection of maps was introduced by the famous cartographer Gerhardus Mercator, who, after publishing his world chart in 1569, dedicated his final years to produce a large atlas, which was released in 1595, one year after his death. Thrower (1972, p. 56) claimed that "*it is undoubtedly because Mercator used the term 'atlas' for a book of maps that it is in use today*".

In general, atlases can be understood as a collection of maps with a specific purpose and organized in the form of a book, which usually includes tables, graphs and text. The word "atlas" can also be used to describe a collection of information that covers a field of knowledge, for example, an Atlas of Anatomy or History. However, in this chapter the word refers to geographic atlases.

'Traditional' atlases, such as books, are bound publications and therefore have a fixed linear structure. Topics are developed linearly throughout the publication. The maps are developed according to a fixed format, limited to the size of the page. However they cannot be considered to be books, as noted by Alonso (1968):

> "*To the layman, any book consisting mainly of maps is an atlas, but technically to the geographer, no cased collection of maps deserves the name unless it be comprehensive in its field, systematically arranged, authoritatively edited and presented in a unified format.*" (Alonso 1968, p. 108)

According to Keates (1989) the use of maps in atlases is very flexible, he argued that "*Although the term 'atlas' is frequently associated with the concepts of 'world' and 'small scale', there are atlases with large-scale plans (city street guides), special-purpose atlases (such as road atlases for motorists), and special-subject atlases (such as an atlas of agriculture)*" (Keates, 1989, p.235). Generally, Keates (1989) highlighted that one could discern atlases by its scale; topic; and target audience.

Ormeling (1995, p. 2128) classified traditional atlases in regards to their contents as: geographical atlases; historical; national/regional; topographic; and thematic atlases. Considering communication purposes, the following types of atlases could be identified: educational, navigational, physical planning, reference, and management/monitoring. Furthermore, Borchert (1999) stated that different categories of atlases can be distinguished according to format, geographical coverage, thematic content, information level, purpose, publisher, quality and price.

Focussing on interactivity, Peterson (1998) has stated that, despite new advances in interactive cartography, the concept of interactivity itself is not a new one for cartography. He divided the history of cartography into three periods. The first is characterised by interactivity, but consisted of ephemeral, maps. According to Peterson it is very probable that the first maps were results of conversations. Maybe, these maps could have been the consequence of discussions about the location of enemy tribes or better sites for hunting. Perhaps, they were drawn on sand. What is clear is that they were not meant to last, but to enrich communication, at the same time providing additional information – the result of the conversation. About interactivity in early cartography Peterson (1995a, p. 10) had this to say:

> "*That map in the sand was not the kind of static map that we find today on paper. The meaning of the symbols would have been explained as the map was created. The second person would have asked questions that influenced how the map was drawn. As new features were added, they may have obscured part of the existing map. Indeed this first map would have been very much like the kind of interactive and dynamic map that we are attempting to create today with the computer.*"

Peterson identified a further stage in the evolution of cartography with regards to interactivity. In that way, Peterson (1998, p. 3) argued that "*A major shift occurred long ago as a stable medium was used and maps were transformed into static objects, first on clay and later on paper*", thus it was possible to create durable maps that could also be distributed to map users in different locations. Therefore, the cartographer was necessary just to create the map. Once the map was ready it could be distributed and used by anyone, anywhere. This was an important transition for cartography and was crucial for the history of the mankind. However, this evolution separated cartographer from map user and, hence, the interactive factor was removed. Cartography, as a result, dived into a static period.

The third period has seen the introduction of computers. They were initially used as a tool and later as a medium, bringing back interactivity to cartography. However, as Peterson has highlighted, it is a different kind of interactivity - human vs. computer. Nevertheless, after centuries of static maps (mainly on paper) people got used to think maps as static representations. This thought, which Peterson (1998) called 'paper thinking', now provides one major drawback for interactive cartography - it is hard for the present atlas-user generation to overcome the way they were initially taught to conceive maps. But, as technology and interactive maps become ubiquitous, this obstacle should tend to vanish in the near future.

2.4 Digital Atlases: the search for a definition

The technological advances represented by the use of computers for the production and distribution of maps have had a major impact since the early eighties and, therefore, created a new category of atlases: digital (or electronic) atlases. Atlases, as described previously, were studied and produced for centuries, however, digital atlases have a shorter history and, consequently, concepts have been developed over the last few years. The first digital atlases were developed during the eighties and an increasing research effort in the field has been carried out since then (Rystedt 1996).

Ormeling (1995) and Kraak (2001b) also noted that the development of digital atlases started in the late eighties. The authors consider the *Atlas of Arkansas*, presented in 1987 during the 13th International Cartographic Conference of the International Cartographic Association (ICA), the first digital atlas to be developed.

According to Siekierska and Williams (1996), the first digital atlas developed was the *Electronic Atlas of Canada*, in 1981. This pioneer atlas was the result of a long Canadian tradition in producing national atlases. Afterwards, the Canadian government created the National Atlas Information System (NAIS), aiming to create digital databanks for mapping as well as facilitating the digital production of paper maps. Thenceforth the following years were distinguished by the development of many other digital atlases either by governments, universities or private companies.

In 1986 the *Digital Atlas of the World* was created by Delorme Mapping Systems. Analysing the use of that atlas, Siekierska and Taylor (1991, p. 12) stated that "*apart from scale change and the additions of overlays, the analytical capabilities are limited*".

Kraak (2001b) considered this first digital atlas as an extension of a paper atlas, in digital media, as it was comprised by a set of static maps accessed via a menu. As stated by the author the development of digital atlases presents similarities with the history of computers in cartography. The beginning was characterised by hardware limitations, such as storage capacity, and software, represented by the lack of authoring tools for developing more interactive applications.

According to Kraak and Ormeling (1996, p. 183) atlases are "*intentional combinations of maps, structured in such a way that given objectives are reached. In a way, atlases are similar to rhetoric: if a number of arguments are presented in a speech in a given sequence, a specific conclusion is reached.*". This definition can be applied either to paper or digital atlases, however, the idea of defining an atlas as a bound collection of maps should be reviewed.

Siekierska and Taylor (1991, p. 11) tried to fill the existing gap between the traditional definition of paper atlases and digital atlases by creating a new definition of digital atlases, which stated that "*The electronic atlas is a new form of cartographic presentation and can be defined as an atlas developed for use primarily on electronic media.*"

Koop (1993, p. 129), created a more flexible definition of atlas, as a "*Systematic and coherent collection of geographical data in analogue or digital form, representing a particular area and/or one or more geographical themes, based on a narrative together with tools for navigation, information retrieval, analysis and presentation*."

Elzakker (1993) claimed that a digital atlas, and particularly an analytical atlas, is a special kind of GIS. In his opinion the main difference between digital atlases and GIS is that digital atlases have a narrative faculty, once they are designed to attend a specific purpose. He defines electronic atlases as "*a computerised geographic information system – related to a certain area or theme in connection with a given purpose – with an additional narrative faculty in which maps play a dominant role*" (Elzakker 1993, p. 147).

The same definition was adopted by Ormeling (1995, p. 2127). Other authors such as Richard (1999) and Borchert (1999), also stated that nowadays atlases could be considered a collection of maps distributed either on paper or by digital means.

Kraak and Ormeling (2003, p. 154) considered that "*If paper atlases are considered intentional combination of maps, then not all electronic atlases might fit in this definition. Some could better be defined as intentional combinations of specially processed spatial data sets, together with the software to produce maps from them*". In other words, maps do not comprise digital atlases necessarily, but according to the authors the narrative is a cornerstone concept to define atlases.

As can be seen by these many definitions of digital atlases, the development of digital atlases has fostered an increased research focus since the early nineties. It is important, however, to highlight that as the development of digital atlases constituted a new field at that time, the first definitions tried to explain digital atlas by comparing them to paper atlases. In this way the first, and most obvious, difference emphasised was the medium. Further definitions focussed not only the medium but atlas use as well, by putting the emphasis on aspects such as the narrative or navigation tools.

2.5 Digital Atlases: characteristics

With the introduction of this new field of research in cartography, the researchers tried to summarise differences and similarities, as well as advantages and disadvantages that could be identified between digital and paper atlases.

As stated previously, Canada played a pioneer role in the field of digital atlases. Siekierska (1984), explaining the procedures adopted for elaborating the early version of the Electronic Atlas of Canada, stated that the important aspect of digital atlases was that they made it feasible to generate maps that were user-demanded or user-created. In this way the user's needs would be more likely fulfilled. The author argued, however, that the main difference between digital and paper atlases was that with digital atlases the analysis was made directly on the data set, the input data, instead of the traditional analysis being made directly in the final product, the printed map.

In other words, in the early eighties Siekierska proposed that digital atlases could provide an exploratory environment in which the user interacts with the information directly stored in the data bank, using the map as an interface. In this way, Siekierska (1984) saw that the proliferation of digital atlases would be an important field of research for cartography in years to come.

Summarising the characteristics of electronic atlases, Siekierska and Taylor (1991) indicated that important advantages were the fact that those products provide tools for innovative displays and analysis such as queries, overlay, animation, interactive zoom, scroll and pan. In addition, they emphasised the reduced cost of producing a digital atlas as a significant advantage, once they could be reproduced and distributed to a wider audience with lower costs, when compared to paper atlases.

Bakker *et al* (1987), analysing national atlases, foresaw that digital production of national atlases would be an important trend in the future, however, it was very unlikely that national atlases on paper would disappear completely. It is impossible to verify, by official statistics, if the authors were right, nevertheless sixteen years later papers presented and published on the proceedings of the 21st International Cartographic Conference, supported what the authors predicted, that digital atlases have become paramount atlas products. At that conference, digital and hybrid atlases represented 83% of the atlases presented (table 2-2).

The *National Atlas of Spain*, for example (Aranaz *et al.* 2003), was first published on paper, afterwards a digital version in CD-ROM was implemented and at that time a future version for the Internet was being developed. However, the paper atlas was still being produced and new formats were being released to provide better user handling. Other examples of national atlases produced both on paper and digital formats presented in that conference are the *National Housing Spatial Investment Potential Atlas of South Africa* (Biermann and Smit 2003); the *Census Atlas of the United States* (Brewer *et al.* 2003), the *Atlas of Oregon* (Buckley *et al.* 2003) and the *National Atlas of Russia* (Zhukovsky and Sveshnikov 2003). The atlases presented just in digital version were the *Atlas of Switzerland* (Huber and Schmid 2003) and the *Statistical Atlas of the European Union* (Pucher *et al.* 2003).

In a similar way to Bakker *et al* (1987), Ormeling (1995) predicted that by the year of 2000 paper atlases would be published with a CD-ROM as a digital complement. Even though after a decade his prediction was not achieved, the number of digital and hybrid atlas, atlases available both on paper and digital formats, has increased sharply. The number of paper atlases presented, on the contrary, decreased considerably (table 2-2).

Type of Atlas	1995	2003
Paper*	74%	17%
Digital	14%	50%
Hybrid	12%	33%

* Atlases presented with no reference to the medium were considered paper atlases.

Table 2-2. Number of atlases presented in the International Cartographic Conference, in percentage.

Ormeling (1995) proposed digital atlases should have three main functions:

- **To provide background information:** which could be tables with the statistics used to create the maps, photos, texts, graphs or drawings;
- **To expose other geographical views of the data:** the digital complement should be able to produce maps different from those published, based on the same data. This function would be possible by using different classification systems and changing the number of classes or even different boundaries; and
- **To provide additional information:** paper atlases have a series of issues to consider regarding their development. However, the cost of the publication could be isolated as the main issue. In this way the digital counterpart could provide more information than that published, with reduced cost.

Rystedt (1996, p. 1) considered that "*An electronic atlas can contain data and software giving the user possibilities to more thoroughly investigate the topics presented in the book version of the atlas*". The author claimed that the use of different media and GIS functions would improve the potential of the new kind of atlas and furthermore the challenge would be to develop digital atlases for the Internet.

It seems, despite the advantages highlighted, that both paper and digital atlases have their advantages and disadvantages. Analysing this issue, Koop (1993) claimed that the main asset of paper atlases is the "lazy armchair function". In contrast the major drawbacks of paper products would be the high cost of such products and the time spent to update them. The author also noted the advantages of digital atlases: they are easy to update and provide new forms of cartographic communication.

Kraak and Ormeling (1996) considered that the advantages of digital atlases are: the possibility of creating customized maps; the immediate provision of geometric information; the possibility of going beyond static map frames by using interactive tools (such as pan and zoom); the use of animations to depict data over time; links provided with databanks to provide additional information regarding features highlighted or clicked by the user (and here interactivity is, once more, an important point); the integration of multimedia; and the possibility of improving manipulation and display of information by different levels of aggregation of data, from small to large regions.

Additionally, Peterson (1999b, pp. 35-36) analysed the advantages of paper for cartography over digital media and saw two major advantages: paper maps are easy to carry and paper supports higher spatial resolution. However, Peterson argued that, although paper is better for cartography, it is incompatible to represent dynamic phenomena. On the other hand, he considered the major advantages of digital maps to be that: they are more effective in representing dynamic phenomena; when distributed by networks they can be delivered much quicker than paper maps; they are more current; and they change the traditional map use, as digital maps can be interactive, and therefore the user's attitude towards the map is different as they engage the information more deeply.

Comparing digital and paper atlases, Schneider (2002, p. 24) stated the following about the advantages of digital atlases over its paper equivalents:

> "*They (the user) can generate new maps or can adapt existing maps according to their needs. The transmission of information takes place in real time, not linearly, but rather via a thematic or spatial-oriented navigation. The use of digital multimedia, over different media, allows presenting a specific issue to the atlas audience. Moreover, it is possible to simulate temporal and spatial processes by using animations. The large storing capacity of electronic media permits furthermore, not only a*

selection of data, but rather to offer complete records in different scale levels. Finally AIS (Atlas Information Systems) can be updated and expanded easily." (translated from German)

Analysing the same issue, advantages of digital atlases, Borchert (1999) assembled a comprehensive list that is summarised in table 2-3.

Attribute	***Description***
Exploration	Exploration can be understood as the amount of freedom given to the user in order to explore the contents of the atlas. The use of GIS functionalities can be included in this concept. Interactivity is a key component in an exploratory atlas.
Dynamics/Animation	The use of animation and its new visual variables brings new forms of communicating spatial data.
Customisability	Once more the issue of interactivity is present; at this point the concept is to allow the user to customise the map as the interface of the information, by changing layers or visual variables for example, in order to attend individual requirements.
Integration with diverse media	It is possible to integrate the digital atlas with textbook, paper atlas, working sheet, wall map, and so on. In this way new didactic perspectives could be reached.
Current contents	A digital atlas can be easily updated; if the product is networked its contents are current and immediately available to the user.
Portability	The digital atlas is easier to transport when available in discrete media, moreover if it is available on the Internet portability is not an issue. However, the computers are still heavy.

Table 2-3. Summary of the advantages of digital compared to traditional atlases (after Borchert, 1999, p. 76).

Also focussing on the differences between paper and electronic atlases, Ormeling (1996) summarised what he saw to be the main differences between them. These are shown in table 2-4.

Paper Atlases/View-only Atlases	**Interactive Atlases/Analytical Atlases**
Static	Dynamic
Passive	Interactive
Maps only	Maps and multimedia
Limited/selective	Complete
Fixed map frames	Panning and zooming possible
Compromise for all types of use	Customised
Maps as final product	Maps as interface

Table 2-4. Differences between paper and electronic atlases, after (Ormeling, 1996, p. 33).

Ormeling (1996) considered view-only atlases and paper atlases in the same category because, according to his arguments, view-only atlases do not use technology 'adequately', which can be understood as, although view-only atlases are digital atlases they do not take advantage of the resources available in the digital medium. He made use of multimedia and the dual concepts static vs. dynamic, passive vs. interactive to analyse the differences between paper and digital maps.

2.6 Digital Atlases: classification

Digital atlases are a type of atlas that can be distinguished by its digital format, either discrete (produced for distribution in floppy disks, CD-Rom or DVD) or networked. Besides the traditional classification of atlases, more specific classifications considering only digital atlases have been developed. Siekierska (1991) classified digital atlases in three groups, considering basically the level of interactivity and the analytic potential provided. There, digital atlases were subdivided as being:

- View-only atlases;
- Atlases that generate maps on demand; and
- Analytical atlases based on GIS capabilities.

Also, analysing the 'state-of-the-art' in atlas production and describing the procedures adopted to develop the Electronic Atlas of Canada, Siekierska and Taylor (1991) implied that one could discern basically between two types of digital atlases:

- View-only atlases, which could be considered an extension of paper maps in digital form because this kind of atlas allows the user to access stored static maps; and
- Atlases with dynamic interaction and analysis, which would provide more flexible functions such as selection of particular features, addition of data, changes of scale and customisable interface, for instance.

Moreover, Kraak and Ormeling (1996) stated that one could discern the following types of digital atlases:

- View-only atlases, in the same way as Siekierska and Taylor (1991), the authors considered this kind of atlas to be an extension of paper atlases, however they noted three advantages as being: the reduced cost of reproducing digital atlases, the possibility of consulting more than one map at the same time (by dividing the screen) and random access to the maps (instead of the linear structure of paper atlases). It is believed, however, that bound publications can be considered hypertextual, because the reader can read them at random and the author can use footnotes.

- Interactive atlases that provide the user the opportunity of interacting with the data set, either by changing colour schemas, classification methods or the number of classes displayed.
- Analytical atlases, where queries to the databank can be made directly from the map, as the map is just a graphical interface to the data. In addition, data sets could be combined in order to create new data sets. Therefore the user is not restricted to the data provided within the atlas itself. Although this kind of atlas incorporates most GIS functions the authors re-state that the emphasis is on analysing the data and visualizing the results.

Which classification to choose? When considering the various classifications outlined previously, the work of Kraak and Ormeling (1996) is considered to be the most appropriate, because it not only considers and expands previous upon discussions and classifications; but it also takes into account the structure of the atlas, the level of interactivity and the technology employed. The inclusion of all of these elements provides what is considered to be the best classification.

2.7 Digital atlas: merely a variant of a GIS?

It seems that some categories of atlases are somewhat similar to GIS, however the authors argued that the main difference is that atlases "*give major importance to the presentation and display of spatial information while in most GISs is on information retrieval and analysis of data*" (Siekierska and Taylor 1991, p. 14).

It is undeniable that there are similarities between Geographic Information Systems and some kinds of digital atlases. Conversely, as stated by Elzakker (1993) probably the main difference is that digital atlases emphasise the use of cartographic methods to improve the analysis and presentation of the maps and on the narrative, which intends to improve the user's comprehension of the atlas information.

However, the question remains. If today's atlases are not necessarily comprised of maps, but also by data sets and software that allow the creation of maps on-demand, just like a GIS, what is the real difference between GIS and digital atlases?

Kraak and Ormeling (1996, pp. 183-184) addressed this question as follows:

> "*The maps in electronic atlas function as an interface with the atlas database. This combination of database and graphical user interface (GUI) and other software functions developed to access the information is different from a GIS: special care is taken to relate all data sets to each other, to allow them to be experienced as related, to let them tell, in conjunction, a specific story or narrative. There will usually be a central theme*"

Bär and Sieber (1999) proposed three approaches for using GIS when developing digital atlases. The first they called Multimedia in GIS, which can be understood as the integration of multimedia functionalities within GIS systems in order to create cartographic products such as atlases and decision-support systems. The advantage of this approach, according to the authors, is that as multimedia is introduced into the GIS, all spatial and geometrical functions are predefined within the system and, hence, there is no need to develop them. The authors claimed, though, that this approach is "*the fastest way of bringing full GIS functionality to multimedia*" (Ibid., p. 236). However, the main drawbacks outlined were that: GIS systems provide limited multimedia functionalities, the design of the application can not be made independently and the user interface is not friendly, as GIS users are not necessarily multimedia developers.

The second approach is called GIS in Multimedia. According to Schneider (2001) this approach corresponds to the integration of GIS functionalities into multimedia authoring systems. On one hand, the advantage of this approach is that the user interface can be created with more flexibility, as the developer is not restricted to a GIS environment. Another advantage is that cartographic functions can be customised in order to meet particular user's needs. Conversely, this approach had some disadvantages, among them the fact that this approach is hard to develop, because "*even low level analytical functionality, data structures and GIS techniques have to be explicitly defined and implemented by the authors*" (Bär and Sieber 1999,

p. 236). Also this approach does not provide the same cartographic quality as well as analytical tools as the previous approach.

This approach was adopted by Ramos (2001) for developing a prototype digital atlas of agriculture in Sao Paulo state, Brazil. In her research the author summarised the disadvantages of the GIS in Multimedia approach, which were the painstaking work of development could dissuade people of working in this field, particularly professionals with little programming expertise, and the cost of the developer license of GIS packages is extremely high compared to the standard license. This second point is particularly important in developing countries such as Brazil, where research funds, most of time, are not sufficient to cover research expenses.

With the aim of overcoming the drawbacks associated with these first two methods, Bär and Sieber (1999) proposed a third approach, GIS Analysis for Multimedia Atlases. The authors claimed that none of the previous approaches were meant to specifically respect cartographic characteristics, thus, the proposed approach was intended not only to overcome the known limitations of GIS-based approaches, but to preserve its analytical potential as well. This approach is based on a multimedia atlas development environment, which is comprised of a GIS, the authoring system and a multimedia map extension that transforms GIS objects into cartographic objects. In this way GIS features would be preserved.

Schneider (1999) stated that the focus of digital atlases is on information presentation and summarised the main differences between GIS and digital atlases, or multimedia atlas information systems. These are shown in table 2-5.

	GIS	**Multimedia AIS**
Use of interface	Complex	Easy
Users	Experts	Non-experts
Computing time	Long	Short
Control by	Users	Authors
Main focus	Handling of data	Visualization of topics
Data	Unprepared	Edited
Output medium	Paper	Screen

Table 2-5. Main differences between GIS and Multimedia Atlas Information Systems (after Schneider, 1999, p. 830).

The differences between GIS and digital atlases shown in table 2-5 are, sometimes, tricky or even subtle. For instance, the use of interfaces in digital atlases should be easy, but with these applications the interface is customised, but this does not necessarily result in an easy to use product. In addition, the control of digital atlas is said to be done by the author, however, as can be noticed by the many different kinds of atlas discussed, in some situations the author has full control over the atlas and in other situations they have little control.

The main focus of GIS, as claimed by Schneider (1999), is on data handling. However, it cannot be overlooked, though, that without proper visualisation of the results, the analytical work in GIS environment would be compromised. It is believed that, considering this focus issue, the difference between GIS and digital atlases is that the first comprises the four classical functions: data capture, manipulation, analysis and presentation; and the second can comprise manipulation, analysis and presentation. These functions in digital atlases can be implemented at different levels of complexity, depending on the purpose of the atlas.

Additionally, the output medium for both, GIS and digital atlases, could be either paper or screen, therefore it is considered that this particular feature should not be used to distinguish between them.

Considering the comments above, it is believed that another view of the differences between GIS and digital atlases is necessary. The differences are shown in table 2-6.

	GIS	**Digital Atlases**
Interface	Complex and complete	Customised according to the purpose and the target audience of the atlas
Users	Experts	Non-experts
Computing time	Depends on the project	Short
Controlled by	The user	The author, who allows different levels of control to the user.
Focus	Data capture, manipulation, analysis and presentation	Data manipulation, analysis and presentation. Not all these function must be provided, depending on the purpose of the atlas.
Data	Unprepared	Edited
Purpose	There is no purpose in GIS, the application is open for any kind of data input and analysis	The digital atlas has a purpose, and it was prepared to deliver the conveyed information.

Table 2-6. Differences between GIS and Digital Atlases (after Schneider, 1999).

Finally, it is important to note that the subject of the similarities between atlases and GIS is not a new one. This question was raised by Bakker *et al* (1987); at that time, comparing national atlases on paper and GIS. The authors argued that:

> "*The traditional national atlas can therefore be conceived as a non-characterised geographic information system in its own right: it was the first medium which enabled users to compare, overlay or otherwise combine data, for the first time presented at similar scales at a similar degree of generalization.*" (Bakker *et al.* 1987, p. 83)

Considering their point of view, as the first national atlas, the atlas of Finland, was published in 1899, one could assume that the question should be: is GIS a kind of atlas? The answer is, undoubtedly, not; but the converging point between atlases (in any medium) and GIS is that both are tools for spatial analysis and cognition.

2.8 The evolving medium: the transition from discrete atlases to Internet atlases

The study of contemporary atlases involves two distinctive transitions: from paper to digital and from discrete to networked atlases. Cartwright (1999a) provided an extensive analysis on the evolving technology of optical storage media, from Videodiscs, in the early seventies to the modern DVDs. However, the rise of the Internet as a medium for cartography in the mid-nineties has changed the research focus of digital atlases developers: from discrete storage to the World Wide Web.

Peterson (2003) indicates the advantages of the Internet as a medium to cartography, for the author although the screen is still a major drawback for using computer as a medium for cartography "*... the Internet makes it possible to distribute the map to many people. Therefore the sum total of map use/communication across all individuals is greater with the Internet*" (Peterson, 2003, p. 443). In this way, recent figures of Internet audience provide extra support for using Internet as a medium to digital atlases. According to the ClickZ Network (2005b) the global online population corresponded to 1.08 billion people in 2005. In 2010 the predicted Internet population would be 1.8 billion people worldwide (ClickZ Network 2005b).

The expressive growth of the Internet audience makes it a very effective way of distributing cartography, and particularly atlases. There are many ways of publishing maps on the Internet. Kraak (2001a) provided an analysis on different Internet maps, identifying the following map types:

- **Static Maps** – Static maps are those maps that offer no more than a basic level of interactivity. In a way they are similar to paper maps and they are a very common way of publishing Web maps. The author identifies two kinds of static maps:
  - **View only** – Static view only maps are those maps where there is no interaction and/or dynamics whatsoever. Still raster maps are considered to fit in this category; and
  - **Interactive interface and/or contents** – This kind of Web map comprises clickable maps, maps where the user will get responses depending on the map element clicked. Maps where the user can switch layers on and off and use zoom and pan are examples in this category.
- **Dynamic Maps** – Dynamic maps are maps that show dynamic processes and/or contents. The author subdivides dynamic maps into two groups:
  - **View only** – Simple cartographic animations are examples of dynamic view only Web maps. Some examples are developed using animated GIFs or vector animations, the last can be developed, for example, using Flash (Macromedia) or SVG (Scalable Vector Graphics). These maps show the spatial dynamics of a feature usually over time. In this kind of Web map the user is generally provided with controls to pause, play, go forward or backwards, however, in some kinds of formats (such as animated GIFs) this kind of control is not viable and the animation is executed continuously; and
  - **Interactive interface and/or contents** – In this kind of Web map, the user can interact with the map in a more immersive way. Three-dimensional cartographic models are considered to fit in this category as the user can literally freely navigate throughout the map. Other kind of interactive can be implemented as objects within the model can be linked to other Web pages.

However, the definition and classification of different Web maps is not a simple task because technology is constantly evolving and providing new capabilities and perspectives to Internet Cartography. For instance, it is fairly straightforward to implement Web links to any map object in vector maps, raster maps can also be linked to other pages, the whole map can be a hyperlink or the image can be subdivided into several different links. Therefore this kind of feature cannot be used to distinguish different kinds of Web maps.

Internet maps can be classified according to several aspects. Considering technology, they can be divided into maps based on proprietary technology or open standards. Considering architecture, they can be divided into client-side maps and server-side maps. Considering contents they could be divided into stand-alone maps and data-driven maps, and so on.

The GIS industry have early noticed the potential of the Internet as a medium for cartography and have developed a number of tools for Internet map publishing, therefore, Internet applications based on GIS tools are very common. A recent trend in Internet cartography is the use of open standards for publishing on the Web.

Recent developments in cartography for the Internet have been done towards using open standard technologies for Web publishing. *Open standards* can be defined as standards established by a public body (comprised by members of industry and/or public sectors) with the purpose of providing guidelines for their field of activity. By definition open standards are not proprietary, in other words, they do not belong to any individual or company. The World Wide Web Consortium (W3C) has focused on developing open standards for publishing on the Internet. The W3C developed the eXtensible Markup Language (XML), which is a standard for exchanging data via the Internet. Other standards were developed based on XML, amongst them the Scalable Vector Graphics (SVG) that corresponds to a standard for publishing vector graphics on the Internet.

SVG maps are basically text files that are rendered on the Web browser through a SVG viewer. It is expected, however, that as the format becomes popular further versions of Web browsers will be able to interpret SVG files with no need of a plug-in. Several examples of Internet cartography, and atlases, based on SVG can be found. Also, Newmann and Winter (2003) provided an extensive overview on the use of SVG and open standards for Internet cartography.

It is believed that using SVG will allow publishing maps on the Internet in a more extensive and flexible way; however some programming knowledge is required in order to develop SVG maps. To minimize this drawback further research is necessary to develop self-explanatory SVG map templates. Such templates would foster the use of SVG as a tool for Internet map publishing and provide means for developing interactive Internet maps at low cost.

2.9 Chapter Summary

Computers have become not only a tool for producing cartography, but a medium for it. It is difficult to find statistics about the number of atlases produced annually; as a result one could argue that any analysis regarding the importance of computers as a medium for cartography, and particularly for atlases, is nothing but conjecture. It is believed, though, that despite the lack of official figures, computers have emerged as a major medium for cartography, and the increasing number of digital atlases presented in the last international cartographic conferences corroborates it.

This chapter focused on understanding digital atlases by assuming that, as they are meant to be used in a different medium, they need a particular definition. However the search for a definition of digital atlases raises other questions for reflexion. The main point is the blurred distinction between digital atlases and GIS. As the technology for production of digital atlases evolves, it is harder to distinct between them. However, it is important to remember that digital atlases not necessarily include GIS.

The chapter also focused the Internet as a medium for digital atlases. Internet maps can be classified through different points of view and some definitions were discussed. Recently open standards technologies have emerged as a significant research trend in the field, it is believed that such technologies offer not only the opportunity of delivering interactive Internet atlases at low cost, but they can be used to involve more atlas developers in Internet publishing as well.

3 Digital Atlases: cornerstone concepts

3.1 Chapter Overview

The purpose of this chapter is to provide a wide overview on different concepts related to the development of digital atlases. The topics covered in this chapter range from theoretical concepts such as geovisualisation, hypermedia and hypermaps, cartographic metaphors and metaphors in multimedia mapping products to delivery medium (discrete and networked).

It is important to provide this wide overview because, although this research aims to propose a methodology for publishing school atlases on the Web, the final product presented here will be a suggestion. Prospective Web developers could use the tools provided here to produce their own atlases. However, being aware of the theoretical concepts as well as the multimedia functionalities that could be implemented in digital atlases, Brazilian school atlas developers could go beyond the scope of this research. They could use the methodology proposed here as a starting point for their work and not be restricted by it.

The idea behind this chapter is to introduce the reader to the concepts related to the scope of this research, and to provide background information to corroborate the development choices that are further explained in chapter 5.

3.2 Geovisualisation

Geovisualisation (Dykes *et al.* 2005), also referred to as Cartographic Visualisation (MacEachren and Ganter 1990), Geographic Visualisation or Geovis (MacEachren 1994), is a relatively new concept in spatial sciences. The concept of geovisualisation emerged from the visualisation movement during the eighties, which was based on the introduction of computer graphic techniques to enhance the human ability to apprehend information (MacEachren and Ganter 1990).

Visualisation, however, is not a new concept. It is rather a mental process of acquiring knowledge. Generally, visualisation can be understood as the creation of a mental image derived from an abstract concept (Dürsteler 2002; Infovis.net 2006). An abstract concept is, by definition, not visible. Therefore, visualisation is a process that does not necessarily employ vision (Dürsteler 2002). However, it is necessary to emphasise that vision is the sense that provides humans with the greatest input of information, and although the mental process of visualising information does not require vision, it is undeniable that information obtained via this sense may play a significant role in the mental creation of symbols and images that result from the process.

Information visualisation, another recurring terminology, has been described as:

> "*It is a process of transforming information into a visual form enabling the viewer to observe, browse, make sense, and understand the information. It typically employs computers to process the information and computer screens to view it using methods of interactive graphics, imaging, and visual design. It relies on the visual system to perceive and process the information.*" (Utah 2004)

Scientific visualisation was defined as "*the use of computer imaging technology as a tool for comprehending data obtained by simulation or physical measurement*" (Haber and McNabb 1990). Therefore, computers can be seen as tools for scientific visualisation. Visvaligam (1991) claimed that other tools have been used to provided scientific insight like microscopes and telescopes. These tools that have helped to humans to see what was hitherto unseen. Computers, however, not only provide new visual perspectives, but also allow simulation, manipulation and communication of large amounts of data in a small fraction of the time that would be employed if they were not used.

The geospatial community also defined the concept of visualisation. According to MacEachren (1992) visualisation is considered

> "*a human ability to develop mental images (often of relationships that have no visible form) together with the use of tools that can facilitate and augment this ability. Successful visualization tools allow our visual and cognitive processes to almost automatically focus on the patterns depicted rather than on mentally generating those patterns*" (MacEachren 1992)

In the same year, MacEachren *et al* (1992) defined visualisation as:

> "*Visualization, as considered here, is not restricted to a method of computing (...) Visualization is foremost an act of cognition, a human ability to develop mental representations that allow geographers to identify patterns and to create or impose order. The mental representations formed and the patterns people see are closely linked to expectations they bring to a given situation*." (MacEachren *et al.* 1992, p. 101).

In this way, MacEachren *et al* imply that aspects other than tools may play a role in the visualisation information. As visualisation is considered a mental process of apprehending knowledge, the person's background knowledge, experience and expectations can interfere in the visualisation of information.

Geographic visualisation, defined by Cartwright *et al* (2004) as "*the application of scientific communication theory to mapping artifacts*", became an increasing focus of research attention by the early nineties. DiBiase (1990), discussing the concept of visualisation and its application to spatial sciences proposed a model to understand visual methods where the process is divided into two realms: private and public (figure 3-1).

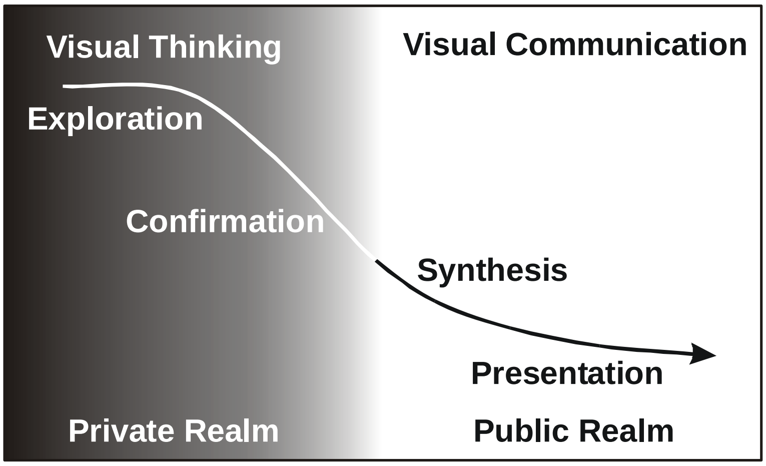


Figure 3-1. A framework for visualisation proposed by DiBiase (Re-drawn from DiBiase, 1990).

At the private realm, called visual thinking, the user explores data and confirms hypothesis. Correspondingly, in the public realm, also referred as visual communication, the user can synthetise the information and present the results. As stated by the author visual thinking can be understood as the creation of ideas through the exploration and interpretation of information, originally non-visible; on the other hand visual communication is the generation of final visual representations, the result of the process. In the foreword to the Web version of the paper originally published in 1990, DiBiase acknowledged works focused on exploratory data analysis and semiology of graphics helped him to lay the foundations of the visualisation concept.

MacEachren and Ganter (1990) provided an early discussion about the application of visualisation tools. The authors, similar to DiBiase, emphasised the duality public/private as a cornerstone of the visualisation framework.

Furthermore, Taylor (1993) proposed a conceptual model of cartography. The visualisation model proposed by Taylor (1993) evolved further to the concept of Cybercartography (figure 3-2). Figure 3-2A portrays the original visualisation framework proposed by Taylor in 1993, this was represented by a triangular diagram where visualisation is understood as the integration of cognition and analysis, communication (visual and non-visual) and new computer and multimedia techniques (that provide interaction and dynamism).

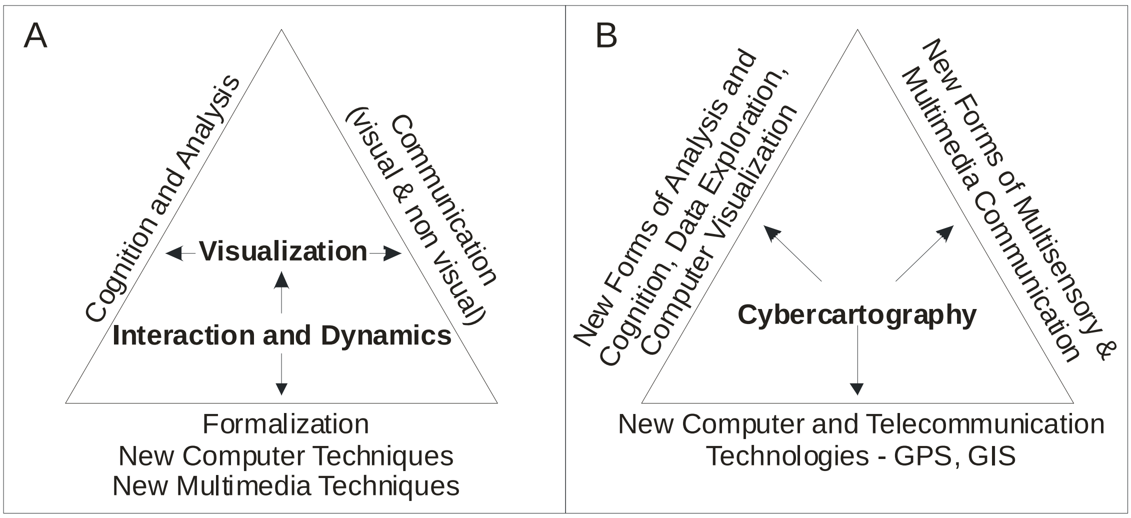


Figure 3-2. Conceptual model of Cartography - figure 2A- according to Taylor (1993, p. 48) and cybercartography - figure 2B – redrawn after Taylor (2003, p. 406).

Figure 3-2B portrays the concept of Cybercartography. In this diagram the triangular conception was maintained, however the components changed. In this updated view, Taylor (2003) conceived cybercartography as the result of the combination of concepts related to novel multisensory and multimedia communication techniques, computer visualisation and data exploration, and new computer and communication technologies. To summarise, according to Taylor (2003), Cybercartography is a cartographic paradigm that emerged from this triumvirate: technology, multimedia communication and data exploration and visualisation.

The main difference between the views provided by DiBiase (1990) and Taylor (1993, 2003), as emphasised by MacEachren (1994), is that the latter stressed the role of computer graphics as part of the visualisation process. DiBiase, on the contrary, focused his attention on the exploration of data and the mental processes involved in the visualisation of information.

Mac Eachren *et al* (1992, p. 101) defined geographic visualisation as "*the use of concrete visual representations – whether on paper or through computer displays or other media – to make spatial contexts and problems visible, so as to engage the most powerful human information-processing abilities, those associated with vision*."

The scientific debate on visualisation was intensified in the early nineties with several publications. Hearnshaw and Unwin (1994) compiled a book focusing mainly on the interaction between Geographical Information Systems (GIS) and scientific visualisation since "*Both fields draw heavily on developments in database management, computer graphics, user interface design, image processing and so on*." (Hearnshaw and Unwin 1994, p. xiii). MacEachren and Taylor (1994) edited a book about focusing on visualisation and cartography, approaching a range of topics such as software tools for visualisation, interface design, multimedia, and cognition. MacEachren (1994) proposed his view of a geovisualisation framework (Figure 3-3). According to the author, geographical visualisation should be understood as a tri-dimensional space. The model, called cartography[3], was defined by MacEachren as a representation of the map use. According to this model, the map is seen as a tool for the visualisation process.

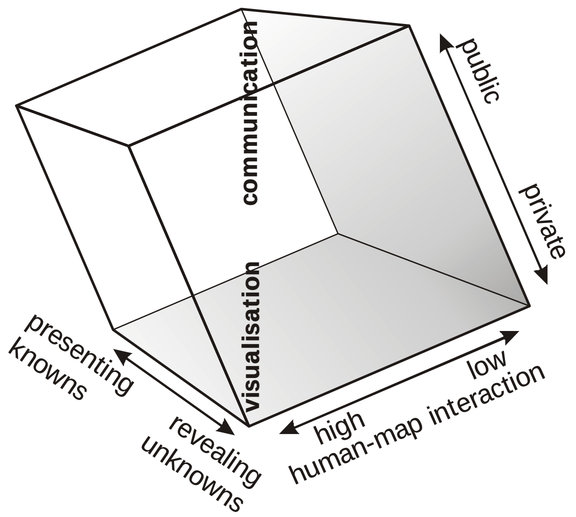


Figure 3-3. MacEachren's view of geovisualisation, also called Cartography[3](Re-drawn from MacEachren, 1994, p. 6).

Three main factors, identified in figure 3-3, would define whether the map was applied for visualisation or communication: level of interaction (high or low); type of audience (public or private); and the purpose of the map (presenting knowns or revealing unknowns). Visualisation and communications were seen in opposite corners of the cube, in this way a map designed to be used by a wide public, with low interactivity and presenting known information would have been designed for communication. On the other hand, a map designed to individual use, to be used in a highly interactive environment and aiming to reveal unknown information would have been designed for visualisation.

MacEachren (1995) outlined different ways to define visualisation. According to the author, "*In the most general sense of 'to make visible', it can be treated as a superordinate category to which cartography belongs*" (MacEachren 1995, p. 355). Scientific visualisation is defined by the author as the use of "*advanced computer technology to facilitate 'making visible' scientific data and concepts*" (MacEachren 1995, p. 355). Finally, visualisation can be understood as "*making visible in the sense of mental images*" (MacEachren 1995, p. 355).

Geographical visualisation (GVis), can be generally seen as the application of visualisation to spatial sciences. According to Buckley *et al* (2005) the International Cartographic Association (ICA) created in 1995 a Commission on Geographic

Visualisation linking researchers throughout the world with the aim of advancing the agenda on spatial visualisation. The commission defined GVis as follows

> "*GVis (Geographic Visualization) can be defined as a form of map-based information visualization that emphasizes development and assessment of visual methods designed to facilitate the exploration, analysis, synthesis, and presentation of georeferenced information. GVis has a combined emphasis on development of theory, tools, and methods and on understanding how the tools and methods are used to prompt thinking and facilitate decision making.*" (MacEachren and Kraak 2003)

The commission highlighted four research themes on GVis for the 21st Century (MacEachren and Kraak 2003): representation; interface design; database-visualisation links; and cognitive aspects of visualisation tool use. The following sections briefly describe these themes.

3.2.1 Representation

Analysing the role of visual representation in the GVis, Fairbairn *et al* (2000) stressed advances in technology had brought new representation possibilities. The authors claimed that it was important to understand new technologies because they continuously expand the "cartographic tool box" and affect not only representation but all other issues highlighted as research themes by the Commission on Visualisation and Virtual Environments (the expanded name of the ICA commission). The authors outlined emerging themes of research in representation, such as the need to understand the characteristics of the data in order to better translate it into visual language; in this way they proposed classical work by Bertin (1973) and Tufte (1983), as a cornerstone for further research.

Dykes *et al.* (2005) emphasised that it was important to determine the limits, advantages and disadvantages of using both traditional and new representation methods. They also stressed the need to assess those innovative tools; in this way the user could take the most advantage of interactivity, animations, hypermedia, etc.

Therefore, Dykes *et al.* (2005) implied that it is crucial to consider usability issues when working with innovative representations, about this Dykes *et al.* (2005, p. 8) stated that:

> "*Yet a compelling need exists to develop both the theory and practice to support universal access and usability for geospatial data. This will require new approaches and methods that support the personalisation of geovisualization tools to assist particular users and user groups with particular geovisualization tasks*."

Fairbairn *et al* (2000) also highlighted that new methods to collect data and new kinds of data would create a need to expand methods of representation. According to the authors, the purpose and effectiveness of representation, interactivity and technology (as stated previously) were considered other aspects to be focus of future investigation.

3.2.2 Interface design

The Interface is considered the basis of interactivity; considering the importance of the interface, Wills (1996, p. 187 - cited in Cartwright et al, 2000) had this to say:

> "*What makes a technology interactive? Is radio interactive? Television? What about books, lectures, conference sessions? Is interactive multimedia really interactive? A TECHNOLOGY is not interactive – it is the INTERFACE we design for it that is interactive.*"

The interface is, in fact, the communication channel between the user and the visualisation application. The interface design defines the flow of information between user and visualisation application and vice-versa. Cartwright *et al* (2000) emphasised that it was important to make spatial information more widely available for the public. The Internet is a fairly democratic publishing medium; therefore research effort should be focused on providing more natural and user-friendly interfaces to geospatial information. Cartwright *et al* (2000) indicated new devices, multi-sensory interfaces and virtual environments as some of the issues to be further investigated related to interface design.

Dykes *et al.* (2005) corroborated the need to further research in interface design for novel devices, notably mobile phones and Personal Digital Assistants (PDAs). These type of devices make it feasible to deliver cartography almost anywhere. The maps delivered can be personalised with consideration not only to the user's preferences and demands, but also their actual location as well. This new class of device made it possible for the development of Location Based Services (LBS), adding a new dimension to cartography. Typical LBS interfaces are shown in figure 3-4.

Figure 3-4. Example of map interfaces in PDAs and mobile phones.

Source: < http://www.viamichelin.com/viamichelin/fra/tpl/prs/pho/img/PDA_MapSonic_screenshot _3d_big.gif > and < http://www.esri.com/industries/locationservices/graphics/map_phone-lg.jpg >

One example of research in interface and map design for mobile devices was that of Coors *et al.* (2005). They researched the use of 2D and 3D maps for delivering route maps via mobile devices. The results demonstrated that the majority of the users had a very positive attitude towards the 3D maps, preferring these maps over their 2D counterparts.

Gartner (2003) also demonstrated an example of using mobile devices for delivering spatial information and maps. In his work Gartner supported the use of multimedia environment in 'TeleCartography' (mobile cartography). This environment, according to Gartner, could include: list of coordinates of reference points; written information, sound; simple graphics; maps (and other cartographic forms); images; 3D graphics and animations.

It is believed that new wireless devices such and mobile phones, car navigation devices and PDAs offer a new challenge to cartography. New theoretical approaches for using those devices are currently under development and the design of user interfaces for those devices is one of the main focus of research in the field.

3.2.3 Database-visualisation links

According to Gahegan *et al* (2000), the wide availability of geographic information, either scientific or business-related, made it possible to generate complex geographic datasets. One of the great challenges for researchers in geovisualisation is to find ways to facilitate the combination of different datasets and provide visual insight on real-world patterns and processes. The working group on database-visualisation links identified as key issues in the field: Knowledge Discovery (KD), a concept derived from computer science based on the exploration of large datasets to knowledge acquisition; geocomputation, the use of concepts from KD and data mining to geographical information datasets; and exploratory visual analysis.

Dykes *et al.* (2005, p. 7) have this to say about the use of large datasets for geovisualisation:

> "*Geospatial data sets of progressively larger size and increasingly complex structure offer a continuing challenge for geovisualization as we aim to develop appropriate techniques, tools and approaches. Whilst the initial promise of visualization was based upon leveraging the power of human vision to extract meaning from complex data sets, many existing techniques do not scale well to the massive datasets that are increasingly common.*"

3.2.4 Cognitive aspects of visualisation tool use

The forth research topic on the agenda of the Commission of Visualisation and Virtual Environments covers cognition and usability issues. Slocum *et al* (2000) emphasised that the advances in computer technology have provided new perspectives for visualisation, however they argued that a new theoretical cognitive framework should be developed and the visualisation methods should be tested according to usability engineering principles. Dykes *et al.* (2005) supported this view, claiming that methods from Human-Computer Interaction (HCI), notably research in usability, should be viewed as a guiding principle for researchers in this area.

Slocum *et al* (2000) outlined a number of research challenges in the field, including geospatial virtual environments; dynamic representations; metaphors and schemata in interface design; training people to use geovisualisation methods; collaborative geovisualisation; and developing a methodology to evaluate geovisualisation methods.

The development of geovisualisation tools, and particularly digital atlases, involves a myriad of concepts that comprises the rise of hypertext and its application to cartography, hypermaps; multimedia and its different applications to cartography; metaphorical approaches in multimedia cartography; and broadcasting medium, etc. These concepts are examined in the following sections.

3.3 Hypermaps

Hypertext can be described as a way of accessing information where different media (text, pictures, audio, and video) can be mutually linked in a network of nodes. This word is more commonly used to describe digital applications and more recently to the Internet. Therefore, hypertext is related to architecture of information, in other words, it allows the information to be explored in a non-linear manner.

It is argued that the concept of hypertext is not new and, although not formally described, has always been present (Ramos 2005). Traditional books, introduced in the West as long as sixteen hundred years ago (Chartier 1999), can be also described as hypertextual. Codex gradually replaced scroll documents, quite common in ancient civilizations. Although the nature of books in codex form is linear, once the pages are organized in sequence, they can also be hypertextual because the reader can not only break the sequence by reading chapters in a different order, but also the writer can make use of footnotes to provide additional information (Chartier 1999).

The roots of the concept of hypertext can be found in writing produced at the end of the Second World War (Cartwright 1999a). Vannevar Bush, the director of the Office of Scientific Research and Development, United States, published in 1945 the essay titled “As We May Think” where he argued for the creation of a system, MEMEX, that would be a “*device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory*” (Bush 1945).

During the sixties the concept of hypertext was formalised by Theodore Nelson. In a series of publications Nelson described his ideas about hypertext and proposed the creation of Xanadu, an ambitious project that aimed to develop a world-wide hypertext. However, Nelson refused to include the World Wide Web in his schema and he described it as having only a “shallow structure” (Nelson 2001).

The hypermap is the application of hypertext concepts to spatial information in the form of maps. The concept was formalized by Laurini and Milleret-Raffort (1989), and they defined hypermaps as follows:

> “*The great idea of hypermaps is to extend hyperdocument concepts by integrating geographic references. Should geographic references remain at literal level, geographic references can be modeled by hypermap links. But, for many documents, literal geographic references are not enough to correctly cover the space they speak about: a coordinate-based referencing system is necessary through a cartographic system*”. (Laurini and Milleret-Raffort 1989, p. 313)

Generally, two kinds of hypermaps can be identified. Static hypermaps are those that remain in a formal level, in other words, pre-processed maps, usually available as static images, are linked to each other via image maps, subdivisions of the map that are linked to other contents. The other kind of hypermap is the dynamic hypermap.

Dynamic hypermaps maps do not exist physically, but rather 'virtually'. Here a dataset is provided along with tools to create maps dynamically, attending to users' demands for a map to be generated.

Kraak and Driel (1997) addressed the hyper-terminology by explaining in a diagram (figure 3-5) the subtle differences. However they emphasized that the concept of hypermap comprised both clickable and dynamic maps.

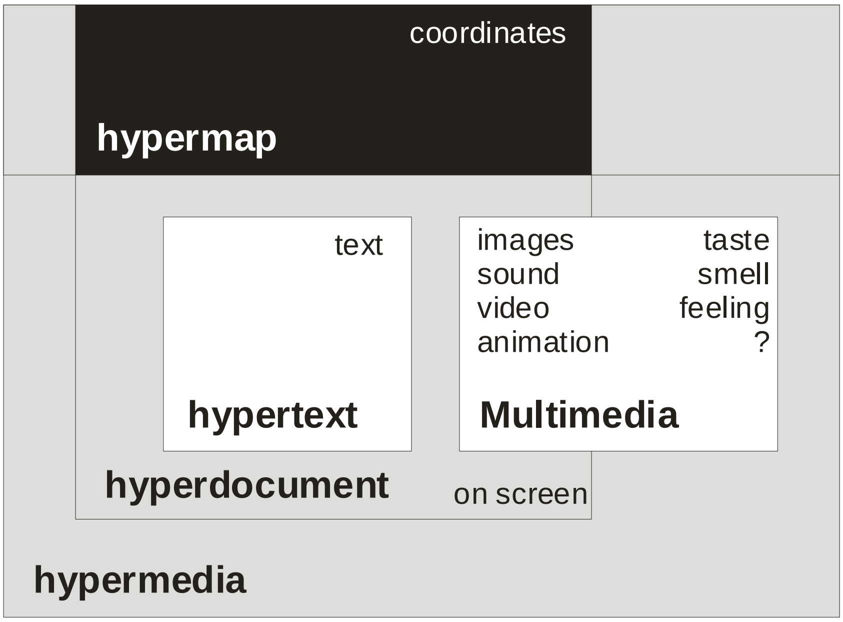


Figure 3-5. Hyper-terminology (Kraak and Driel, 1997, p. 459).

According to Kraak and Driel's (1997) view, hypermap is a concept derived from hypermedia. The hypermap is understood to be a hyperdocument dedicated to deliver maps on screen. These maps can be either dynamic or simple clickable maps, they also can (but they do not *have to*) employ GIS technology.

3.4 Multimedia

Multimedia is an important tool for visualisation that emerged in the early nineties. It is viewed as a key concept for the development of digital atlases. Many definitions for multimedia can be found. As stated by Ramos (2001), there are authors that believe that, considering the meaning of the word, multimedia can be understood as an amalgamation of diverse media comprising from just video to a complete suite of resources.

Laurini and Thompson (1992, p. 595) stated that "***multimedia*** *in the jargon of the computer and electronic industries, comprise a variety of analogue and digital forms of data that come together via common channels of communication*."

According to Peterson (1995b, p. 127), multimedia can be described as "*the various combinations of text, graphics, animation, sound, and video for the purposes of improving communication.*". Peterson claimed that although multimedia could be considered even a slide presentation along with sound, the use of computers as a medium for multimedia has given an additional component to it, interactivity.

Miller (1996, p. 11) defined multimedia as "*The merging of audio, video, still imagery, graphics, animation and text within a computerised environment to form an interactive, dynamic and randomly and/or associatively accessed whole*.". In this way, Miller considered that multimedia was not only a combination of diverse media transmitted via digital means, but multimedia was necessarily interactive. Therefore Laurini and Thompson (1992), Peterson (1995b), and Miller (1996) emphasised not only the contents but also the importance of the computer as a medium for multimedia applications.

Multimedia can also be understood as an interface for cartography. However, as stated by Cartwright and Peterson (1999, p. 5) "*The traditional map form can be seen as a form of multimedia, whereby lines, colours, text, rendering, symbols, diagrams and carefully chosen content, were used to impart a 'story' about reality*". They continued to say that, in the digital age, paper can be seen as just one possible delivery medium. This means that paper has been conveying maps for centuries, but currently information can be delivered in many forms, not just on paper.

For this research, multimedia was defined as the use of a composition of diverse media with the purpose of enhancing the communication of a particular message. Multimedia encompasses interactive and non-interactive applications and can be conveyed either in digital or non-digital media.

It is important to stress, however, that hypermedia and interactive multimedia are not considered synonyms. The first refers to the use of a hypertextual structure within the multimedia, and the second refers to interactive multimedia, which besides being interactive can be also linear or even follow a structured direction.

3.5 User Interface and Metaphors

Interaction is another key concept in geovisualisation tools, however, as emphasised by Cartwright *et al* (2000) technology is not itself interactive. An intermediary tier, the user interface, makes it feasible the two-way communication between data and user in geovisualisation applications. This is a premise for interactivity.

Metaphors are commonly employed in graphical interfaces as well in human communication. As stated by Peuquet (2002), metaphors in spoken language are seen as the use of a word to imply another and, therefore, facilitate the comprehension of the message. In graphical language, metaphors can be described as the use of graphic symbols to represent something else. In this way, as mapping is about using symbols to represent the geographical space, maps can be seen as metaphors to the real world.

Metaphorical approaches are employed to help human-computer interaction. The development of graphic interfaces made it possible to develop graphic metaphors to better facilitate the use of computers. The technological development of output devices made it feasible the transition from complex command lines to Graphical User Interface (GUI). The GUI was first introduced by the Xerox Corporation's Palo Alto Research Center (PARC) in the early seventies (Cartwright 1999a). The idea of their pioneer research was to develop an interface using symbols that could be intuitively associated with the function that they represented.

In this way, some important metaphors were developed on that time and are still in use. Some examples are the arrow to represent pointer devices, changes in the cursor's shape to tell the user the system's activity, menus offering different command options, the use of windows to represent different programs or instances of the same program, scroll bars, buttons, dialog boxes, and so on.

However, despite being what can now be described as ubiquitous interface, the GUI based on icons and windows is not the only possible interface. Nelson (1999) claimed that regardless the arguments about all other metaphors, the main metaphor developed by PARC's research was the paper metaphor, as XEROX was a printing and paper technology company. In this way even the notion WYSIWYG (an acronym for What You See Is What You Get) meant that the user was supposed to get something on paper, therefore, according to his view, the concept was nothing but the repetition of the paper metaphor. Nelson (1999) claimed that nothing in interface design could be conceived at PARC apart from the paper paradigm. The author emphasised that after decades the PARC's interface and metaphors were still the most widely known and used, he argued that

> "*Any types of graphics are possible; yet the term "GUI", supposedly short for Graphical User Interface, is used for only one kind of graphical user interface, the icon-and-window view they put together at Xerox PARC in the early seventies. There are thousands of other things that a graphical user interface could be. So we shouldn't call today's standard interface a GUI, since no graphic alternatives have been seen; it's a PUI, or PARC User Interface, still almost exactly what they were doing at PARC twenty-five years ago*" Nelson (1999).

Contrary to Nelson's claim, though, other GUIs have been seen. Some examples are games interfaces and virtual reality applications. Nevertheless, these interfaces were developed for specific purposes.

As emphasised by Cartwright and Hunter (1999) the desktop metaphor, employed by both Apple and Microsoft, has become a natural interface for personal computers. In this metaphor, similar to a desktop, icons that represent different programs or files can be distributed throughout the screen, just like stationary items on a physical desk; other office metaphors used are folders and rubbish bins.

3.5.1 The map as a metaphor

As a representation of the real world, the map itself can be considered a metaphor. Traditional cartographic theory relies heavily on metaphors. Bertin (1973) outlined the guiding principles of the semiology of graphics.

The semiology of graphics is a theoretical approach that is based on the characteristics of the information to be mapped. According to its principles, the starting point to the creation of any map is the analysis of the information to represent. Therefore, the components of the information have to be identified.

According to Bertin (1973), the relationship between components of the information can be difference, order or quantity. Consequently, the components can be organized into three levels: selective, ordered or quantitative.

The representation of the components in the map is made by considering which visual variables are suitable in the situation. Here is when metaphors are employed. Thus, it is necessary to respect the correspondence between the organization level of the component the characteristic of the visual variable chosen to represent the information, in a metaphorical manner.

The visual variables established by Bertin are: size, tone, grain or texture, colour, orientation and shape. In this way, Bertin employs the visual variable size to represent quantity; the visual variables size, value, and grain are recommended to represent order, and so forth.

Figure 3-6 outlines the visual properties (quantitative – Q, ordered – O, selective - ≠ and associative - ≡) of the visual variables, and some examples of the application to information related to point, line and area, are given as well.

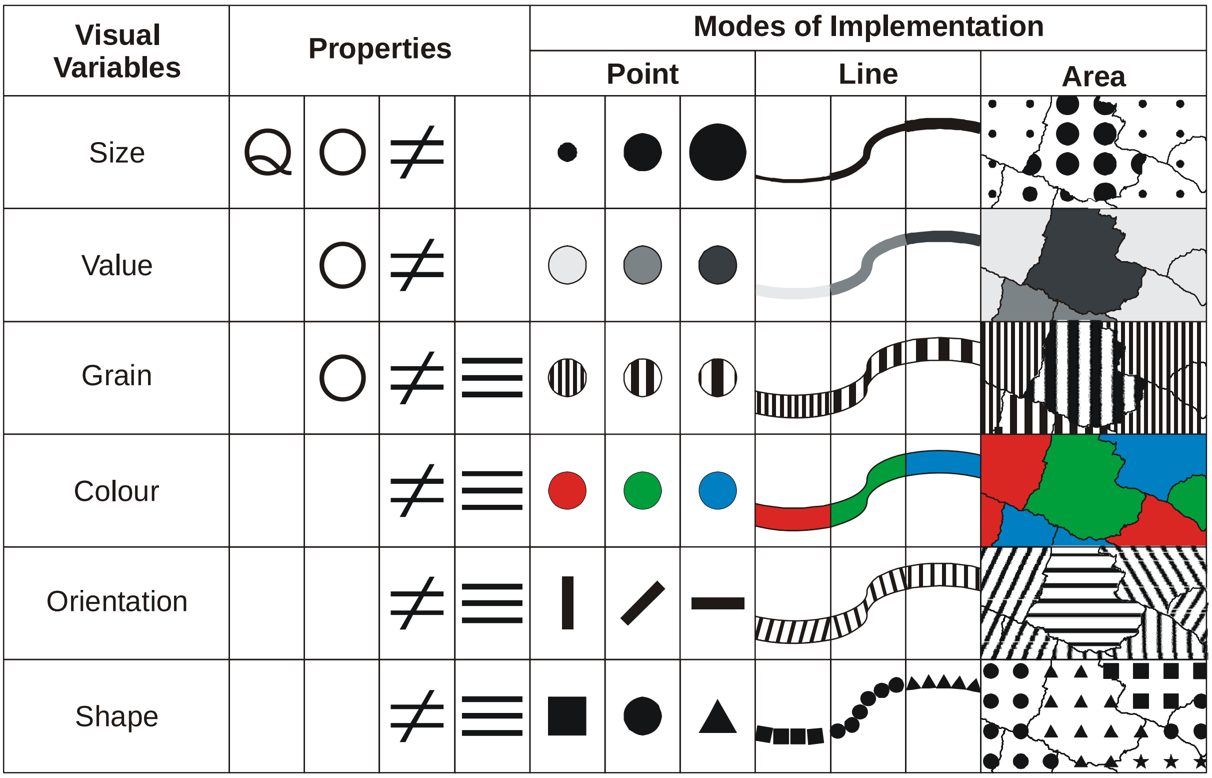


Figure 3-6. Graphic variables proposed by Bertin (1973), redrawn from Cardoso (1984, p. 42).

Figure 3-7 shows an example of the use of the visual variable size to communicate quantitative data. In the example portrayed a cartogram represents population in different countries, the size of the country changes according their population. In this case, the focus is more on communication the amount of people living in the country than in portraying the actual location and shape of the country itself. In that way the author of the map can get the message across quickly.

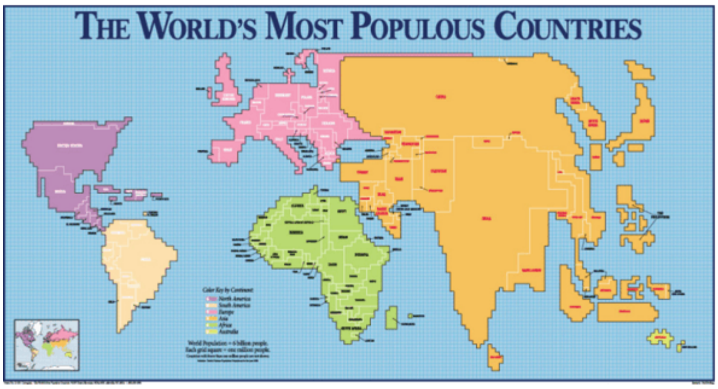


Figure 3-7. The use of size metaphor in thematic cartography.

Sourcet: <http://www.odt.org/hdp/>

3.5.2 Metaphors in multimedia map applications

Like their use in paper maps, metaphors are commonly used to convey messages in multimedia map applications. It is believed that in multimedia maps two different kinds of metaphors can be outlined: graphical metaphors and conceptual metaphors.

Graphical metaphors are considered to be the use of graphic symbols to imply particular actions. Figure 3-8 outlines some examples of graphical metaphors.

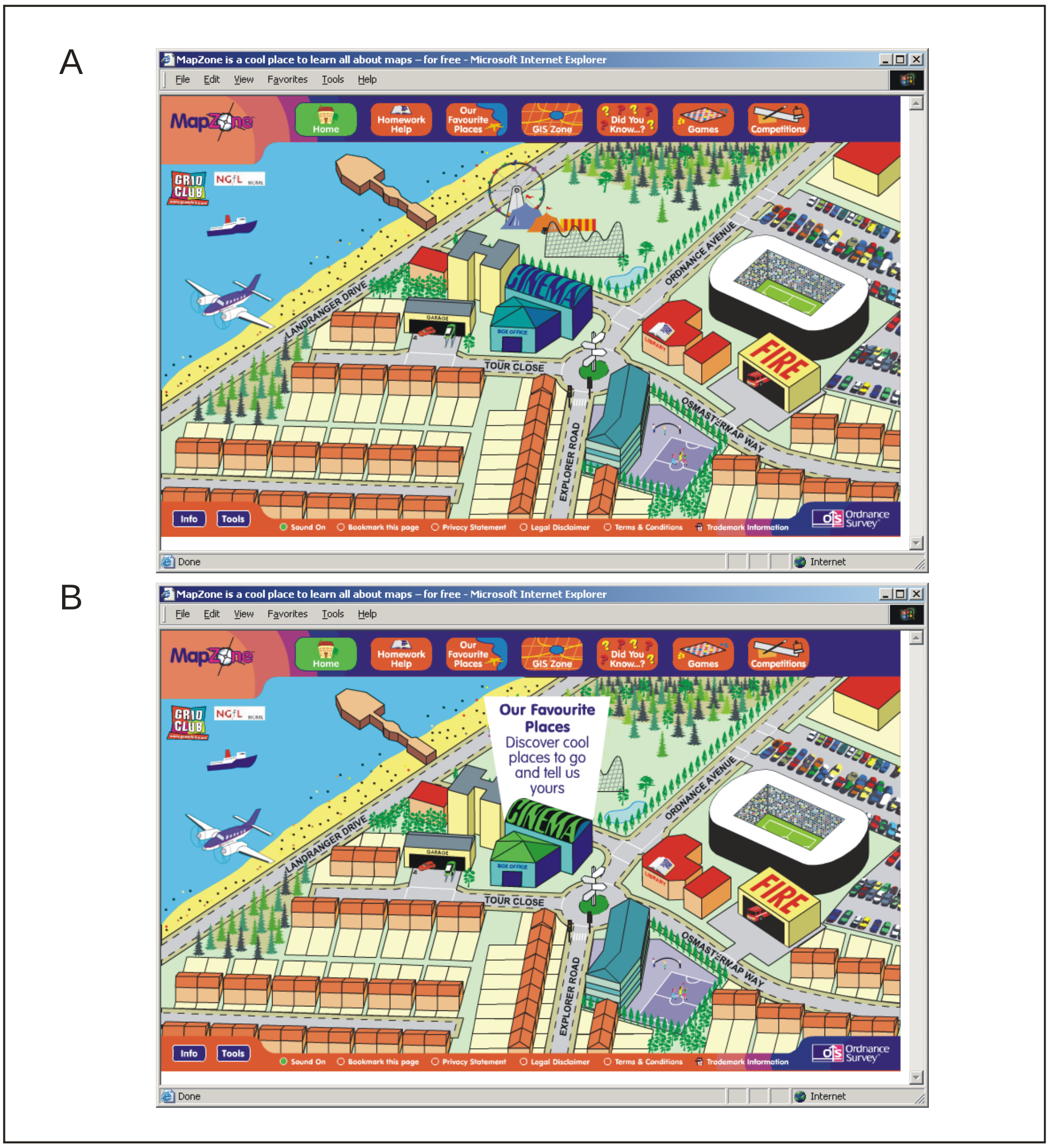


Figure 3-8. The MapZone interface.

Source: <http://www.mapzone.co.uk/index.htm>

Figure 3-8 shows the graphical interface of the *MapZone* Web site, from the Ordnance Survey, Britain's topographic mapping organisation. This site, dedicated to geographical education, was built using the city as a metaphor. When the user explores the screen with the pointer device roll-over effects show hidden options. In the example available in figure 3-8, when the pointer touches the cinema (figure 3-8A) the building is highlighted to show the option associated to that part of the screen (figure 3-8B).

Other graphical metaphors can be found, such as the door to imply entry to something. In the example illustrated in figure 3-9 the user is invited to choose between two different languages for the interface by clicking one of the doors.

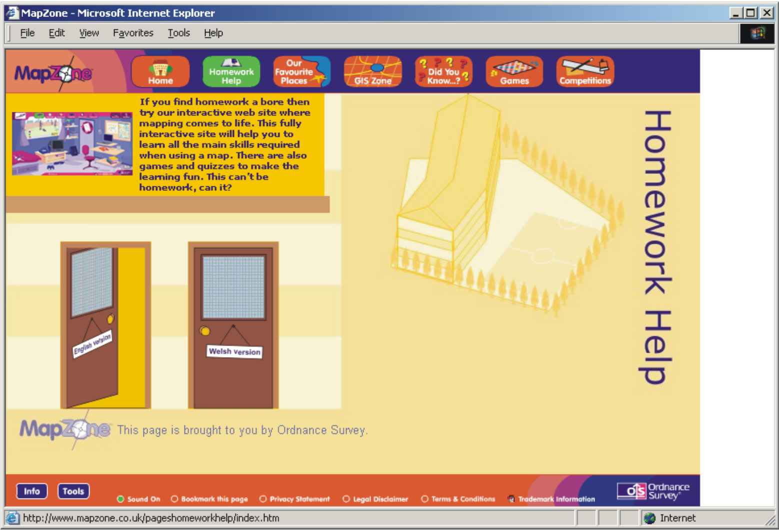


Figure 3-9. The door as a metaphor to two different choices within the application.
Source <http://www.mapzone.co.uk/pageshomeworkhelp/gateway.cfm>

Figure 3-10 illustrates another metaphorical example within the *MapZone* Web site. In this interface a bedroom is used to engage the student with the contents of the site. Here, several objects within the interface are reactive. In the example shown (figure 3-10) the 'parents' can be seen through the window working in the backyard (figure 3-10A), when the pointer device touches the window the student is informed about what it represents, the 'parents zone'.

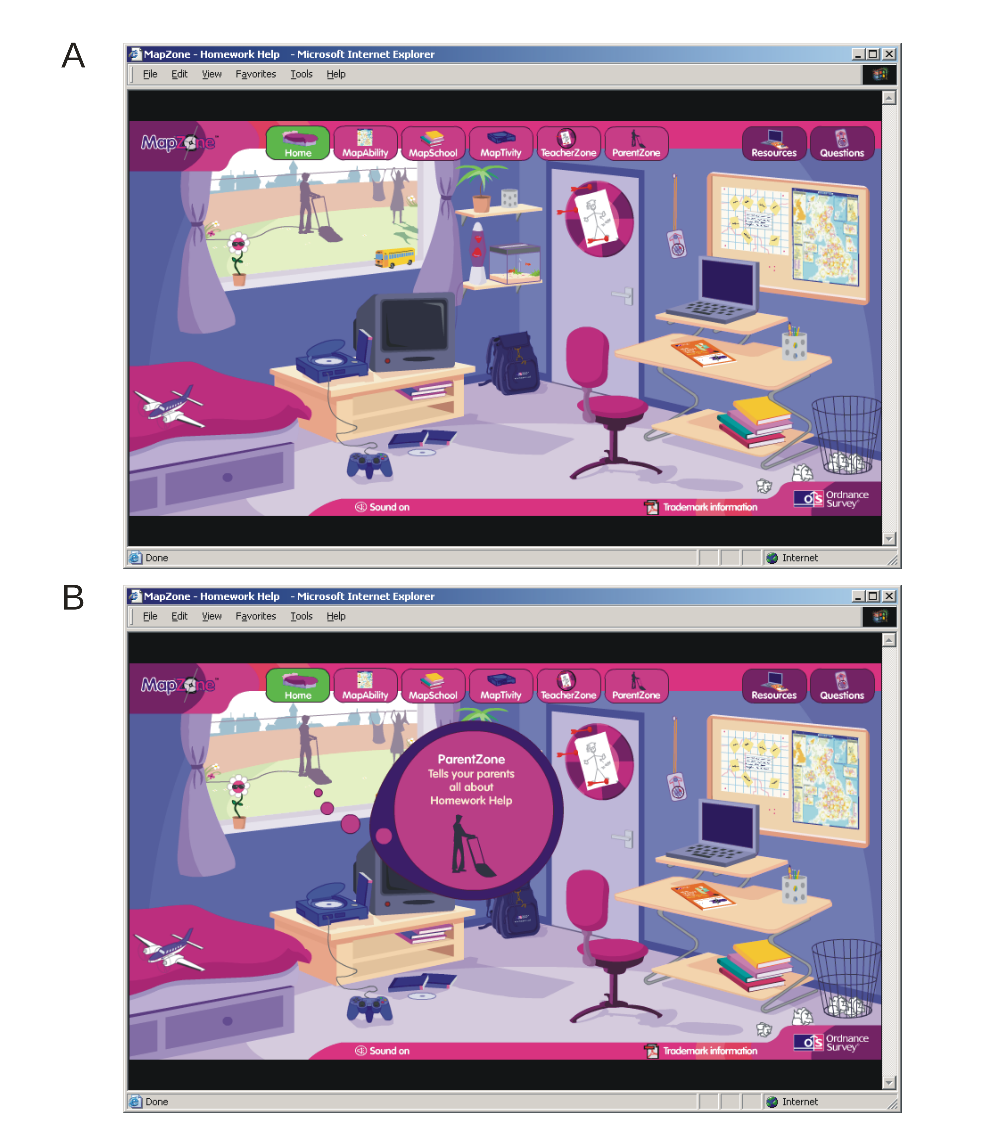


Figure 3-10. The bedroom metaphor.

Available at http://www.mapzone.co.uk/pageshomeworkhelp/index.htm

Cartwright (1999b) and Cartwright and Hunter (1999) focused on the study of conceptual multimedia map metaphors. These are believed to be metaphors related to the architecture of information. Conceptual metaphors normally make use of graphical metaphors to enhance the map metaphor in multimedia products. Cartwright's metaphors include:

- *The Storyteller*, which is believed to be a metaphor that many people feel comfortable with. In this metaphor a narration in digital audio files, similarly to storytelling, is used to present the user information about the area.

- *The Navigator*; in this metaphor key points landmarks are highlighted on the map and used as a guide for navigation. This metaphor is suitable for inexperienced users, or people not used to deal with maps;
- *The Guide* is a metaphor that can be applied when the user has no previous knowledge about the area and has little ability to efficiently navigate within the package. "*The Guide insures that pertinent information is automatically chosen for the user*" (Cartwright 1999b, p. 340);
- *The Sage* is a metaphor linking the multimedia map to other applications, like Web sites for additional information, and/or direct contact with specialists in the field portrayed;
- *The Data Store*, the map offers access to further information that can the queried, either by roll-over reaction or by "magnifier lenses";
- *The Fact Book* is the metaphor where the user is provided links to additional information repositories, both commercial and public (Cartwright 1999b);
- *The Gameplayer* is an approach where maps and other spatial information can be structured in form of a game, for example as a jigsaw puzzle or a matching game. This kind of metaphor has an obvious application for education as the user can engage with the map in a challenging way;
- *The Theatre* is a metaphor where the user can choose between been the passive audience, a player on the stage, the director or even scripting the play. In this way the application can range from passive to fully controlled by the user;
- *The Toolbox*, in this approach real-time cameras around the world could be used to link relevant places to the multimedia map, these cameras could be used to connect users as well as to gather information from different places.

Figure 3-11 illustrates an example of *The Theatre* metaphor. In this Web site, a VRML model of the Museum of the USSR Museum is provided. The idea is to immerse the user in the model, thereby the user is invited to assume the identity of one of the avatars spread throughout the application, and be a player on the stage. All the metaphors report to real life situations. For example, to have an aerial view the user will click on a helicopter that is flying all the time. If the user wants to walk on the park of inside the museum they will click on one of the avatars standing in many different locations. (figure 3-11).

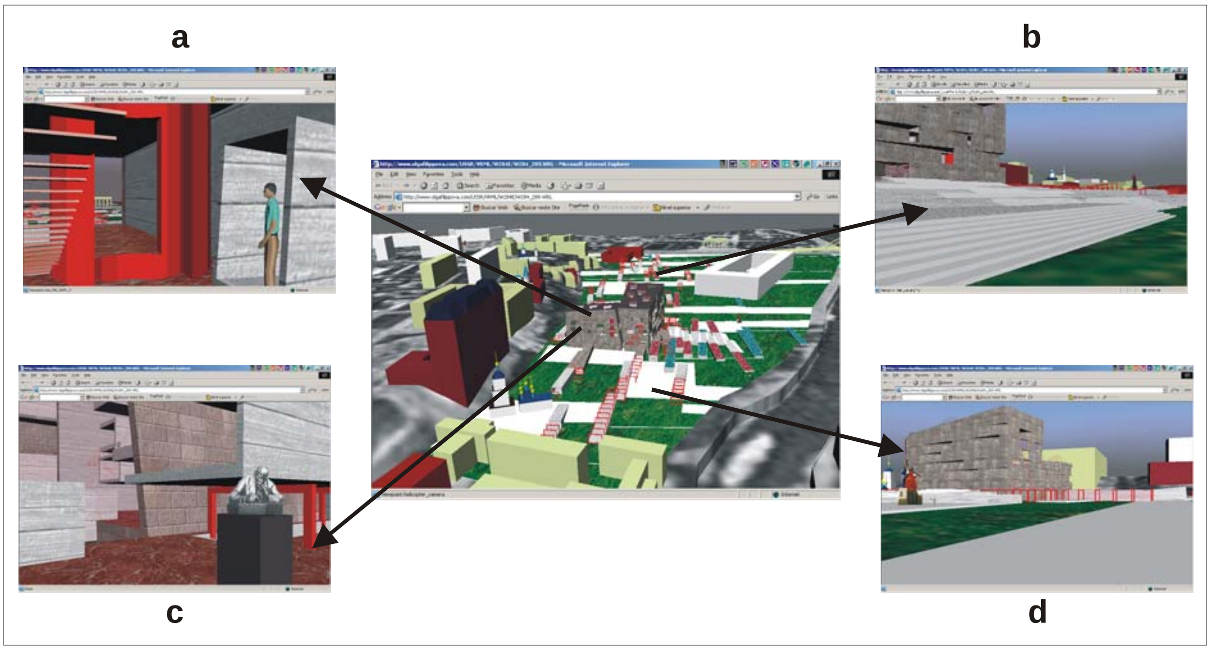


Figure 3-11. The user interface and metaphors of the USSR Museum Web site.

Source: <http://www.olgafilippova.com/USSR/VRML/W284E/W284_289.WRL>

The *Gameplayer* metaphor, as stated previously, has a natural application for educational products. In the example bellow (figure 3-12) the *Gameplayer* metaphor is used in the *Tirol Atlas 4 Kids*. In this example, a matching game is proposed, where the child has to match the map with the corresponding name.

Figure 3-12. The Gameplayer metaphor in the *Tirol Atlas 4 Kids*.

Source: <http://tirolatlas.uibk.ac.at/kids/modules/memory/beznt/?page=2&lang=de&mode=2>

Graphical and conceptual multimedia map metaphors were explained here to illustrate the gamut of approaches that can be adopted when developing a digital atlas. Several graphical metaphors were adopted in the methodology proposed in this research and can be verified in chapter 5. Regarding conceptual metaphors, it is believed that the contents of the *School Atlas of Rio Claro*, used for developing the methodology and producing a small prototype, allow the use of two different approaches: the sage and the storyteller.

The sage can be adopted as the contents could be linked with multimedia contents, external sites and paper activities. The storyteller metaphor was adopted in the paper version of the atlas and can be easily implemented in the digital product, for instance when the city is presented, in the beginning of the atlas, the first map introduced is the world map and the last is the map of the city. The cartographic concept explored is scale; when dealing with maps from small to large scale the student is guided to the comprehension of the concept, just like in story telling.

3.6 Cartographic Animations

Cartographic animations can also be included in digital school atlases and are considered to be potentially beneficial for spatial cognition. Harrower *et al* (2000, p. 281) highlighted that "*the potential power of animated maps lies in their ability to prompt a conceptualization of temporal continuity; thus facilitating and understanding of process rather than state*". Harrower *et al* (2000) also stressed that user-controlled animations would be more effective for learning.

However, there are some disagreements among researchers about the advantages of using cartographic animation for educational purposes. In general, research in the field provides support for using animation for spatial cognition (Slocum *et al.* 2001). However, Morrison *et al* (2000, p. 6) stated that there was not much evidence that animations are more effective than static graphics for learning.

> "*By now, the failures to find beneficial effects of animation over equivalent static diagrams is not surprising. For the few successes, the animated graphics in fact were not equivalent to the static graphics. In some of the most carefully controlled cases, the animations conveyed detailed information about the microsteps. It may be that this sort of information is more easily conveyed in animations than in static diagrams, and that*

> *would be sufficient reason for using them. However, in many other cases animations may have failed because they were difficult to perceive or because they mismatched people's conceptions of motion, which are often discrete rather than continuous.*"

The Morrison *et al* (2000) suggested that two principles needed to be followed in order to develop successful animations: animations must be easy to perceive and understand and the information to be conveyed by the animation must be evident. It is important to remember that these principles are valid not only for animations, but for static maps as well. However, Morrison *et al* (2000) suggested that even following those principles the effectiveness of animations in facilitating learning must be assessed.

The findings reported by Harrower *et al* (2000), Slocum *et al* (2001) and Morrison *et al* (2000) re-stated the importance of using animation for educational purposes, even though the last ones stated that there is no evidence about the effectiveness of animations there is no disagreement among the authors that animations have a natural potential for communicating spatial and temporal phenomenon.

More recently, Hanewinkel and Tzschaschel (2005) reported their findings on the effectiveness of using cartographic animations for spatial cognition in the context of the German National Atlas for Schools. They indicated a number of advantages for using cartographic animation in the classroom, amongst them: cartographic animations facilitate learning of dynamic processes (distinguishing temporal and spatial dimensions of geographical phenomenon); and they can promote the engagement of students and teachers with the map in an interactive fashion.

Midtbø and Larsen (2005, p. 160), comparing the use of static maps and animated maps for spatial cognition claimed that "*animations seem to be favourable when rate of change is used as variable. Animations are specially suited for small changes which are difficult to detect in a series of static maps*". Midtbø and Larsen (2005) stated, however, that their study was conducted with a small group of map users (38 people) and a larger group would have provided more substantial evidence to corroborate these findings. As can be seen the field of research in the effectiveness of cartographic animation for spatial cognition is open for further contributions.

Animation is understood as a technique where several images, either in individual frames or produced by interpolation between key frames, are displayed in a sequential fashion. Slight differences between the images together with a particular frame rate cause to the human eye the impression of continuous movement, due to a phenomenon known as persistence of vision.

The main benefit of using animation for cartography is highlighted by Peterson (1995b, p. 48) as follows "*The most important aspect of animation is that it depicts something that would not be evident in the frames were viewed individually. In a sense, what happens between each frame is more important than what exists on each frame*".

The interest of using animation techniques to depict spatial phenomena is not new. According to Peterson (1999a) the first cartographic animation, developed by Disney studios in 1940 depicted the invasion of Warsaw, Poland, by German troops in the Second World War (figure 3-13).

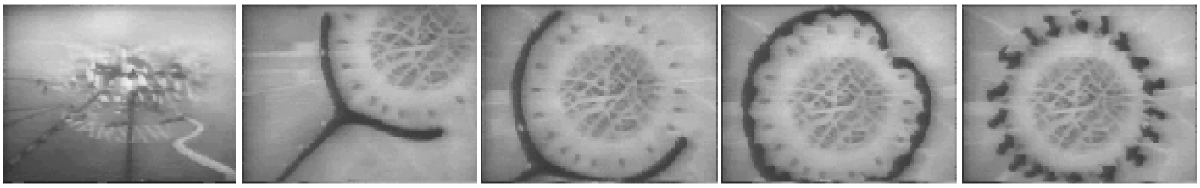


Figure 3-13. Selected frames from the animation of the invasion of Warsaw by German troops, developed by Disney Studios, 1940 (Source: Peterson 1999a, p. 376).

However, as emphasised by Campbell and Egbert (1990) the first researcher to focus the attention on the use of cartographic animations was Norman Thrower. In research conducted during the fifties and sixties, Thrower described the potential of using cartographic animation and depicted the results of a research with users of animated maps. According to his findings (Thrower 1961), users of cartographic animations were more concerned in understanding the spatial dynamics of the phenomenon portrayed in the animation than in finding its exact location.

The first, and obvious, application of animation techniques to spatial data was the creation of temporal animations. In that way, the first computer-assisted cartographic animation was provided by Tobler (1970).

Harrower (2004) provided and overview of the history of cartographic animation. In his timeline he highlighted the evolution of animated maps considering its production, storage medium, distribution and user interaction (figure 3-14). Considering Harrower's view as a guideline, one can establish parallels between the development of cartographic animations and multimedia cartography with regards to its storage medium, distribution and user interaction.

Similarly to multimedia cartography, in early stages cartographic animations were stored in discrete, magnetic medium. With the technological evolution of storage devices, digital medium was introduced. However, the Internet, and mainly the Web, completely transformed the way people access spatial information, either in static, dynamic, animated and/or interactive form.

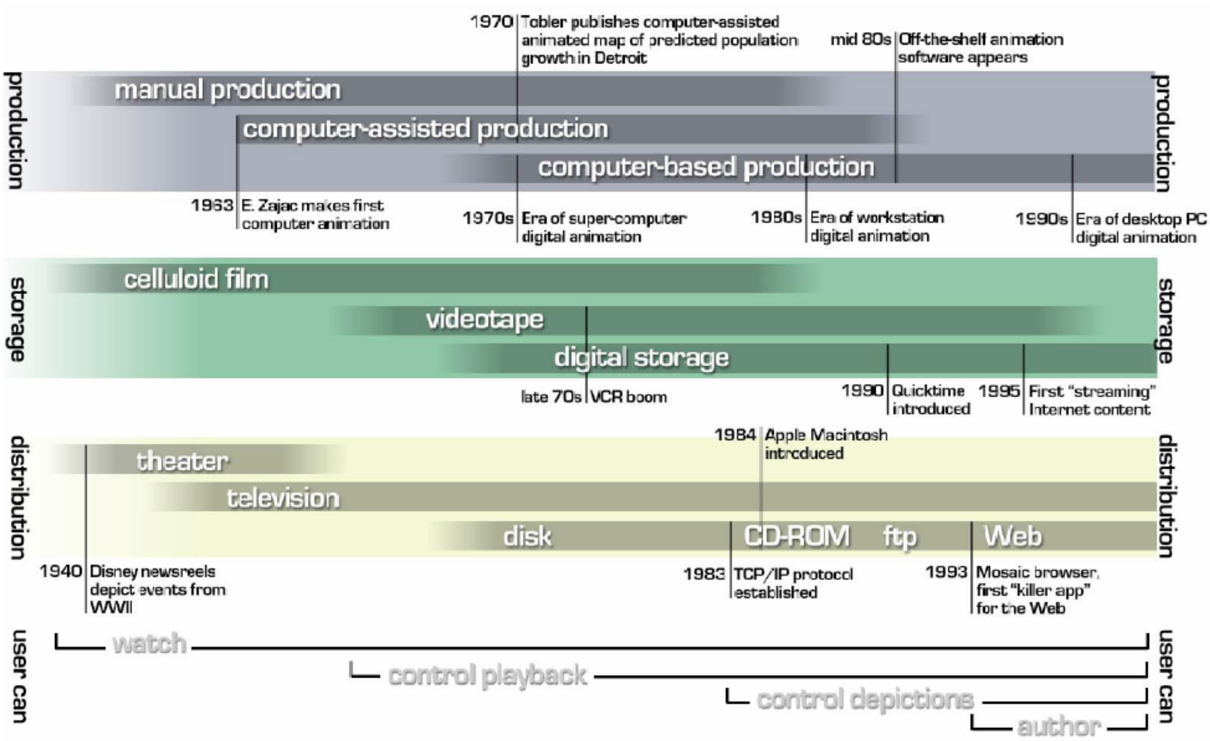
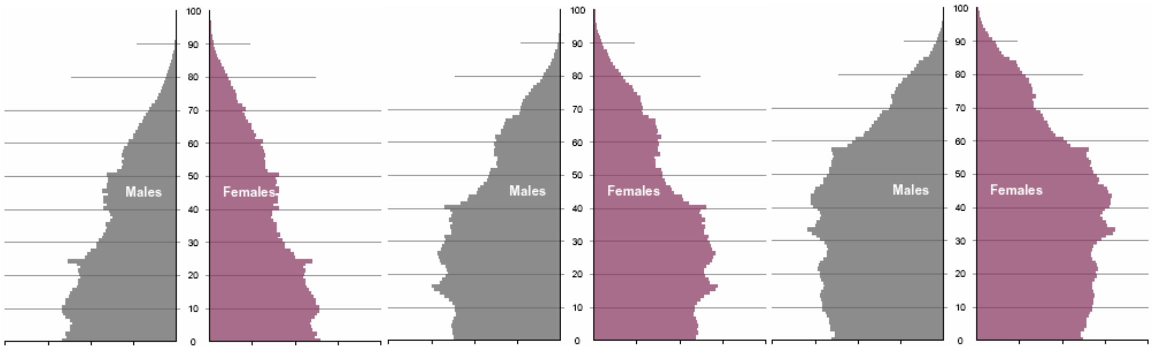


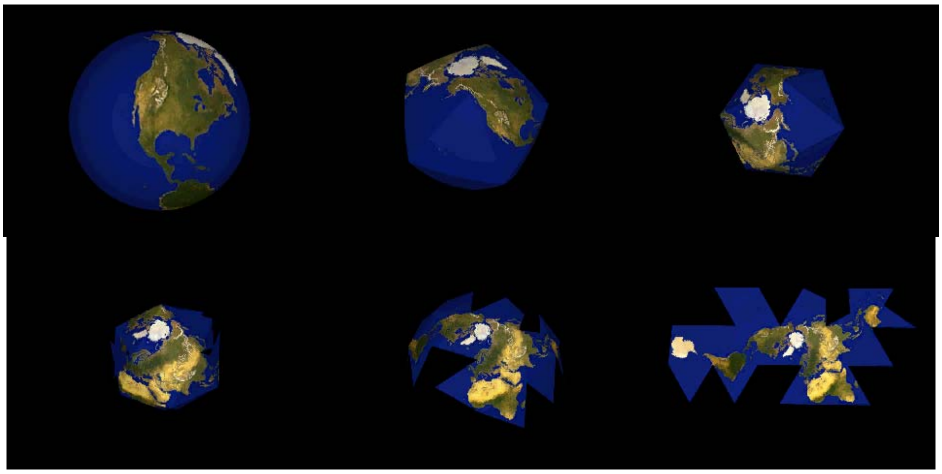
Figure 3-14. The evolution of cartographic animations according to Harrower (2004).

Additionally to the visual variables proposed by Bertin (1973), discussed in section 3.3 in this chapter, Peterson (1995b, p. 52) proposed new variables that should be considered when producing cartographic animations. These are size, shape, position, speed, viewpoint, distance, scene, texture, pattern, shading, and colour. Their use and some examples from the Internet are shown in the table 3-1.

<table>
<tr><th>Variable</th><th>Characteristics</th></tr>
<tr><td>Size</td><td>Changes in size within the animation can be used to convey quantitative information. A temporal animation of a population pyramid of a particular country would make evident the demographic dynamics of the country through changes in bar sizes.</td></tr>
<tr><td colspan="2">

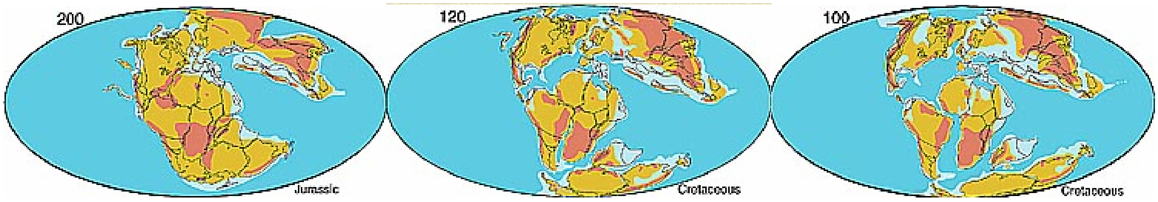


Example of temporal animation of a population pyramid. Here the variable size is used to emphasise the demographic dynamics of Australia from 1971 to 2050. Source: http://www.abs.gov.au/Websitedbs/d3310114.nsf/home/population%20pyramid%20files/$FILE/poppyr.svg</td></tr>
<tr><td>Shape</td><td>Changes in shape of particular objects in the animated map can emphasise the information conveyed. Peterson gives an example of an animated map where different map frames would be constructed in different map projections. This would make it easier to the user to understand distortion between different projections.</td></tr>
<tr><td colspan="2">



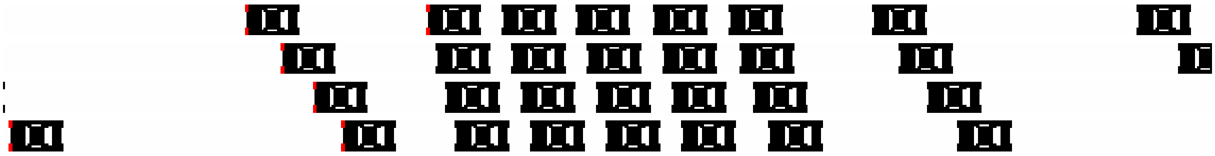
Different frames of an animation depicting cartographic projections. Here the shape of the planet changes to emphasise the need for geometrical transformation in maps, transposing information from a spherical shape onto a flat surface. Source: http://www.westnet.com/~crywalt/unfold.html</td></tr>
<tr><td>Position</td><td>Movement of particular objects within the map throughout the animation would make evident the spatial dynamics of that element</td></tr>
</table>

along a given period of time. One classical example is the animation of continental drift, where continents move apart to portray the theory of plate tectonics.



Different frames of a temporal animation depicting the continental drift. Here two variables are used, position and speed. Source: http://www.scotese.com/pangeanim.htm

Speed The speed applied to the movements of elements within the animation can emphasise the temporal scale of the animation. The use of a temporal legend is advised to make the temporal change more clear.



A sequence of frames depicting a model of wave jams, where the decrease of speed of one car is important to understand the phenomenon. Source: http://www.smartmotorist.com/wav/wav.htm

Viewpoint Animations using different viewpoints could make more clear landscape characteristics such as topography, for instance.

This VRML animation allows the user to freely explore the terrain through different points of view. The study area is highlighted. Source: http://user.gs.rmit.edu.au/caa/VFT/startvrml.htm

Distance Additionally to viewpoint, distance is a variable that provides the user a different view point related to change of scale. An example of this kind of animation is provided by Google Earth, where the user can quickly animate a route between two different point on the earth’s surface. The application will first zoom out of the initial point, rotate the globe towards the destination point and then zoom in. The user, as a result, will see different information about both locations in different levels of detail.

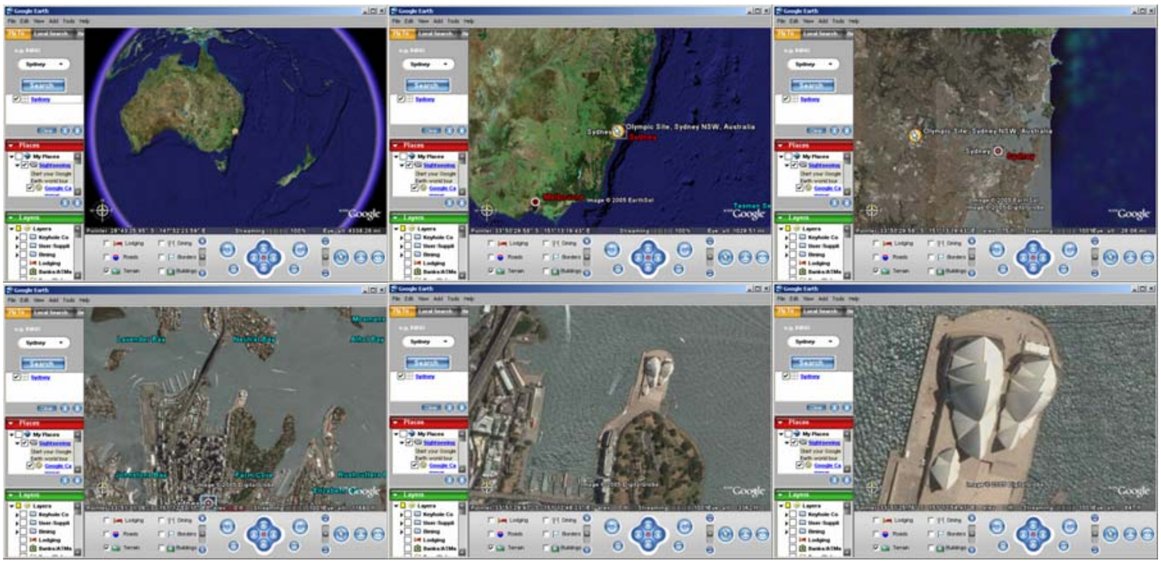
	 Sequence of animation from *Google Earth*, using the camera metaphor, where the user can zoom in to their required level of detail. From a global scale (first frame) to a particular building (last frame).
Scene	Scene is understood as the use of transition effects, such as fading, dropping, sliding, and so on to imply change in the subject within the animation.
Texture Pattern Shading Colour	These animation variables can be used to make more evident the information depicted within the animation. For instance, in a 3D modelled animation, different textures, patterns and colours can be used to imply different land use. Similarly, shading can be employed to depict topographic information.

Table 3-1. Animation variables, after Peterson (1995b).

Cartographic animations can be classified according to different criteria. Considering its development two categories can be distinguished. Frame-based animation and cast-based animation (Peterson 1995b).

Frame-based animations are created by a sequence of individual frames that are displayed in a certain frame rate, giving the human eye the illusion of movement. Each frame is an individual raster image, where all elements are blended together. Those images can be created in any image processing software.

Cast-based animations are vector-based animations. There, objects are placed against a background and can be moved individually. In this way, multiple layers within the animation will contain different objects that can be moved independently.

Generally speaking, frame-based animations files are heavier than their cast-based counterparts. The last ones have became very popular in recent years, mainly because the resultant files are smaller and, therefore, can be quickly downloaded over the Internet (Harrower 2004).

As highlighted previously, in figure 3-14, animations have also become increasingly interactive. Initially the user was able to watch it, in a second period they could also control the playback, with the introduction of digital storage medium and the use of personal computers for animation, the user was also able to control representations and finally, with the popularization of computers, with more affordable prices, and the realize of easy-to-use animation software the users of computer animation have became potential authors as well.

3.7 The medium

Contrary to paper atlases, digital atlases can be reproduced in diverse mediums. Generally speaking digital media can be divided into two groups: discrete and networked.

3.7.1 Discrete medium

Although many different discrete mediums for digital atlases could be identified, from magnetic tapes to the now almost obsolete 3.5'' floppy discs, in this research the work of Cartwright (1999a) will be considered the starting point for analysis. The introduction of optical storage medium represented a major shift for digital cartography. Unlike magnetic medium, optical medium was stable, durable, and large enough to cope with big files. Cartwright (1999a) provided an extensive overview on digital discrete medium for multimedia cartography and identified the following types:

- **Videodisc:** This is considered the first digital storage medium and it was first presented in 1972. This medium stored analogue video signals and each side of a 12'' disc could store up to 52,000 frames of images;
- **CD-ROM:** This optical storage medium was developed in the early eighties. In this medium digital information is engraved onto the surface of the disc and it is read by a bean of infrared light. A CD-ROM can storage between 650-700

megabytes of data. The spot size and the space between tracks in CD-ROM is 1.6 μm (micrometre) (figure 3-15).

- **DVD:** This format was release by the mid-nineties. Generally speaking, DVDs are optical discs where the data is engraved and read by a bean of light, just as CD-ROMs. However the spot size in DVDs as well as the track-to-track spacing is smaller than in CD-ROM (1.1 μm and 0.74 μm respectively) and, therefore, the storage capacity is much higher (figure 3-15).

In addition to the work presented by Cartwright (1999a), some novel mediums have been developed. Since then, the optical storage technology has evolved and two new formats have been seen:

- **Blu-ray Disc or BD:** Developed by the Blu-Ray Founders Group, a group of companies that comprises Hitachi, LG, Matsushita, Pioneer, Philips, Samsung, Sharp, Sony, Thomson, and Mitsubishi. Dell and HP are two corporations that recently announced their support to the initiative. In this medium, data are read by a bean of blue laser, which has a smaller wavelength (405 nm – nanometre – for blue laser against 650 nm for red laser). Smaller wavelength means that data can be engraved closer in the disc's surface. This product is already in the market and can storage up to 27 GB of data(Milster 2005).
- **High Definition DVD or HD DVD:** This format was previously known as the AOD (Advanced Optical Disk), and was developed by NC and Toshiba. Similarly to BD it works with blue laser, however, differently from BD it "*requires the least optical system development of the new optical disc technologies. Decoder chips and system architecture are necessary, but no alterations to the basic DVD optical system are required.*" (Milster 2005, p. 31). This specification is not yet commercially available and its storage capacity can achieve 49 GB.

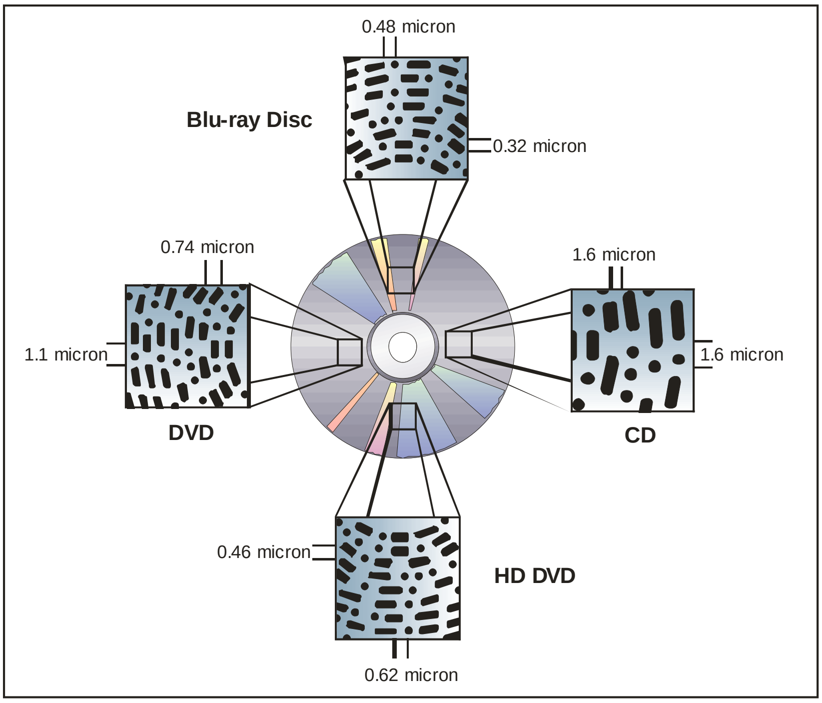


Figure 3-15. Comparison of storage systems amongst CD, DVD, HD DVD and *Blu-ray* disc.
Source: Ramos (2005, p. 125) and Milster (2005).

3.7.2 Networked Cartography

Computer networks have emerged as an important communication medium in the second half of the 20th century, but the most recent innovation that has changed the way in which people communicate is the Internet. The Internet, a global network of computers, initially targeted academic and military audiences. However, in the early nineties a series of developments, from the rise of the World Wide Web to the beginning of commercial Internet access, have sparked a communication revolution that swept the world (Peterson 1997; 2003).

Nowadays the Internet has become not only a major source of information, but it is also changing reading habits. According to a recent research undertaken by Nielsen/NetRatings (2005) 21% of Internet users that read newspapers have moved to online versions of newspapers as their primarily source of information. On the other hand, 72% of Internet users that read newspapers remained loyal to printed versions and 7% split their preference between online and printed reading.

In a similar fashion, the Internet has changed the way people access maps. Therefore, the Internet has increasingly become a medium for publishing cartography. The growth of the Internet as well as Internet map use is object of analysis in Chapter four. According to Peterson (2005) research on cartography on the Internet started in 1995. After ten years of research he identified Internet map use, Internet map delivery, Internet Multimedia Mapping and Internet Mobile Mapping as the main research interests in the field.

The following chapter, Maps on the Internet, focuses on the development of the Internet. The chapter also focuses on different concepts and technologies for publishing maps and analyses them in detail explaining the choices for appropriate delivery mechanisms to support this research.

3.8 Architecture of Information

The production of atlases, despite the medium chosen, involves a plethora of choices. The audience is one of the fist choices that have to be done. Other choices include subjects to be explored, level of detail, the scale of maps, and so forth. It is not the focus of this research to discuss these stages of atlas production in detail, for more information regarding atlas production the reader is advised to refer to Keates (1989). The production of digital atlases, however, involves additional stages that will be explored in more detail.

Borchert (1999) identified different concepts related to the production of multimedia atlases, they encompass:

- General Concepts: they include the choice of contents, target audience and purpose of the atlas. The issues involved here are related to the geographic coverage, thematic contents and narrative chosen.
- Production: the need for a team of specialised staff in multimedia production is required. This need was also emphasised by Cartwright (1996). Other aspects involved in this stage are the choice of metaphors to be employed within the atlas, the storage media, user computer platform, the graphical user interface and the tools used to develop the product.
- Media: multimedia atlases can comprise not only static maps, but also cartographic animations, map with interactive composition of layer and pan and zooming functionalities.

- Information Retrieval: Borchert (1999) identified four different forms of information retrieval within multimedia atlases:
  - *Closed Multimedia* is seen as a multimedia atlas created within an multimedia authoring environment, with media links and user access controlled by the producer;
  - *Database Multimedia* associates the multimedia atlas application to a database. Borchert (1999) argued that the user usually does not perceive the difference in the information retrieval between database driven and closed multimedia atlases.
  - *Extended Database Multimedia Atlas* is the kind of atlas where the user is provided direct access to the dataset, not using the map as an interface.
  - *Extended Database Multimedia Atlas with Mapping Module* is the type of multimedia atlas where a dataset with geometry is associated to dataset of attribute data, with the use of mapping objects the user can produce their own maps.
- Map Interaction: Borchert (1999) identified different kinds of user-map interaction:
  - *Customised maps*: maps that can be adapted to user's demands, such as changes of colour scheme; number or range of classes in coropleth maps; changes of scale both in display and in level of information depicted;
  - *Hypermedia maps*: maps that provide hyperlinks either within the map page; within the atlas application (an attribute being displayed after the click of the mouse in a particular feature of the map for instance) and links external to the atlas, that will connect particular features of the map to external applications and/or Web sites;
  - *Cartometric abilities*: tools that allow the user to perform measurements such as area and distance within the map; and
  - *Analysing functions*: corresponds to the use of GIS functions within the multimedia atlas environment, which allows the inclusion of more extensive analytical capabilities.

3.9 Chapter Summary

This chapter summarised concepts in multimedia atlas production. The goal here was to provide background information for the reader to understand future choices made within the development stage of this research.

The chapter covered theoretical concepts such as geovisualisation. Geovisualisation is believed to be the starting point of any project aiming to produce a digital atlas, particularly with educational purposes because, as seen in the definitions provided, geovisualisation is to use of digital techniques to enhance humans understanding of the geographical space. A brief history of research in geovisualisation was provided as well as a summary of the new research trends in the field, amongst them cognitive aspects of visualisation tool use.

Another concept related to the production of digital atlases is the concept of hypermaps. Hypermaps were first described in the late 1980s and comprise the concept of the map as an interactive interface to other contents that could include more detailed maps, data tables and multimedia features. Hypermaps can be implemented using simple HTML image map functions, they can also be GIS driven. The choice of the kind of hypermap to be used in a digital atlas depends upon the kind of information available and the resources available (including human resources).

Interface metaphors were also object of analysis in this chapter. Interaction is a key component in a digital atlas and interaction, as seen in this chapter, is implemented through interface design. Two different kinds of metaphors that could be applied to digital atlases were described: graphical and conceptual metaphors. Graphical metaphors were described as metaphorical interface elements that are included in the interface design to imply a particular action; a button for instance invites the user to click on it. Conceptual metaphors, as seen in the chapter, are metaphors employed in the whole application design. In this way they are more related to the architecture of information within the digital atlas application.

Cartographic animation was another concept analysed in detail. Cartographic animations are considered to be a valuable tool for education and therefore they are considered highly beneficial in digital atlases. The use of animations in atlases, however, is more likely to be applied to atlases conceived directly for digital publishing. That is not the case covered in this research because the methodology proposed here is based on paper atlases. Nevertheless cartographic animations were included in this chapter because it is believed that future atlases developed for the Web would benefit from using cartographic animations as a tool for spatial cognition.

Two different distribution medium for digital atlases were analysed in this chapter. Discrete medium, mainly optical storage devices such as CD, DVD and new DVD formats such as Blu-ray Discs and HD DVDs were discussed. The Internet is another important medium for digital atlases, chapter four focuses specifically on Internet Cartography.

To conclude, the chapter aimed to pack up the concepts focusing on the architecture of an atlas application, describing different possibilities of development with regards map interaction, media and information retrieval.

This chapter aimed to encompass an amalgamation of tools and concepts that are applied when producing a digital atlas product. Concepts related theoretical foundations, to the production of multimedia-based applications and delivery medium were depicted in this chapter.

The next chapter focuses specifically on the delivery medium chosen within the scope of this research, the Internet, its evolving history and structure. The next chapter also describes technologies for delivering maps on the Web, considering the target audience of this research, Brazilian school atlas developers. The chapter also illustrates the technologies used in this research.

4 Maps on the Internet

4.1 Chapter Overview

Nowadays maps are immediately available to the general public, in weather forecasts on television or newspapers, locating issues in a geographical context. Maps are omnipresent. Sometimes they are very accurate and rich in information, sometimes not. However it is obvious that geographical knowledge, and particularly geographical knowledge via maps, has become more and more a part of everyday life.

This chapter begins by analysing the development of the Internet and the growing Internet audience worldwide and particularly in Brazil. Moreover it analyses selected technologies for publishing static and interactive Web maps.

Then, the focus moves to the analysis of the present state of the art in research in cartography for children and related digital map publishing in Brazil, focusing attention on the present state of atlas development for Internet publication. Aspects such as information structure, themes, media and technologies employed are illustrated by the analysis of selected Internet atlases.

Understanding the concepts related to World Wide Web (Web) atlases production, as well as reflecting on the evolving cartographic tools being provided for children via the Internet provides information for further analysis this was done in order to gauge the potential of using the Web for providing spatial information, in the form of an atlas, for teaching geography.

It is believed that the best opportunity to introduce cartographic literacy is in the school, particularly in the primary school. According to Almeida (1995, p. 2114), "*schools should prepare students to comprehend, historically, the spatial organization of a society and to know the techniques and necessary instruments for elaboration of graphical images which represent it*". In a study, Almeida (*op cit*) developed a methodological proposal for teaching geographical concepts by using maps following three principles: using three-dimensional models; solving proposed problems; and fostering active participation of students. To summarise, the main idea was to foster interactivity using map products. Interactivity is considered to be one of the basic elements in the teaching-learning process.

Recent research in Brazil has focused on developing municipal school atlases with an underlying idea to teach geographic concepts by using student's reality (Almeida 2005). In other words, it is believed that if students are able to understand their 'near' space, they will be more likely to understand more complex and abstract geographical concepts. Conversely, the technological advances represented by the introduction of computers in the cartographic production process, and more recently in the distribution process, have changed the way that cartography is developed and published. As a result, electronic atlases are a new reality and there are many examples of electronic atlases: as discrete media resources; and on the Internet. This chapter also focuses on the analysis of the structure of some atlases used for educational purposes. This analysis will provide insight into the present state of the art of digital atlases production and will provide foundation for the basics of a Web as alternative publishing media for local school atlases. In chapter five guidelines for developing school atlases on the Internet for teaching geography to Brazilian primary school children are proposed in order to provide generic 'templates' which can be used to establish any Internet-delivered atlas for early geographical education applications in Brazil.

4.2 Delivery medium: the Internet

Computers were initially conceived and developed to operate as isolated calculating devices. However, in the 1960s a revolution began to change the way computers were used, from isolated devices to a medium for communicating and linking people (Abbate 1999). As a result, it has irreversibly changed society as a whole.

The computer network that began the Internet was ARPANET (Advanced Research Projects Agency Network), developed by the ARPA (Advanced Research Projects Agency), sponsored by the Department of Defence of the United States of America. Its initial purpose included the need to link strategic centres of research and military facilities in case of a national emergency. The great technological innovation introduced with the ARPANET was packet switching, a way of communicating data via networks where packets of data are separated and individually directed throughout the network, via nodes that can be shared.

Initially the NCP (Network Control Program) was used as the communication protocol within the network. In 1983 the TCP/IP (Transmission Control Protocol/Internet Protocol) replaced the NCP and can be considered to be the beginnings of the Internet.

However, as emphasised by Abbate (1999, p. 113) "*the Internet was not part of ARPA's initial networking plans. The Internet represented a new approach to networking, and its creation was prompted by a series of unforeseen events*".

For being initially a government funded initiative, ARPANET targeted mainly research centres and the military. By the mid-1980s there was a growing number of linked networks and educational users and the National Science Foundation (NSF) became involved in the project. By the late 1980s ARPANET was closed and the NSF took over the task of managing the Internet. This in fact transferred the control of the network from the military to a civilian agency.

By the early 1990s there was active debate in the network community as to whether the Internet should or should not be open to commercial access. As the NSF was still a government foundation, the original purpose of the Internet, to be a non-profit tool for research and education, was maintained. However, with the introduction of private backbones and Internet providers around 1994, commercial access to the Internet was available and the Internet audience began to grow exponentially.

Parallel to the evolution of both the infrastructure and control of the network that happened during the 1980s and early 1990s, other revolutions took place within the Internet itself. The most remarkable innovation was the advent of the World Wide Web, or simply the Web.

The Web was developed in 1989 by Tim Berners-Lee (Peterson 1997), whilst working for the European Organization for Nuclear Research (CERN) in Geneva, Switzerland. The idea of the Web was to apply the principle of hypertext. Berners-Lee developed a system based in pages linked together in a hypertextual manner (Peterson 1997). The resources available on the Internet, or Web pages could be accessed via a single software, the Web Browser. Additionally, the Web was conceived as a non-proprietary medium, in other words, new pages and Web servers could be added to the Web with no fees charged. In 1993 the Web was made available for public use.

Also in 1993 the National Center for Supercomputing Applications (NCSA), associated with the University of Illinoins, United States of America, released the first graphical Web Browser, the *Mosaic*. *Mosaic* became quickly widespread, however, by mid-1990s it was overtaken by two major browsers, the *Internet Explorer* (by Microsoft) and the *Netscape Navigator* (by Netscape Communications Corporation).

The exponential global growth of the World Wide Web during the 1990s has had a major impact to society - in the way people accessed information; in decision making; and, the topic of this research, in the way maps are conceived, developed and distributed.

4.3 Information Society: Internet audience and Internet map audience

Throughout human history information has been controlled by few, so knowledge could be manipulated, examples are the medieval libraries with very restrict access or maps from the renascence, restricting access to the information contained in those sources, at the time, was considered crucial to maintain the *status quo* (Chartier 1999). However, the Internet changed the way society accesses information. Information technology has broken the few-to-many structure of traditional communication methods, making information sources directly available to the user. This New Media delivery mechanism has affected several aspects of life, including education.

Commercial access to the Internet expanded greatly by the mid-1990s. The network, initially conceived mainly as a medium to link research centres and educational institutions, sparkled an information revolution that swept the globe. With the popularisation of the Internet, as well as other communication technologies such as mobile phones, PDAs, to recent advances in portable devices such as Play Station Portable and other devices that combine functions as mobile phones and portable computers with the ability to deliver digital television and audio. The introduction of these technologies irreversibly changed society: from information-rich society to actual information-dominated society (Kellerman 2002). As a result the concept of information society has emerged.

The information society can be seen through two different aspects: economic and cultural. Considering economic aspects, information itself is the most important commodity in the information society. Culturally, it is a society where there are continuous and increasing conditions for flourish ideas, human creativity and intellectuality (Kellerman 2002).

Webster (1999, p. 151) summarised the importance of information as a commodity in the information society as follows:

> "*Information is coming to occupy center stage as the key strategic resource on which the organization of the world economy is dependent. The modern world demands the coordination of globally distributed manufacture, planning across and between sovereign states, and marketing throughout continents. Information is axial to these diverse activities and, thus, is of heightened importance in the contemporary world*."

According to Castells (1999) the information society has emerged from a fusion of independent processes. The first was the Information Technology Revolution, intensified in the 1970s. The restructuring of capitalism took place during the 1980s and a myriad of social and cultural movements have flourished throughout the world, particularly post-1960s.

Kellerman (2002) identified three different phases within the emergence of the information society (figure 4-1).

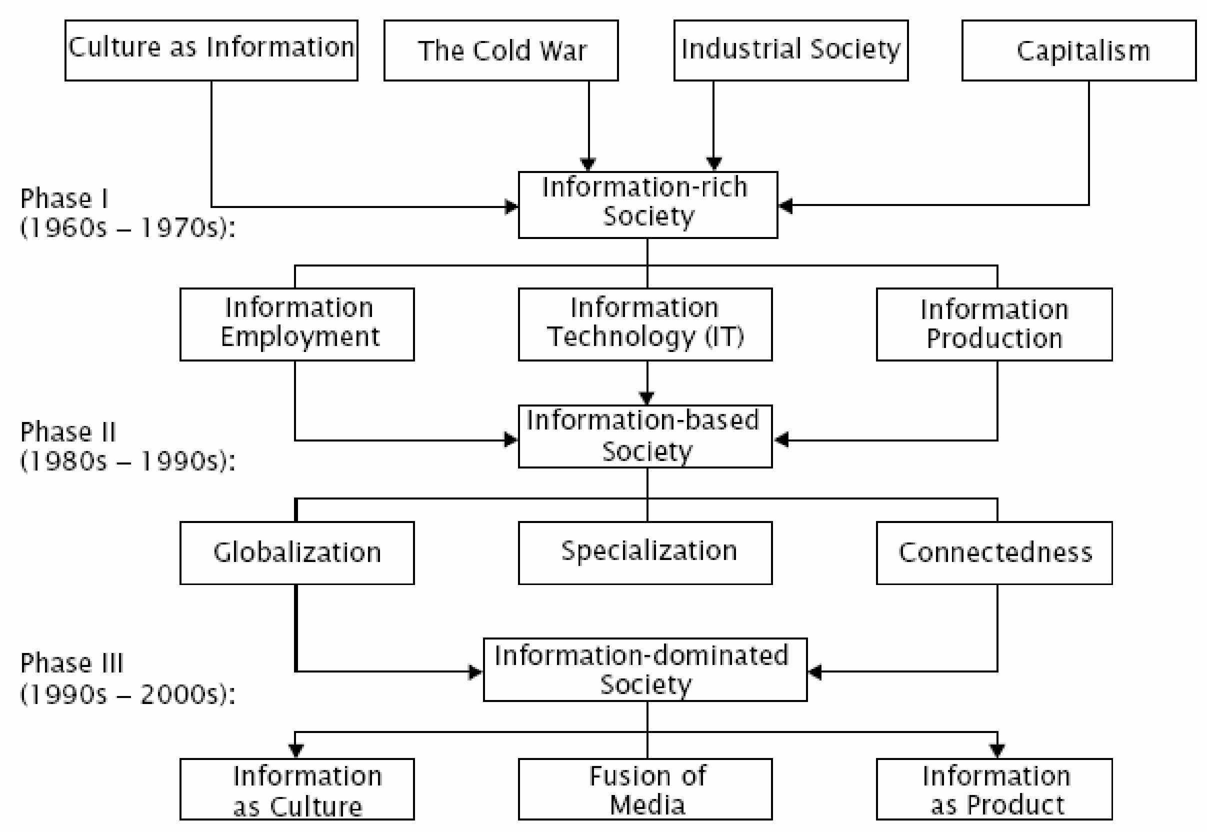


Figure 4-1. Three stages of the development of the information society. (Copied from Kellerman, 2002, p. 11).

Stage one happened during the 1960s and 1970s. This stage is called 'information rich society'. Here the fusion of cultural changes and historical processes together with the introduction of new technologies of information, led to the growth in information production, accompanied by growth in research in academic institutions.

The second phase is 'information based-society'. This stage lasted from the 1980s to the 1990s. It was characterised by the growth in information volume, technological improvements and a wider employment of technology in everyday life. New information devices such as mobile phones, desktop and laptop computers and fax machines were quickly disseminated and adopted.

Additionally, developments in international telephony, commercial access to the Internet and the popularisation of cable and satellite television led to an increased *connectivity*. Connectivity means that people in general are increasingly connected to an information service and/or information device, wether via television, the Internet, or the mobile phone.

The third phase identified by Kellerman (2002) is the ‘information-dominated society’. This is the present stage of development of the information society. Kellerman (2002) argued that at this stage information production, transmission and use have become one of the (or maybe *the*) core economic and social activity in society. Kellerman (2002) also highlighted that this stage of development is characterised not only by information being a major commodity, but also by the fusion of information media.

Media fusion happens when one device can attain different capabilities, like a PDA (Portable Digital Assistant) operating as well as a mobile phone and connecting to the Internet. This also happens when one company provides different communication systems like mobile phones, fixed phone lines, Internet connection and cable television. There are many examples of such companies, in Brazil the telecommunications company Telefonica provides Internet access as well as mobile and fixes telephone lines, the television giant Rede Globo also provides Internet access and it hosts a busy Information Portal in Brazil; in Australia partnerships between Internet and television companies have happened recently, examples are the partnership between Channel Seven and Yahoo and Channel Nine and MSN.

The growing importance of the Internet in the information society can be seen by the Internet audience figures. Figure 4-2 shows the growing worldwide Internet audience from 1990 to 2002 (in millions).

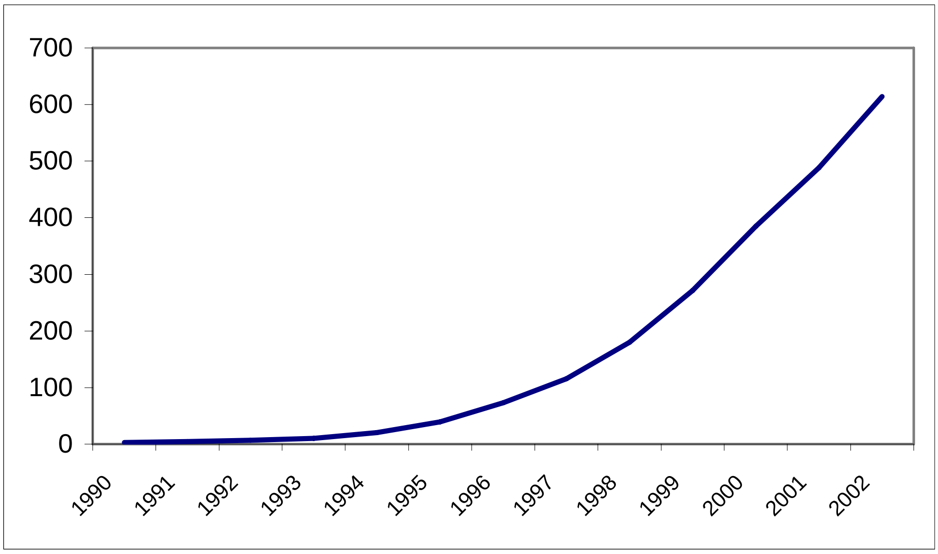


Figure 4-2. Worldwide Internet audience, 1990 to 2002, in millions.

Source: United Nations Statistics Division, 2005.

Considering the world's population with Internet access, the growth of the Internet seems to be even more significant. Figure 4-3 portraits the percentage of world's population with Internet access.

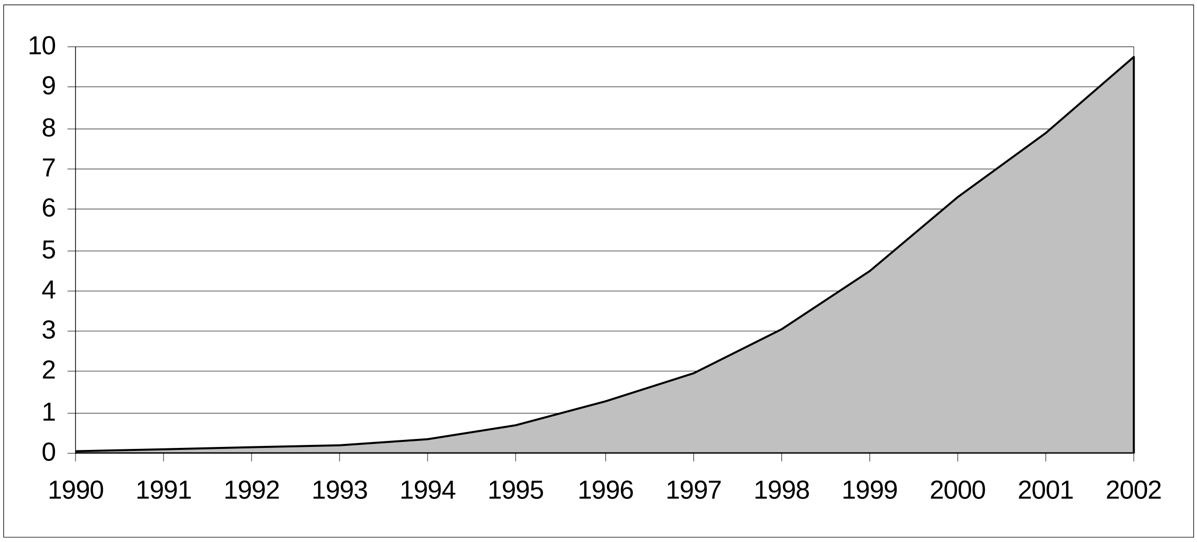


Figure 4-3. Percentage of world's population with Internet access (1990 – 2002).
Source: United Nations Statistics Division and Ibiblio (2005).

As shown in figure 4-3, in 1990 the Internet reached 0.05% of world's population, twelve years later, in 2002, 9.75% of world's population had access to the Internet. Moreover, the ClickZ Network (2005a) provides some additional figures about global Internet audience. According to that source the worldwide Internet audience in 2004 was 934 million (14.4% of world's population), the Web site provides projections for 2005, 1.07 billion Internet users corresponding to 16.26% of global population. In 2006 the Web site indicates a universe of 1.21 billion of Internet users (18.12% of world's population) and it estimates for 2007 an Internet population of 1.35 billion, 19.93% of world's predicted population.

The same trend in Internet audience was seen in Brazil during the same period. Reviewing data available in the United Nations Statistics Division (2005) the growth in Internet audience figures in Brazil was very significant. The first official figure of Internet audience in Brazil was available for 1991, when it was noted that there was about five thousand Internet users in the country. During the following three years (1992 to 1994) the Internet audience continued to grow steadily, from twenty thousand users in 1992 to forty thousand in 1993 and sixty thousand in 1994.

In 1995 the beginning of commercial access to the Internet was reflected in the audience figures, in 1995 the Internet audience jumped to one hundred and seventy thousand users. In 1996 the growth was even more significant, with the Brazilian Internet audience reaching seven hundred and forty thousand users. In the following two years the audience nearly doubled yearly, reaching two and a half million users in 1998. By 2000 the Internet audience in Brazil reached five million users and in 2002 (the last year available in the United Nations Statistics Division) the Internet population in Brazil had reached fourteen million and three hundred thousand users (figure 4-4).

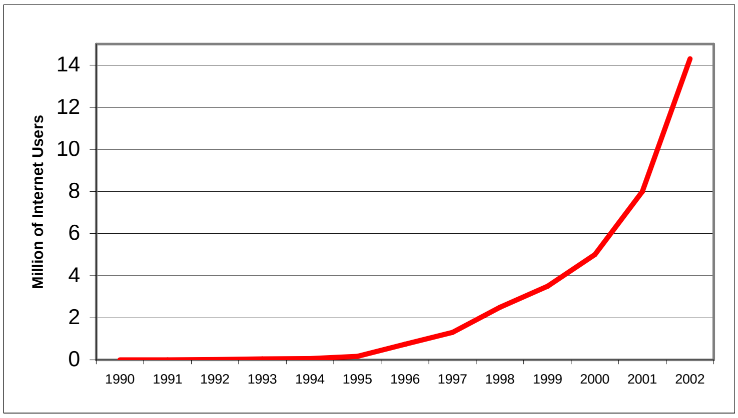


Figure 4-4. Brazilian Internet audience, in millions (1990 – 2002).

Source: United Nations Statistics Division, 2005.

According to the online research group Nielsen/Netratings (2006) the estimated Brazilian Internet population reached 18.3 million users in July, 2005 and 20 million users by January 2006. In addition, the number of Brazilian domains registered increased remarkably from 1996 to 2005; in 1996 42 thousand Internet domains registered in Brazil, by the end of 2005 there was 8.1 million Brazilian Internet domains registered (figure 4-5).

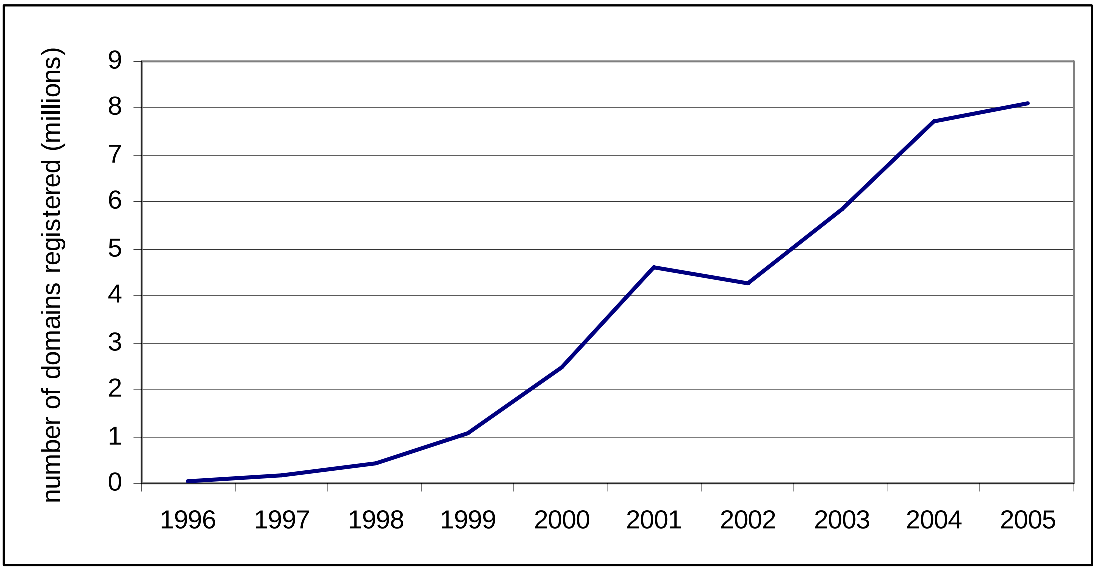


Figure 4-5. Brazilian Domains registered, in millions (CGI 2006).

Source: Comitê Gestor da Internet, CGI (2006).

However, the Internet audience is not necessarily the Internet map audience. Peterson (2003) provided an insight on Internet map usage. Peterson argued that growth in the number of maps distributed through the Internet can be appreciated by reviewing four major Web sites (Mapquest, Fourmilab, Xerox Parc and the US Census). However different Web map providers have their own Web access statistics. Figures provided by Peterson (2001) show how sharply the number of Web delivered maps increased between 1997 to 2001 (Table 4-1).

Site	1997	1999	2001
www.mapquest.com	700,000	5,000,000	20,000,000*
www.fourmilab.ch	35,000	63,000	219,000
pubWeb.parc.xerox.com	80,000	100,000	120,000
http://tiger.census.gov	35,000	70,000	100,000
Total	850,000	5,233,000	20,439,000

* Refers to information obtained by personal communication.

Table 4-1. Number of maps downloaded in some commercial Web sites, on a daily basis (Source: Peterson 2001, p. 2310)

The strong increase of maps downloaded from the Web sites listed in 4-1 illustrates the growing trend of using the World Wide Web to publish maps. In addition, it can be argued that as the world's Internet audience increases, the number of Web maps distributed should increase as well. As stated previously, the academic community also realised the importance of the Internet as a delivery medium for cartography.

This can be verified by the figures provided in table 2-2, in Chapter 2 section 2.5 (page 20). The table demonstrates the growing number of papers focusing on digital atlas publishing available in proceedings of International Cartographic Conferences, organised by the International Cartographic Association.

Nevertheless, the figures on provided Internet map usage do not give insight in a particular trend in Internet access that has been identified recently (Peterson 2005). The growing number of users that access the Internet from mobile devices. Peterson (2005) highlighted that in 2003 about 16% of Web users connected the Internet via mobile devices, in 2004 it was predicted that the number would be 42% and 57% in 2007. However Peterson emphasised that these users were likely to be also connected to the Internet by wired devices.

4.4 Publishing cartography on the Internet

The Internet is a democratic medium. This statement is also valid when it is used to describe Internet cartography. Internet maps not only reach a wider audience, but the Internet also allows virtually anyone to publish maps. There are different methods for publishing maps on the Internet, from simple image maps that do not require extensive technical knowledge, to Web GIS and 3D applications, where more technical knowledge is required.

Kraak (2001a) identified four main 'actors' that influence on the design of Web maps: the user, the provider, the environment and the map content. As emphasised by the Kraak, these actor are not exclusive to the Internet, and there are specific questions to be considered when using the Internet. These are:

- **The user.** The whole purpose of a Web map (as any other map) is to deliver information to the user. The choice of the target public of the Web map is crucial to determine the content, the use environment and the information architecture to be employed. The interface design is another important aspect to be considered related to the target audience. As interface designed for a juvenile audience would be different to an interface designed for adults. Similarly, an interface designed for a government Web site would be different to another designed for entertainment. As highlighted in Chapter 3, section

3.2, user interaction and usability issues have increasingly become a major focus of research on the Commission in Visualisation and Virtual Environments of the International Cartographic Association.

- **The provider.** As emphasised by Kraak (2001a), the Internet map user usually expects to have the information (here, the map) delivered within a very short period of time. In order to prevent delays, the developer has to conceive the map as effectively as possible, avoiding heavy graphics that would make the files larger. This places some additional challenges on the map developer. However, the digital medium can provide some useful tools to overcome what could be initially seen as a disadvantage when using digital media. For example, the developer could hide information that would be downloaded from the server by a mouse click, if the user chooses so, or information could be revealed when the user passes the mouse over a particular feature of the map. The map can also be moved on the screen and whenever the user wants to see an adjacent area of the map view they pan the map on the screen, sending a request to the server to provide the additional map view needed.
- **The environment.** The environment in which the Web map is displayed is another aspect to be considered by the developer. There are different browsers that will show the map in slightly different ways. Frequently the map developer uses a particular technology that demands a plug-in to display the map. However, in many instances the user may not be allowed, or even is willing, to install any new software onto their computer. Another aspect to be considered is that sometimes the client computer does not allow cookies or pop-up windows. The latter are particularly useful when providing further information on a mouse click, rather than loading additional information into the main map window the provider can open a smaller, additional window to display the information requested. Nevertheless, pop-ups are extensively used to deliver unwanted (and frequently inappropriate) advertising. As a result many users simply block pop-up windows in their Web browsers.
- **The contents.** The contents of the map are determined by considering the previous actors. Knowledge of the targeted audience of the map is crucial establish the level of detail to be employed. The technology to be used will

depend on the platform adopted in the client computer; depending on the purpose of the map and the type of Internet connection available in the client computer, the contents could include not only alphanumerical data but also multimedia capabilities, including audio, video, animations and sound.

Kraak (2001a) also established a framework for publishing maps on the Web. According to him, Web maps can be classified according to their level of interactivity, therefore they are divided into two groups: static maps and dynamic maps. These groups are further subdivided into view-only and interactive interface and/or contents.

As highlighted in the Chapter 2 (section 2.8), there are other ways of classifying Web maps. Considering the architecture of the application, it can be client-side or server-side. The client-server architecture is a way of delivering information. Gralla (1999, p. 41) explained the client-server architecture as follows:

> "*In this model, a client computer connects to a server computer on which information resides; the client depends on the server to deliver information. In effect, the client requests the services of a larger computer. These services may involve searching for information and sending it back to the client.*"

Because the connection between the client and server computer is maintained only during the time they are actually exchanging information, the connection is broken when the exchange is finished.

Client-side maps are those designed to run in the client computer, in other words the map is sent to the client computer and runs there, independent from the server. Using this type of map, where the processing is done client-side, network congestion is avoided. Therefore, this kind of map is preferred when the client computer Internet connection is slower, perhaps with a dial-up connection. Client-side maps can be heavier (the file size can be larger) than server-side maps, because in this kind of architecture the developer has to provide the maximum information and interactive functionalities within the same file. Once it is loaded into the client computer it runs there, no other connection will be established with the server, unless the user requests another map or decides to reload the same map. Client-side maps can be either static or interactive.

Server-side maps are the opposite. They are generated on-demand. The Web server has the data and tools necessary to generate maps, but the map itself does not exist, rather it is dynamically generated according to the user's requests. In this type of architecture the client computer will send a request to the server that will query the datasets and subsequently generate the map to be sent to the client. If the client requires further information, another request is sent to the server and another map is generated and returned. This type of architecture is preferred when the application needs to provide a greater freedom to the user in terms of querying a dataset. This is also recommended that when the network connection is not an issue and the user is likely to have a faster broadband connection. Server-side maps can be smaller than their client-side counterparts, because additional information or interactive tools other than the ones requested are not needed. Similar to client-side maps, server-side maps can be either interactive or static.

When considering technology as a concept for classifying Web maps, two general categories could be identified: maps based on proprietary technology and maps based in open standards technologies. This can be further subdivided into two categories: maps created using geotechnologies (for example, technologies related to the Open Geospatial Consortium), and maps constructed using standard technologies (technologies that do not have as their main purpose to generate maps or any spatial products).

Proprietary technology is understood to be the type of technology owned by a company and/or individual, therefore the Web map developer has to purchase a developer package (Whatis 2006). Examples of this type of application are abundant. For example, Web GIS applications such as *ARC IMS* (ESRI), *GeoMedia* Web*Map* (Integraph), etc. However, there are other proprietary applications not designed for Web map publishing, although they can be used with this purpose. The most popular example here is *Flash* (Macromedia).

Open standard technologies can be used free-of-charge. Additionally their source code is open, therefore anyone can open the code that generated the map product and use it as a basis for developing their own product. Open Source relies on the very nature of the Web and the Internet itself. It is developed and maintained by an open forum for those interested in learning and adding new contents to it. HTML (HyperText Markup Language) is the most remarkable example of this kind of technology.

The purpose of this research, as stated previously, is to propose an open standard solution for publishing Brazilian local school atlases on the Web. In this context, one of the main issues to be considering is the cost of using such solution. A number of factors can influence the cost of developing a Web-based atlas; among them are the scope of the project, data availability and the development package to be used. Considering this last factor, table 4-2 compares cost-related issues between an open standard technology, SVG, and a similar proprietary software, *Flash* (Macromedia).

Factor	***SVG***	***Flash***
Ownership	There are no direct costs related to using SVG	As a proprietary software, there is a licence cost
Learning	There are numerous user discussion groups and Web tutorials available. Because SVG is code-based, its learning time could be slower than Flash for unexperienced developers.	The user can rely on software documentation. Learning its in-built programming language, ActionScript, can be harder for unexperienced programmers
Compatibility	For being a relatively new standard, it is believed that the majority of Internet user never had contact with SVG files.	*Flash* has been widely adopted for a number of years and, therefore, most Internet users already have the necessary *Flash* player plug-in installed.
Support	Developers have to rely on SVG discussion groups and other online resources such as http://tech.groups.yahoo.com/group/svg-developers/ and http://www.wdvl.com/Authoring/Languages/XML/SVG/ for assistance.	Macromedia Website provides extensive documentation and communication with support team
Development Environment	Text-based	Graphic User Interface

Table 4-2. Cost-related issues between AVG and *Flash* (Macromedia).

Open Source and Open Standard technologies are the focus of the next section in this chapter.

4.5 Open standard technologies and their application to Web cartography

Standards can be understood as a "*Document, established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context*" (European Committee for Standardization 2004). Standards are necessary in any kind of activity and they are most valuable in computing. However, Neumann and Winter (2000) stressed that "*within the Internet we are only able to speak of a 'Standard', if a majority of companies accepts (applies) a technology, which is actually used by viewers and editors of Web sites*". Neumann and Winter argued that there are basically two types of standards: *de facto* and *de jure* (Neumann and Winter 2003). *De facto* standards are considered to be those developed and implemented by sectors of the industry, which became widely used. *De jure* standards are those developed and validated by a cross-industry organization or consortium.

Open standards can be defined as standards established by a public body (comprised by members of industry and/or public sectors) with the purpose of providing guidelines for their field of activity. By definition open standards are not proprietary, in other words, they do not belong to any individual or company (Standardization 2004).

According to Perens (2004) open standards should follow a number of principles to be considered *open*. Peren's principles can be summarised as follows:

- **Availability:** open standards should be always available to anyone;
- **Maximise end-user choice**: the user should not be restricted to a particular product but rather there should be a number o applications available in the market using an open standard;
- **No royalty**: open standards must be free to implement;
- **No discrimination**: standard organizations should not give preference to one particular implementer;
- **Predatory practices:** standard certification organizations should take action in order to avoid the use of predatory practices, which would undermine the fairness of open standards.

The issue of open standards is not new for those who are engaged in digital cartography. The 'Open Source' movement rose as a collective response to the technological companies, software's owners, which dominated the market for years.

According to the Open Source Initiative (2004), to be considered Open Source the product or application has to address a number of requirements that include:

- **Free redistribution**, the product should be available free of charge. It could be incorporated to other products/programs whether free or commercial, with no restrictions;
- **Open Source code**, the source code of the application should be available as well as the compiled version. In this way, changes could be made to the original code and, therefore, the user should be able to adapt the code to their own needs. Nevertheless, the user should respect the original code and distribute derived code under a diverse name or version number; and
- **Derived works**, the user should be able to produce and distribute derived works from the Open Source application/product.

Technologies integrated in the Open Source movement include the *Linux* operation system and *Apache* Web server. The main concept in this kind of technology is that the source code is available to anyone to freely improve it.

Open Standards and Open Source technologies are important for cartography because they not only allow free communication between different systems and data sharing, but they also provide tools for developing and distributing cartographic applications at relatively low cost.

Several organizations develop different standards that are related to cartography. The Open GIS Consortium (http://opensourcegis.org), for instance, lists a series of spatially-based applications developed under the umbrella of open standards philosophy. Some examples available in the Web site are *Spring*, a GIS and remote sensing application developed by the Brazilian Institute of Spatial Research (INPE); and GeoVRML, a technology for publishing three-dimensional geographic information.

The World Wide Web Consortium (W3C) develops and regulates standards for publishing on the Internet. XML (an acronym for eXtensible Markup Language) is a remarkable example of non-proprietary technology validated by the World Wide Web Consortium (W3C). This language is based on the Standard Generalized Markup Language (SGML), a standard developed by the International Standards Organization (ISO). XML aims to provide guidelines for exchanging data via the Internet. XML is the basis of a series of other standards with different purposes; one of them is the Scalable Vector Graphics (SVG) a vector-based technology for publishing graphics on the Web.

For being open standard and vector-based SVG is a powerful and flexible way of publishing interactive cartography on the Web. However, there are many solutions for Internet map publishing, involving both open standards, open source and proprietary technologies. Some examples of using open source technologies are described in the later sections.

4.6 Static Web map publishing

Static maps are still the most common way of publishing maps on the Internet (Peterson 2003). Static maps consist usually of raster images embedded into HTML documents. The most common raster formats on the Web are GIF (Graphics Interchange Format), JPG (Joint Photographic Experts Group) and PNG (Portable Network Graphics).

Usually, this type of map image is nothing but an illustration that accompanies text. No interactivity is provided, therefore the user cannot zoom in or out, pan, make queries, and so forth. Similarly, clicking in different parts of the map will not result in any specific action. The map is simply an image displayed by the Web browser. Sample Code 1 shows an example of static raster map embedded into an HTML document.

Sample Code 1. A raster map embedded into HTML.

```
<html>
        <head>
                <title>Example of Image Map</title>
        </head>

        <body>
                <img src="brasil.gif" width="170" height="223" border="0" usemap="#Map">
        </body>
</html>
```

Another popular way of publishing static maps on the Web is through the use of PDF (Portable Document Format) files. PDF is a widely adopted standard developed by Adobe Systems. PDF files are platform and software independent, which means that they can be opened, read and printed in an external application using a PDF reader. PDF files can contain either raster or vector graphics and text, they can also contain forms for input by the user.

Figure 4-6 compares the same map published in raster format (on the left) and in PDF format (on the right) rendered in a Web browser.

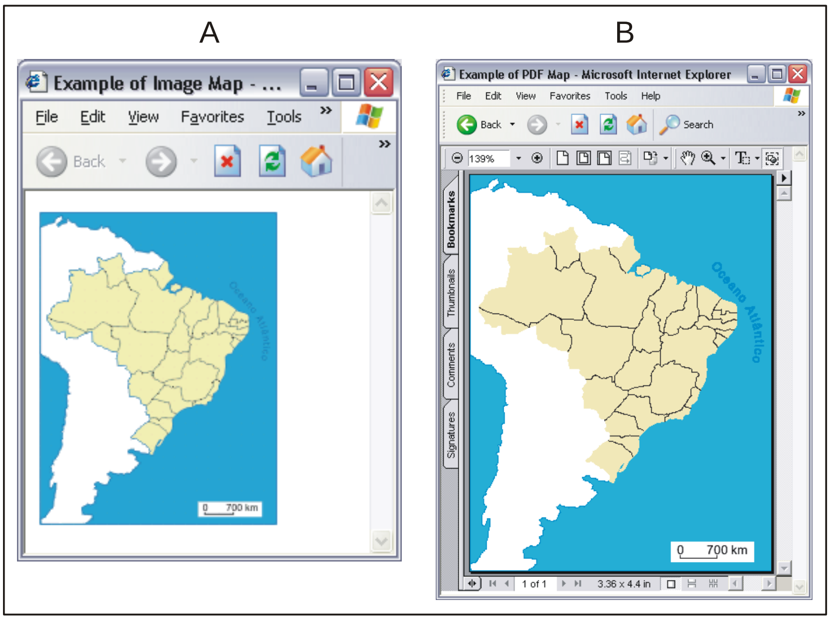


Figure 4-6. Static maps viewed in Internet Explorer.

Figure 4-6A shows how the code provided in Sample Code 1 is rendered in *Internet Explorer* (Microsoft). In this example the map is static. Figure 4-6B shows the same map rendered in *Internet Explorer*, however here the map is not a raster image but a PDF file. The Adobe PDF viewer plug-in allows a certain level of interactivity. Some well known metaphors are used in the plug-in interface such as the magnifying glass (zoom) and hand (pan). The idea is to engage the user to these simple metaphors and to invite them to explore the document.

Peterson (2003) highlighted the difference between both formats (raster image and PDF files) when enlarging maps. Figure 4-7A shows a magnified view of Sao Paulo State in the raster map. In this example the pixels that form the image are visible. The more enlarged the image is the more apparent the pixel structure will be.

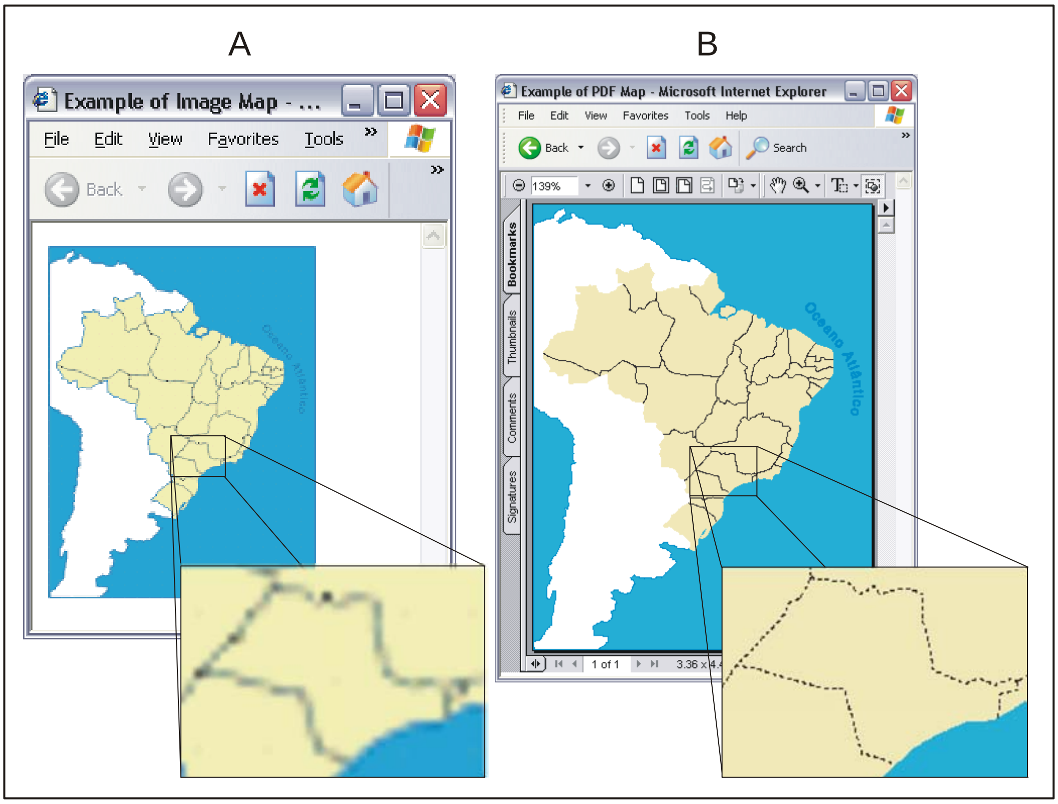


Figure 4-7. Enlarged views of raster and PDF maps.

Figure 4-7B shows an enlargement of Sao Paulo State as a PDF map. Here the original vector map was exported as a PDF file. Therefore the map can be enlarged with no risk of loss of detail. The same enlarged section of the map of Brazil is rendered in higher quality in map 4-7B than map 4-7A.

4.7 Interactive Web map publishing

Static maps can be easily published on the Web with no need for further technologies or any extensive technical knowledge required. However, the Internet as a digital medium offers interactive options that allow the user not only to interact with the map itself, but also to access the dataset used to generate the map. Additionally multimedia capabilities can be incorporated into the digital map product, as described in chapter 3.

There are different ways of publishing interactive cartography on the Web and this section analyses three of them. The technologies examined are simple HTML combined with JavaScript; SVG; and GML. These technologies were chosen because, being open standards, their use involves no cost other than labour.

4.7.1 Using HTML and JavaScript to publish Web maps

Basically, an HTML file itself does not contain any sound, image of any kind of multimedia capability. Instead it contains instructions about the content of the Web page, including references to the multimedia files that comprise the page. When the Web browser loads the page it compiles the instructions and execute the files, rendering a multimedia page. Although HTML is the language used to produce Web pages it can be also used to produce Web map applications in form of clickable maps. An example of a clickable map produced in HTML is provided below (Sample Code 2).

Sample Code 2. A simple clickable map in HTML.

```
<html>
	<head>
		<title>Example of Image Map</title>
	</head>

	<body>
		<img src="brasil.gif" width="170" height="223" border="0" usemap="#Map">
		<map name="Map">
			<area  shape="poly"  coords="38,85,53,98,51,81,62,77,73,83,92,86,106,57,
			93,59,88,54,95,46,88,35,83,44,75,40,62,45,58,42,60,35,58,29,47,34,42,
			33,44,41,35,44,28,40,21,46,21,62,9,67,7,74,13,85,20,83,20,90"
			href="North.htm">
		</map>
	</body>
</html>
```

HTML files are structured into tags that comprise different sections of the document, for instance, the tag <head> outlined above comprises the necessary information for the rendering of the heading of the page, including its title that will be shown on the title bar of the Web browser. In the example the title of the page is “Example of Image Map”.

The body of the HTML document is defined within the <body> tag. In the example provided the body of the page contains one image, called brasil.gif. The other element in the body of the document is identified by the tag <map>. Although this name suggests some kind of cartographic application the use of the <map> tag is far more prosaic. The <map> tag basically subdivides the document into different areas, or hot spots; in the case illustrated the area is a polygon, within the specified coordinates. When the user clicks on the specified area the document North.htm will be loaded.

This simple example of clickable map structured in HTML is widely adopted and can be successfully used in Web map applications. Its use is recommended when the developer is not a specialist, because it can be implemented with little technical knowledge. However if the Web map needs to be constantly updated this is not the best approach because for each update the page has to be edited again. This could be a painstaking task, particularly when the application comprises several maps linked together.

Although a Web map created as described above is interactive, because it responds to the click of the mouse, extra interactivity can be integrated by using a scripting language - JavaScript.

JavaScript is a Web scripting language interpreted by the client Web browser at run time and the JavaScript can be embedded within the HTML code. JavaScript also supports the use of external files, in this way the whole script can be saved in a separate file (with the .js extension) that is referred to within the code.

JavaScript code is comprised within <script> tags. Sample Code 3 shows an example of integrating JavaScript within HTML code to generate rollover maps. The example relies on the use of rollover images, which are images that change when the mouse pointer moves over them. There are two events that can be handled in rollover situations: mouse over and mouse out.

Sample Code 3. Using JavaScript to create rollover effects in maps.

```
<html>
        <head>
                <title>Example of clickable map</title>
                <script language="JavaScript" type="text/JavaScript">
                        North = new Image (170,223);
                        North.src = "North.gif";
                        Brasil = new Image (170,223);
                        Brasil.src = "brasil.gif";
                </script>
        </head>

        <body>
                <img  src="brasil.gif"  width="170"  height="223"  border="0"  usemap="#Map"
                name="interactiveMap">
                <map name="Map">
                        <area shape="poly" coords="38,85,53,98,51,81,62,77,73,83,92,86,106,57,
                        93,59,88,54,95,46,88,35,83,44,75,40,62,45,58,42,60,35,58,29,47,34,42,
                        33,44,41,35,44,28,40,21,46,21,62,9,67,7,74,13,85,20,83,20,90" href="
                        North.htm " onMouseOver="document.interactiveMap.src=North.src"
                        onMouseOut="document.interactiveMap.src=Brasil.src">
                </map>
        </body>
</html>
```

The example illustrated in Sample Code 3 is very similar to Sample Code 2. However, here extra pieces of code were added and are highlighted in green. In the header section the tag <script> indicates to the browser that from that point onwards the document should be treated as a script. In this section a series of images are loaded, these images consist of different maps that will be shown according to different mouse events. There are two event handlers in JavaScript within the tag <area>, that corresponds to the image map that divides the image in a separate link.

The event mouse over will change the source image from the original map, brasil.gif, to a second map, North.gif. On the other hand, the event mouse out will change the secondary image, North.gif, back to the initial image, brasil.gif. *Internet Explorer 6.0* (Microsoft) will display the page as shown in figure 4-8.

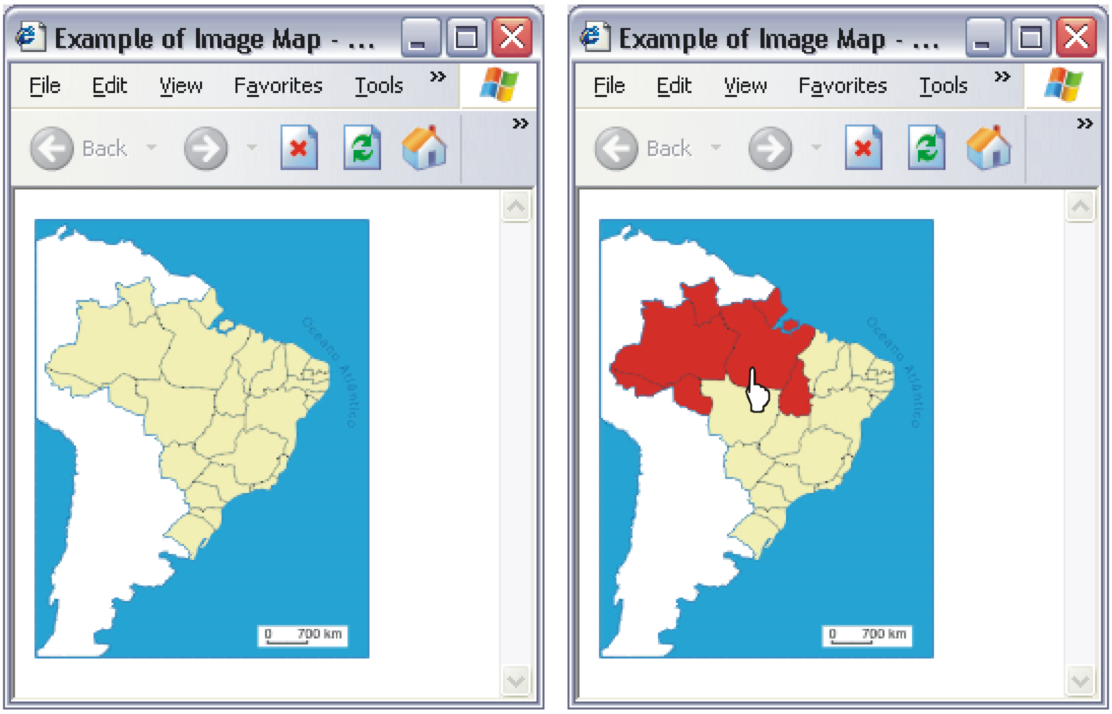


Figure 4-8. HTML and JavaScript used to produce an interactive clickable map.

Figure 4-8A shows how Sample Code 2 is rendered in *Internet Explorer.* Figure 4-8B shows the same map implemented in Sample Code 3, here the area highlighted in red corresponds tho a group of Brazilian northern States, when the mouse pointer moves over the image map, the script automatically changes the base map image from the map in yellow to the map with the north region highlighted in red.

4.7.2 Using Scalable Vector Graphics (SVG) to publish Web maps

The use of open standards, particularly the XML-based SVG, to publish maps on the Internet is a recent trend. Although this chapter does not intend to explore details of both languages, short samples of XML and SVG code are provided in order to illustrate the basic structure of derived documents.

XML was introduced in 1998 by the World Wide Web Consortium aiming to overcome problems with data handling in HTML. In fact XML and HTML were created to achieve different goals: XML is a standard for describing data and HTML is a standard for displaying data.

XML was created as an open-ended technology, in other words, it can be adapted to different applications and be used in different areas. Generally, XML can be used for two purposes:

- Data structure: XML can be used to create the structure of data documents, including descriptions and attributes; and
- Data exchange: XML is a cross-platform technology, which means that it can be used to exchange data between different formats. It can also be used to send data over the Internet.

A XML document follows a series of rules. Sample Code 4 illustrates a simple XML document. The structure of an XML document is reasonably simple as can be seen in Sample Code 4. The first line of the code contains the XML declaration - in the example shown line 1 says that the code following is an XML document version 1.0. There are no pre-defined tags in XML, therefore the user can define their own tags according to the nature of the data. The example provided in Sample Code 4 comprises geometry data about different blocks in a particular suburb. In the XML file the table suburb is created with the tag <suburb> the property id="a" identifies the suburb; each <block> tag comprises a line of the table. The table embraces the fields <id> and <geom>.

Sample Code 4. Fragment of XML code.

```
1. <?xml version="1.0"?>
2. <suburb id="a">
3.     <block>
4.             <id>1028</id>
5.             <geom>M226.5,295.4 L225.8,295.4 L225.5,298.3 L227.7,296.9 L226.5,295.4
```

```
            </geom>
    </block>
    <block>
            <id>1029</id>
            <geom>M227.9,297.1 L226.7,297.8 L228.7,300.2 L229.6,299.7 L227.9,297.1
            </geom>
    </block>
</suburb>
```

As an XML-based standard, SVG documents follow a structure very similar to the structure presented in Sample Code 4. However, there are some specific tags and properties reserved for particular SVG objects.

As vector files, SVG documents follow a coordinate system. However, it is completely the opposite to the Cartesian system, in which the vertical axis (y) is positive above the horizontal axis (x). In SVG the vertical axis has positive values below the intersection point with the horizontal axis (0, 0 coordinates). Figure 4-9 shows the difference between the Cartesian coordinate system and the SVG coordinate system.

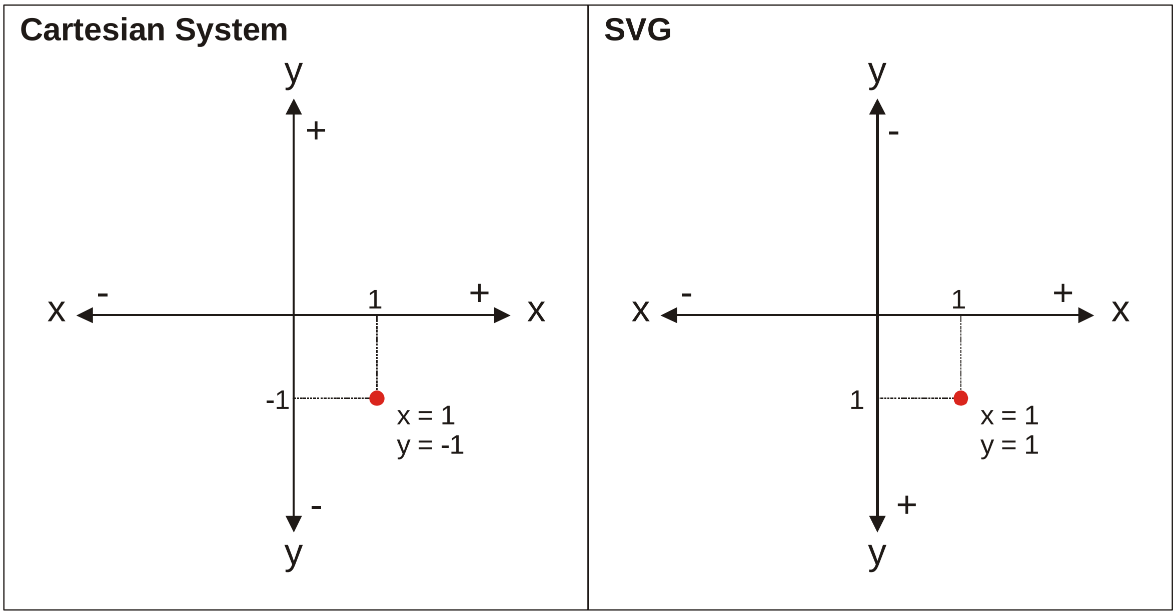


Figure 4-9. The Cartesian and the SVG coordinate system.

In the example illustrated in figure 4-9, a point will have coordinates (1,1) in SVG. These coordinates are rendered by the SVG plug-in as one unit to the right (x) and one unit downwards.

Another important concept in SVG is that different metric units can be used. The most common metric units are pixels, millimetres, centimetres and inches. However percentages of the screen size can also be used. In this way all the dimensions within the SVG file will be calculated according to the size of the screen window.

Sample Code 5 shows a sample piece of SVG code. The first line in Sample Code 5 specifies that the following code is an XML document. The second states the type of the document (SVG in this case) and the DTD (Document Type Definition) used. DTD is a document that defines rules for using tags and attributes to describe contents within the document. The third line, initiated with the <svg> tag, defines the size of the SVG file and the coordinate system. Every SVG document must contain this tag.

The example below comprises one rectangle and three different text components. Note that two text elements are grouped into a ‘g’ element.

Sample Code 5. A simple SVG code.

```
1.  <?xml version="1.0" encoding="iso-8859-1"?>
2.  <!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 20001102//EN" "http://www.w3.org/tr/2000/
        CR-SVG-20001102/DTD/svg-20001102.dtd">
3.  <svg width="220" height="50" viewBox="0 0 220 50">
4.      <rect x="0" y="0" width="216" height="42" fill="#3333CC"/>
5.      <text font-family="Arial Black" font-size="55" fill="#6699FF" x="179" y="40"> ?</text>
6.      <g font-family="Tahoma" fill="white" font-size="13">
7.              <text x="6" y="15">text 1</text>
8.              <text x="6" y="33">text 2</text>
9.      </g>
10. </svg>
```

The SVG file outlined in Sample Code 5, when rendered in a Web browser, with an appropriate plug-in, should appear on the screen as shown in figure 4-10.

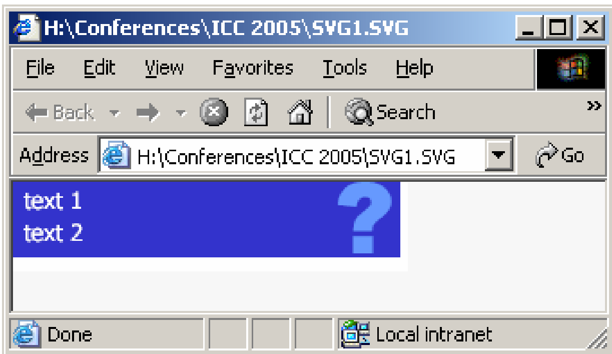


Figure 4-10. Rendering of the code presented in Sample Code 5.

The property viewbox in the <svg> tag establishes the coordinates within the SVG file, in the example provided in Sample Code 5, the SVG file is divided into 220 columns and 50 lines (the first two numbers identify the coordinates x and y of the top left corner and the final two number indicate the coordinates on the bottom right corner). The viewbox property does not necessarily contain the same number of columns and lines as the width and height of the file.

In the example illustrated in figure 4-10, the tag <rect> defines that one rectangle will be rendered. The properties x and y define the starting coordinate for rendering the rectangle (top left corner) width and height define the dimensions of the geometric figure. The border of the rectangle is not defined in Sample Code 5. However, borders can be defined by using the "stroke" and "stroke-width" properties. The property "colour" defines a filling colour for the rectangle. In the example the hexadecimal code 3333CC was used. Colours can also be referred to by English names such as red, yellow and blue and by the RGB palette code (such as 255,255,255 for white, 255,0,0 for red, etc). In the case shown in Sample Code 5 a colour from the Web Safe Palette was used.

The Web Safe Colour Palette (figure 4-11) was developed to provide guidelines for using colours in Web sites. The purpose was to establish a number of colours that would be rendered in the same way in different Web browsers or different hardware. Using the Web Safe Palette the Web developer can design pages knowing exactly how users of different platforms would view the resultant imagery.

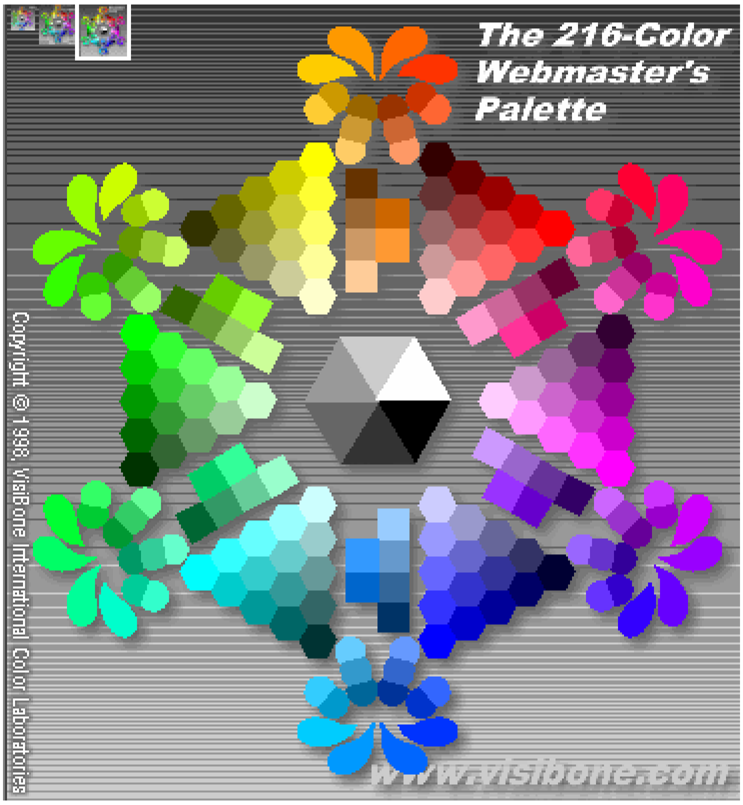


Figure 4-11. The 216 Web safe palette (Source: http://www.visibone.com).

Although the file used as an example here is static, animation can be implemented into SVG files. SMIL (Synchronized Multimedia Integration Language) statements can be used within SVG documents to allow users to create animations involving transformations of objects' attributes, including movement.

SMIL is also a markup language based on XML, developed by the W3C. It divides multimedia files into different streams (for audio, video, text and images) and defines rules for their presentation. Frame animations can be implemented by creating chained animations, controlled by time. It is also possible to implement interactivity within SVG. For complex interactivity it is recommended using a combination of SVG and JavaScript. There are several Web sites dedicated to SVG and SVG tutorials available on the Internet (a good example is the cartonet Web site, http://www.carto.net/papers/svg/samples/). For more detail in the SVG syntax refer to Newmann and Winter (2003) and Campesato (2004)

In this research SVG was the graphical format chosen for developing templates for publishing school atlases on the Web. This choice was made considering the structure of the files provided by the original paper atlas developers. Most of the graphical files provided were in vector format (*Corel Draw* and Macromedia *Free Hand*) and there were some raster images as well (JPG and GIF).

Cost was also another important factor considered, as most of the paper atlases were developed by universities or by partnerships between universities and local councils. Unfortunately in both situations funds are not always available and therefore a low cost solution for publishing atlases on the Internet was necessary.

There are two different approaches that can be used to publish SVG maps on the Internet:

- **Client-side SVG** - SVG files are loaded into the client's computer and run independently (this part of the template is already implemented); and
- **Server-side SVG** – In this case, considering budget restrictions cited previously, a *MySQL* databank, which is an open source application, containing the geometry information to be inserted into SVG maps will run on a Web

server. PHP, another open source application, can be used to communicate the client with the server and deliver the maps.

In this research the client side approach was adopted. The structure of the templates and the rationale for the solutions proposed are covered in chapter 5.

4.7.3 Using Geographic Markup Language (GML) to publish Web maps

Similarly to SVG, GML is an open standard and open source technology developed under the XML umbrella Peng and Tsou (2003). It aims specifically to provide guidelines for exchanging geographic information over the Web. According to Peng and Tsou (2003, p. 306) "*it provides a standard way to encode spatial features, feature properties, feature geometries, and the location of the feature geometries*".

However, different from SVG, GML does not aim to provide guidelines for data display, but rather it focuses on describing geospatial data. Therefore another technology should be used in conjunction with GML client side in order to display maps. SVG can be used in conjunction with GML using XSLT (eXtensible Stylesheet Language Transformations) as an interface between both standards.

> "*According to the "GML has been designed to uphold the principle of separating content from presentation. GML provides mechanisms for the encoding of geographic feature data without regard to how the data may be presented to a human reader. Since GML is an XML application, it can be readily styled into a variety of presentation formats including vector and raster graphics, text, sound and voice.*" (Consortium 2002, p. 7)

Figure 4-12 illustrates how GML and XSLT can be combined to deliver maps over the Internet.

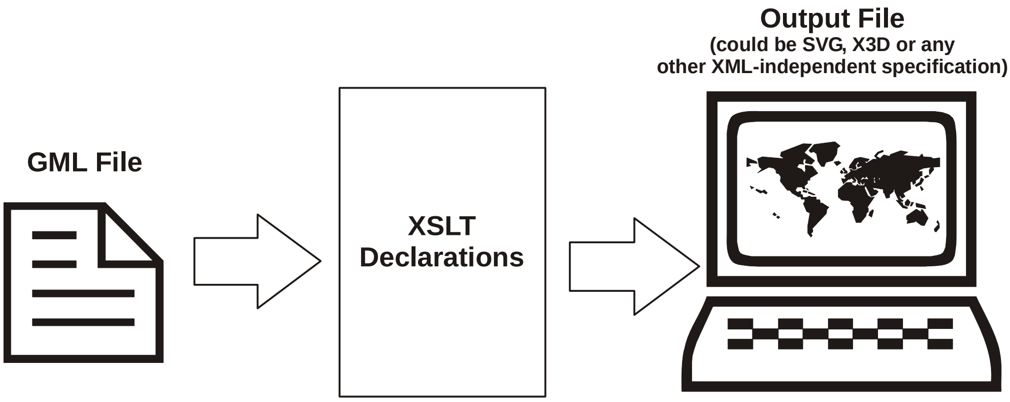


Figure 4-12. The use of GML and XSLT to publish Web Maps.

Similar to XML, GML is a powerful tool for exchanging geographical data over the Internet because it is cross-platform technology, meaning that a GML file can be used to exchange data between different applications. Because GML is not meant to provide maps, but rather geospatial information generally it can be used in conjunction with other graphic specifications, not necessarily W3C recommended SVG and X3D, to deliver maps.

4.8 Atlases on the Web

As stated by Kraak (2001b), atlases are understood to be a collection of maps organized in such a way to address a specific purpose. In general, atlases can be classified as topographic, national and regional, thematic, tourist, and school. What distinguishes the school atlases from other atlases is that "*A school atlas implies a product designed to meet the requirements of a specific clientele*" (Anderson *et al.* 2002, p. 8). In this way, the contents of a school atlas must be designed not only considering cartographic aspects, but also cognitive and psychological aspects as well.

Additionally, Anderson *et al* (2002) compared the general structure of paper atlases and Internet atlases. According to the authors what differ those types of atlases from other atlases is the architecture of information. In paper atlases interaction between maps or any other components is bi-directional and in digital atlases the structure of information is hypertextual.

The purpose of this research was to provide a template for publishing school atlases on the Internet and to propose best practice rules for doing so. However, a number of Web based applications for geographic education were already available. In the following sections some Brazilian and other selected examples were analysed considering structure and main data format to determine the actual trends in Internet Atlas publishing.

4.8.1 Analysing the structure of selected Brazilian Internet Atlases

Despite advances in the field of Cartography for Children in Brazil, much research is still needed for developing cartographic applications for Brazilian school children on the Internet. Considering the technology employed to develop geospatial multimedia products, most Brazilian research (regardless the final educational purpose) was focused on two distinct areas:

- Producing digital products (for discrete media or the Web) using commercial GIS products and other proprietary technology. Examples of research that fit into this category are the works from Pina and Cruz (1999), producing a multimedia atlas in CD-ROM in partnership with a private company. Their product was produced with *GeoMedia* (Intergraph) integrated with *Visual Basic 6.0* (Microsoft). Another example is the work from Kleiner (2000), an interactive Web atlas using *GeoMedia* Web *Map* (Intergraph) and finally Ramos (2001), also produced a CD-ROM based on *GeoMedia* and *Visual Basic 6.0*.
- Producing digital products (for discrete media or the Web) using commercial multimedia products. The work by Castro and Magalhães (1997) is an examples of research in this category, they developed an educational multimedia package using *Director* (Macromedia) for distribution in floppy disks. Russo (1999) produced another educational multimedia package in CD-ROM using *Authorware* (Macromedia). Meneguette (2001) produced and educational atlas for distribution either in CD-ROM or the Internet using *Flash* (Macromedia).

Although there are no official statistics about the number of digital atlases and educational-related map products produced in Brazil, the proceedings of the Brazilian Cartographic Conferences can provide some insight in the state of the art in digital atlas production in the country. In order to identify trends of research the proceedings of the last two conferences, in 2003 and 2005, were analysed. The results are summarised in table 4-3.

Type of work	2003	2005	Comments
Methodology for digital publishing	6	6	Encompasses research in user interface design; different technologies; concepts involved and gathering information for digital geospatial products. Theoretical papers were included in this category.
Products in CD-ROM	2	2	
Products for the Internet	3	4	
Use of existing digital resources for teaching geographical concepts	1	1	Includes the use of online materials and the software LOGO.
Cartography for Children			
Educational product for the Internet		1	
School atlases in CD-ROM		1	
School atlases on paper		3	

* Papers focusing solely on the use of GIS for spatial analysis were not considered.

Table 4-3. Number of papers presented in the last two Brazilian Cartographic Conferences, by categories.

This demonstrates the interest in digital cartographic publishing by the academic community in Brazil. The number of works that analysed theoretical concepts in the field was stable, six papers in each conference. Similarly in both conferences two atlases developed for CD-ROM were presented. In 2003 three products for the Internet were presented and this number increased to four products in 2005. In both conferences there was one paper focusing on the use of existing digital resources for education.

The main difference between the papers presented at both conferences is that in 2005 there was a specific section dedicated to Cartography for Children. One educational product for the Web and one multimedia school atlas on CD-ROM were presented. In the Cartography for Children section four school atlases were presented, one on CD-ROM (the product mentioned above) and three on paper. Initially, the figures seem to suggest gap in publishing cartography for children with digital media. This gap becomes more evident when analysing the proceedings of the National Conferences on Cartography for Children.

In Brazil the working group of Cartography for Children is very active and organized five specific conferences on the topic independently from the National Cartographic

Conference. The conferences took place between 1995 and 2002 with an increasing involvement of the Brazilian academic community. Almeida (2005) reported seventeen papers presented in the first conference on Cartography for Children in 1995; two years later thirty papers were presented in the second conference; in 1999 twenty two papers were presented in the third conference; seventy seven papers were presented in the fourth conference in 2001; and finally eighty five papers were presented in the last Conference in Cartography for Children in 2002. The analysis of the proceeding of those conferences is shown in table 4-4.

Theme	**1995**	**1997**	**1999**	**2001**	**2002**
Teaching Methodology	58	55	18	20	34
Representation of Space	24	14	9	28	16
Supporting Materials	6	28	64	48	41
Professional Improvement	12	3	9	4	8

Table 4-4. Percentage of papers presented in the Brazilian Conferences in Cartography for Children, by theme.(After Almeida, 2005).

Figure 4-13 summarises the evolution of research interest according to the proceedings of the Brazilian Conferences in Cartography for Children from 1995 to 2002. Considering the scope of this research, supporting materials were further analysed. The papers presented in this category were further subdivided into school atlases on paper, 3-D models, multimedia materials, use of remote sensing for education, GIS in the classroom and digital atlases. Figure 4-14 summarises the distribution of papers in those categories from 1995 to 2002.

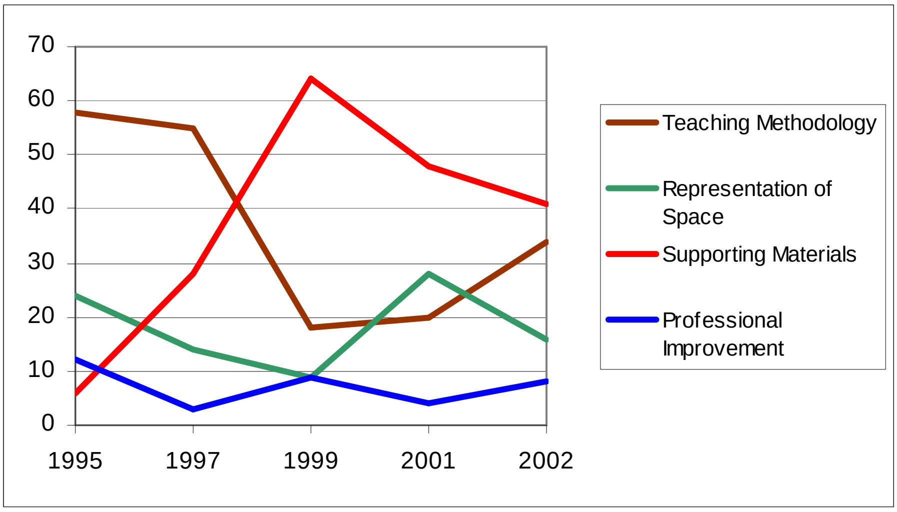


Figure 4-13. Growth of papers presented (in percentage) in the Brazilian Conference for Cartography for Children, by topics (1995-2002).

During this period the growing number of papers presented on the use of digital technology (either remote sensing, GIS, multimedia and digital atlases) in the classroom was remarkable. In 1995 all papers presented were related to the production of school atlases on paper. In 1997 there was a significant number of multimedia-related papers (36% of the total). The growth of multimedia applications was so significant that it achieved the same percentage of papers related to school atlases. Another important point that has to be emphasised was the increased research interest in using digital technology for education. Since 1999 digital technology-related papers have dominated this topic. In 1995 there was no paper in these categories, in 1997 26% of papers presented fitted in this category; in 1999 they were 35% of total papers presented in supporting materials; in 2001 they corresponded to 42% and finally in 2002 papers focusing on the use of digital technology for education corresponded to 54% of all papers presented in the category of supporting materials. Figure 4-14 illustrates this.

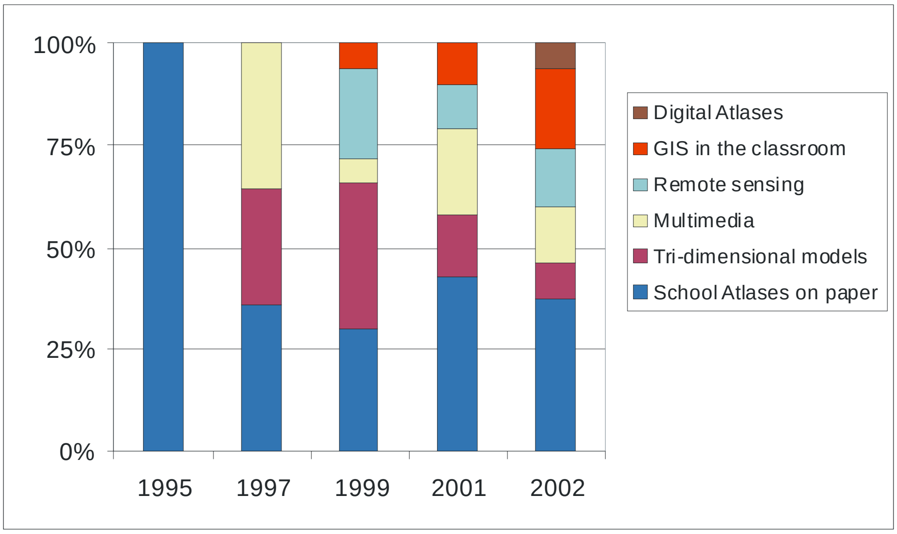


Figure 4-14. Papers presented in the Brazilian Conference on Cartography for Children, included in the supporting materials topic (by sub-categories, in percentage).

Although the figures demonstrate a significant increase of interest in using digital media for education, just 6% of the papers presented in 2002 focused on the development of digital school atlases. This confirms the 'research gap' in the area that this research addresses.

In order to illustrate how Brazilian atlases online have been implemented four Brazilian atlases are analysed in the following sections. However, it must be noted that the target audience of those atlases is not comprised exclusively of school students. The examples of existing cartographic products for education purposes are outlined and their interfaces are shown in figure 4-15.

Environmental Atlas of the city of Sao Paulo (URL 1 - http://atlasambiental.prefeitura.sp.gov.br/index.php). This Web site was developed by a partnership of the Environmental Department and the Urban Planning Department of Sao Paulo. Its purpose is to provide background information for a municipal system of environmental information. The atlas comprises the themes of political maps, demography (density and population growth), education, domiciles, age profile, health, security, family income and socio-economic profile, geology, land use, water supply, sewage system, vegetation and so on. The maps are presented in raster format and with no interactivity. It is possible to enlarge some of the maps, and CAD files as well as the final reports of the project are available for download.

Interactive Atlas of Pontal do Paranapanema (URL 2 - http://www2.prudente.unesp.br/atlaspontal/). This atlas was developed at the University of Sao Paulo State, campus of Presidente Prudente, originally as part of a *Livre Docência* Thesis (Meneguette 2001). The latest version of this atlas, version 4.1, was released in 2003 (Meneguette *et al.* 2003). All versions of the atlas were developed using *Flash* (Macromedia). Version 2.0 consisted of temporal and non-temporal choropleth map animations, a composition of satellite images (Landsat TM5), and thematic maps. The most recent version is still being improved. There are no cartographic animations, therefore the analysis presented here is based on version 2 of the atlas. Version 2 offers the possibility of superimposing additional layers, text, tables and videos. The maps are presented mainly in vector format, but there is no link between the maps and the other media available in form of 'clickable' maps. If the user wants to compare the maps and data available from the tables, for example, they need to alternate between both, choosing them on the menu each time.

Environmental Atlas of Corumbataí River Basin (URL 3 - http://www.rc.unesp.br/igce/ceapla/atlas/index.html). This atlas was developed in the University of Sao Paulo State, Rio Claro Campus. The main concept behind this project was to gather environmental information about the area with the purpose of providing background information for further environmental research. *Flash* was used to create the atlas and the maps available are in the following themes: geology; geomorphology; pedology; climatology and hydrology. This atlas lacks interactivity, as most of information available is structured in a linear basis. The maps are available in raster format and when enlarged they are not so easy to be read and the legend is hidden, making the maps harder to understand. The user can move the map on the screen, by using navigation arrows. An advantage here is that the original maps are available to download, as *Autocad* (Autodesk), *Corel Draw* (Corel), or *Idrisi* (Clark Labs) files. A second version of the atlas is under development and implemented using *ARCIMS* (ESRI).

Geographical School Atlas (URL 4 - http://www.ibge.gov.br/ibgeteen/atlasescolar/index.shtm). This atlas was produced by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística – IBGE*) in 2004. This atlas was developed primarily on CD-ROM and then transferred to the Internet, therefore it is not completely available online. It is comprised of animations that cover topics such as the history of cartography, continental drift theory and the solar system. Animations were developed in *Flash* (Macromedia). Additionally, a number Web-GIS maps are provided, illustrating natural and social variables with Brazilian and World maps. There is no clear multimedia metaphor adopted in this application, the developers employed only interface metaphors such as navigation arrows to move the user throughout the linearly-structured application.

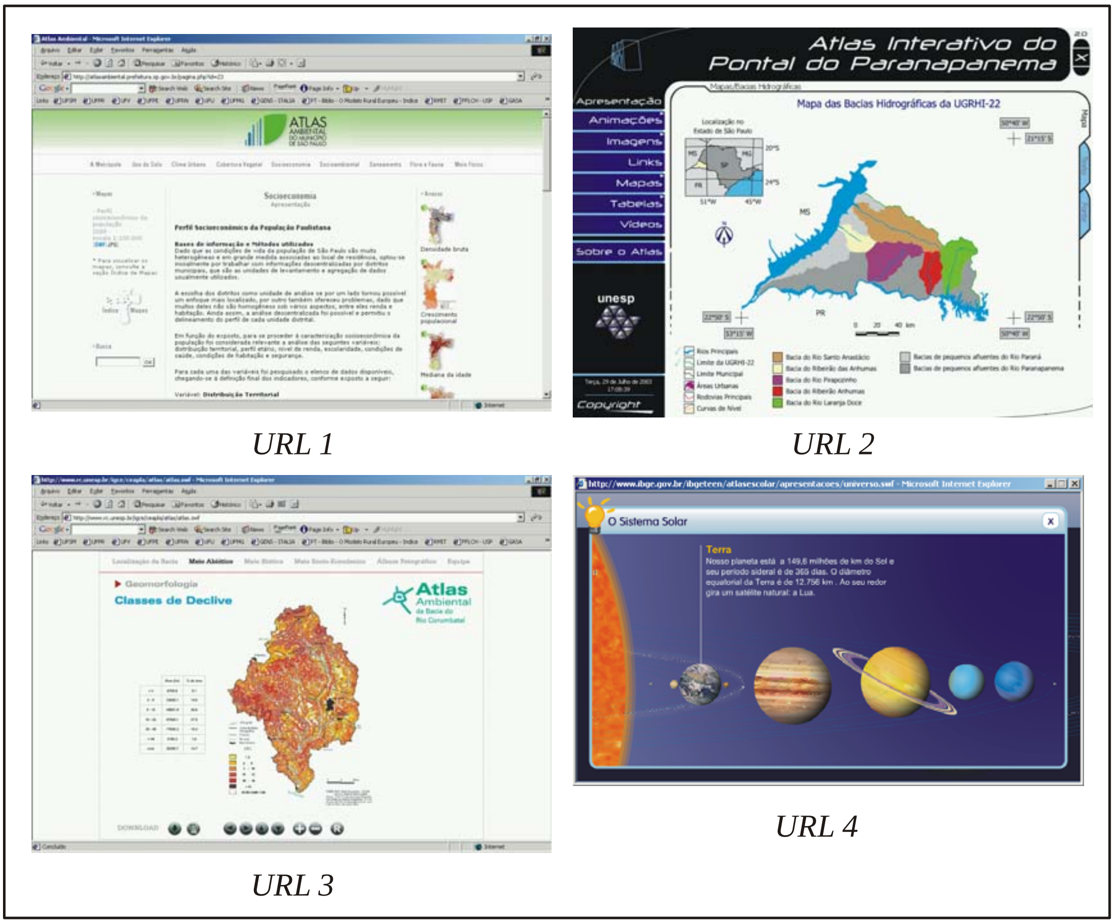


Figure 4-15. Interfaces of Brazilian atlases.

These examples illustrate some Brazilian atlases on the Internet. The atlases outlined provide information for further environmental research, but they can also be used for educational purposes. The only exception is URL4, which is designed specifically for school children. None of the examples allow the user to explore the databases used to create the maps, so dynamic maps are not offered. Most of the maps presented are static and the few animations available are frame-based, offering little user control. In addition the temporal animations have no temporal legend, as Peterson (1995a) claimed to be necessary components of animated maps. The fast frame rate presented, combined with lack of temporal legend makes the animations hard to understand (table 4-5).

Feature	**URL1**	**URL2**	**URL3**	**URL4**
Main Format of maps on the Web site	Raster/Vector	Vector	Raster	Vector
Download of the sources	✓		✓	
Type of Atlas (Kraak and Ormeling 1996)	View-only	View-only	View-only	View-only

Type of Web Maps (Kraak 2001a)	Static/View-only	Dynamic/view-only and Static/Interactive Interface and/or contents	Static/Interactive Interface and/or contents	Dynamic/view-only and Static/Interactive Interface and/or contents
Cartographic Animations		✓		✓
Tables	✓	✓	✓	✓
Graphs			✓	✓
Text	✓	✓	✓	✓

Table 4-5. Characteristics of the Brazilian Internet Atlases.

4.8.2 Atlases on the Internet: some key examples

Throughout the world there are several examples of Web atlases developed for general education and some of them focus particularly on usage by school children. Some examples are listed below and the interfaces are presented in figure 4-16.

School Atlas of Quebec (URL 5 - http://atlasduquebec.qc.ca/scolaire/). This atlas was developed by researchers from the University of Quebec as part of the Canada regional atlases project and it focuses particularly geographic education for school children. According to Anderson *et al* (2002) its planned audience is 8 years or older school children. In order to address the problem of dealing with such an assorted audience, four different interfaces were developed for different age groups (8-10, 10-12, 12-14 and 15 years or older). The main concept of this atlas was to create a child-centred structure, which means a structure that allows children to navigate the atlas, explore the data and construct their own knowledge. In this atlas the Gameplayer metaphor (Cartwright 1999b) was adopted; the interface was designed to reproduce the child's study desk, where the student can interact with its elements in a ludic manner.

Internet Atlas of Switzerland (URL 6 - http://www.karto.ethz.ch/neumann/atlas/atlas.htm). This atlas is a prototype of an online version of the previous paper atlas and CD-ROM atlas of Switzerland. It covers topics such as environment, population, economy, infrastructure, traffic, culture and politics (Hurni *et al.* 1999) and its maps were developed to be published on the Internet. Some education-related activities, such as map puzzles, are available. As stated by Hurni *et al* (1999, pp. 101-102) "*The atlas tries to realise a synthesis between cartography, GIS, and multimedia in this sense that it is not only considered as a collection of* *previously created and hyperlinked maps, but rather a special interface for a mapping system of GIS*.". Version 2.0 of the Atlas was available on CD-ROM and incorporates 3D functionality.

National Geographic MapMachine (URL 7 - http://plasma.nationalgeographic.com/mapmachine/). The *MapMachine* from the National Geographic Society is a powerful and comprehensive map library that includes background information about countries, grouped by continents. Also available are interactive maps where the user can zoom and pan political maps of the globe with satellite images in the background. In addition, diverse resources like interactive images of Mars and street maps of cities in Canada, the United States of America and Europe are available. The Web site provides other assets like reference maps, text, images and some GIS tools.

Australian Coastal Atlas (URL 8 - http://www.ea.gov.au/coasts/atlas/). This atlas was developed by the Australian government and comprises State nodes as well as a national module. It includes interactive maps, where the user can create different combinations of layers and satellite images. Additional tools provide zoom, pan and data bank queries. Some activities are provided for students, from early childhood to tertiary level. Another important aspect is the wide range of information provided and the easy-to-understand interface.

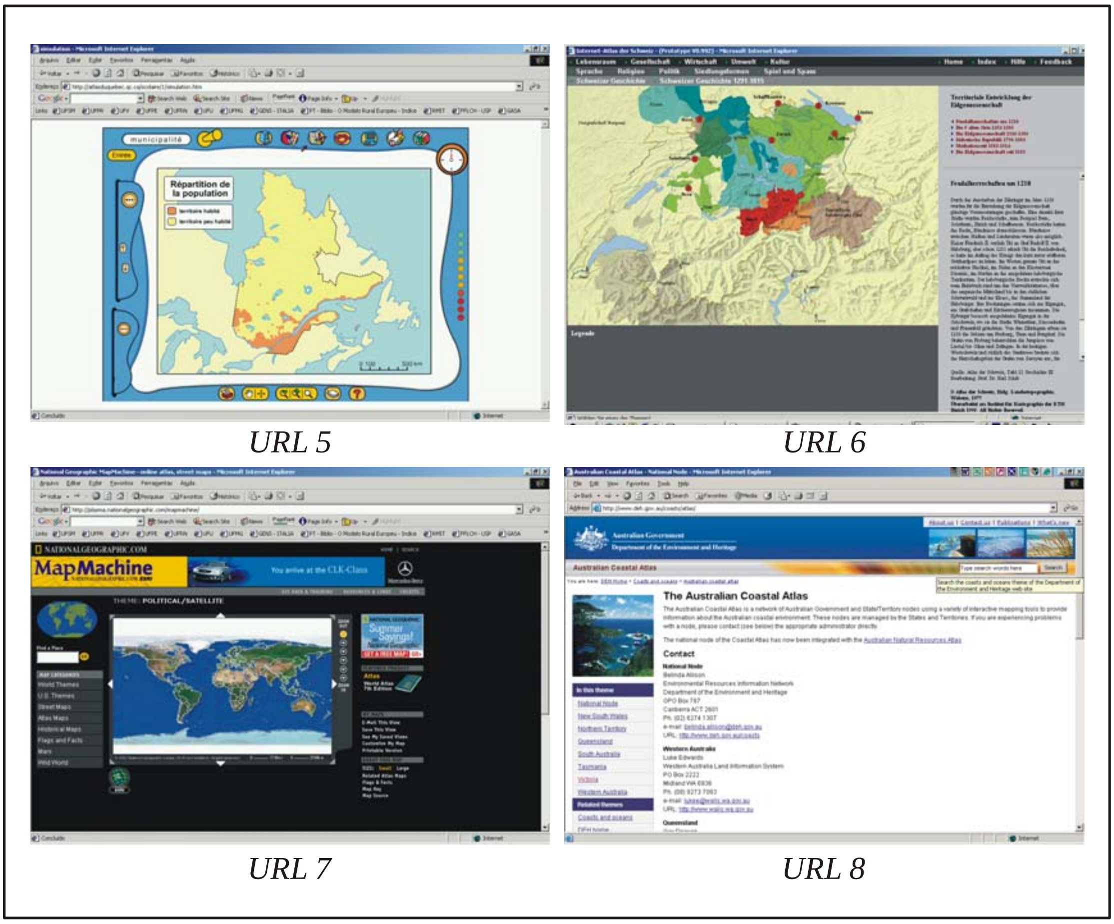


Figure 4-16. Interfaces of Internet atlases.

These examples illustrate the interest in producing atlases in different countries. In some of the examples shown the convergence of GIS, multimedia and the Internet was an important element in atlas production. Additionally, the experiences from focusing specifically on education (URLs 4 and 5) explored how to integrate the student and the product by developing special interfaces or interactive activities to foster the learning process. A summary of the features presented in those applications is provided in table 4-6.

Feature	URL 4	URL 5	URL 6	URL 7
Main Format of maps on the Web site	Vector	Vector/raster	Vector/Raster	Vector
Download of the sources				
Type of Atlas (Kraak and Ormeling 1996)	Interactive	Interactive	Interactive	Analytical
Type of Web Maps (Kraak 2001a)	Static/Interactive Interface and/or contents	Static/Interactive Interface and/or contents	Dynamic/Interactive Interface and/or contents	Dynamic/Interactive Interface and/or contents

Cartographic Animations				
Tables	✓		✓	✓
Graphs				
Text	✓	✓	✓	✓

Table 4-6. Characteristics of Internet Atlases.

4.9 Evaluating the prospect of atlases on the Web for children

Several questions need to be addressed regarding the use Web atlases, and particularly Web atlases produced for educational purposes. The development of GIS and multimedia technology over the last two decades has caused several changes not only to how cartography is produced, but also how it is communicated. Atlases, as cartographic products, are part of this process, and many examples can be found in discrete media and on the Internet.

When developing a digital atlas not only traditional cartographic aspects need to be considered but also other aspects. These include screen resolution, colour schemas (for printer and screen), scales and generalisation, hardware and software requirements, different media to be included, level of interactivity, interface and application metaphors, size of files, etc. Additionally, digital atlases provide more options for development, as not only static, but also dynamic and animated maps can be included. It is believed that the combination of those different kinds of maps within an interactive environment has a strong potential for education. For further discussion on the use of multimedia-based tools for education please refer to chapter 5, section 5.5.

Projects that aim to develop a digital version of an existing paper atlas seem to be harder, as the original product may not fit into a diverse (multi)medium. However, atlases for school children have a specific clientele, with special needs for different age groups. What also needs to be considered is that the cognitive development of 7-year-old students is completely different to 12-year-old ones, so content, activities and interfaces must be designed and implemented considering specific subgroups (Anderson *et al.* 2002).

The recent Brazilian experience in producing paper atlases for school children focused on producing local atlases. The idea was to work with geographical concepts based on the student's personal experience, and, in this way they would be more likely to apprehend geographical knowledge. Although these atlases provided significant results in Brazilian schools (Oliveira 2003), it is believed that digital school atlases focusing the student's reality could reach even better results. There are several advantages of Internet (or even electronic) atlases over their paper equivalents including the possibility of using dynamic media and interactivity.

Another important advantage of Web-based atlases is that they can be produced at low cost, especially if open standard technologies are adopted. They can also be distributed at no cost to the producer to a wider audience. As the recent Brazilian policy on public education has included the use of computers at the classroom (Proinfo 2006), the scenario seems to be more than appropriate for this kind of application.

4.10 Chapter Summary

In this chapter the focus moved to the Internet as a medium for publishing interactive map products and atlases in particular. The objective was to initially introduce the history and development of the Internet, emphasising how this new communication medium has contributed to changing how society accesses and uses information, including geographical information.

Worldwide and Brazilian Internet audience figures were presented and discussed. Furthermore, different technologies for publishing maps on the Internet were analysed, with an emphasis on selected open technologies for static and interactive Web-map publishing. The technology chosen for this research was SVG, a vector standard based on XML and validated by the W3C.

Additionally the proceedings of the last two Brazilian Cartographic Conferences were analysed in order to identify research trends in publishing digital cartographic products. Moreover, the proceedings of all five National Conferences on Cartography for Children in Brazil were analysed with the same purpose. This analysis showed that although there is an increasing interest in the Brazilian academic community for migrating to digital (multi)medium when publishing their educational products not many digital atlases have been realised. This may be caused by a lack of technical knowledge for developing such products. This research aims, therefore, to provide a reasonably easy-to-use and low cost solution.

The examples of Web atlases described aim to illustrate the present 'state-of-the-art' in atlas production. In summary, considering the sample atlases analysed in this chapter that Brazilian atlases on the Internet tend to be mainly 'view-only' atlases, with limited interactivity. In these cases it appears that the main concern was in the atlas content rather than in the atlas use.

The global examples analysed in this chapter were mostly interactive. The first two examples (URLs 5 and 6) were based on static maps, although they included a certain level of interactivity, either through animations or exercises. The user can not manipulate data or generate maps on demand in these atlases.

The examples shown in URLs 7 and 8 are not only interactive but dynamic as well. They provide the user with tools which interact with the data and to dynamically generate maps. These atlases provide references to the sources used to generate the maps and they are GIS-based.

It was found that the Brazilian atlases analysed here, despite containing rich media contents, lack interactivity and dynamism. It is believed that a possible reason for that is the cost of using GIS-based applications for product development. The use of open standards technologies is seen as an alternative for Web atlas production, as these technologies can be used to develop interactive and dynamic maps with no software cost. These technologies are being used in new projects such as the second edition of the *Atlas of Switzerland* (Huber and Schmid 2003) where open standards are to be integrated with multimedia packages and GIS tools.

To reduce production costs of paper atlases for teaching geography, alternative solutions such as partnerships between public administrations and universities have been developed. In this context it is believed that the transition from paper to the Web as the medium for school atlases is a natural process, particularly using open standards technologies such as SVG, XML, and PHP (Hypertext Preprocessor). These technologies could be used to develop Web atlases that offer students not only information already available in their paper counterparts but, as well, they could be developed as interactive or even analytical atlases (according to the classification established by Kraak and Ormeling (1996) comprising animated and dynamic maps, where students could interact with a remote data set to generate their own maps.

The next chapter focuses on the proposed solution for migrating current Brazilian local paper atlases to the Web, as well as fostering paper atlas developers to migrate to the Internet. In this way the average structure of Brazilian local school atlases was analysed and their transition to a set of SVG-based templates was discussed. Additionally, graphic solutions for interface design were analysed and the results presented.

5 Case Study – Using SVG Templates to Publish Brazilian School Atlases

5.1 Chapter Overview

This chapter focuses on the case study of this research. A Brazilian local school atlas was chosen as the source of information for a proposed methodology for publishing a Brazilian local school atlas on the Web. This methodology was based on a set of templates that deal with most of the situations covered in the atlas contents. It is believed that such templates could serve as a tool to increase the availability of local atlases, already published on paper in Brazil, by making them Web-deliverable. These are not commercial atlases, but rather publications derived from research efforts, usually linked to public universities and local or national fostering agencies. It is believed that such a methodology would help those initiatives to provide quality education products for school children in a more extensive and flexible way.

The chapter begins by providing some insight on the current research on Cartography for Children in Brazil and particularly the research on developing local atlases for education. The Brazilian educational system was also the object of analysis and some figures of primary students in Sao Paulo State were presented. Because the atlas chosen to test the methodology described here was the *School Atlas of Rio Claro*, figures of primary school students in Rio Claro are also provided. Finally the chapter focuses on the methodology itself, describing the proposed templates with regards to interface design, code and interactive functionalities.

5.2 Research in Cartography for School Children in Brazil

It is believed that Oliveira (1978) laid the foundation stone for researching the use of cartography for teaching geography in Brazilian schools in 1978 (Oliveira 2003). In her thesis (Oliveira 1978), she stressed the importance of introducing map literacy for young children. The cognitive aspects related to the use of maps in the classroom have been an increasing focus of research since Oliveira's pioneering work.

The research trend introduced by Oliveira (1978) was established in several Brazilian universities, amongst them:

- Minas Gerais state: the research conducted in the Federal University of Minas Gerais, lead by Prof. Janine Gisèle Le Sann;

- Sao Paulo state: the research group in the University of Sao Paulo, lead by Prof. Regina Araújo de Almeida, and the working group in the State University of Sao Paulo, lead by Prof. Rosângela Doin de Almeida;
- Rio de Janeiro state: the research group in the Fluminense Federal University, lead by Prof. Tomoko Paganelli; and
- Parana state: the research group in the University of Maringa, lead by Prof. Elza Passini.

However, as emphasised by Archela (2002) cited by Almeida (2005) in the early nineties the number of publications focusing on Cartography for School Children became significant considering the universe of research of Brazilian Cartography.

Almeida (2005) considered that this may have been a result of several National conferences focusing specifically on Cartography for School Children (as analysed in Chapter 4 section 4.8.1). In addition Almeida emphasised that the number of Masters and PhD Thesis on the topic increased significantly since Oliveira's (1978) research. According to Almeida (2005) 55% of all Brazilian academic theses in cartography focused on school cartography between 1977 and 1997 (figure 5-1).

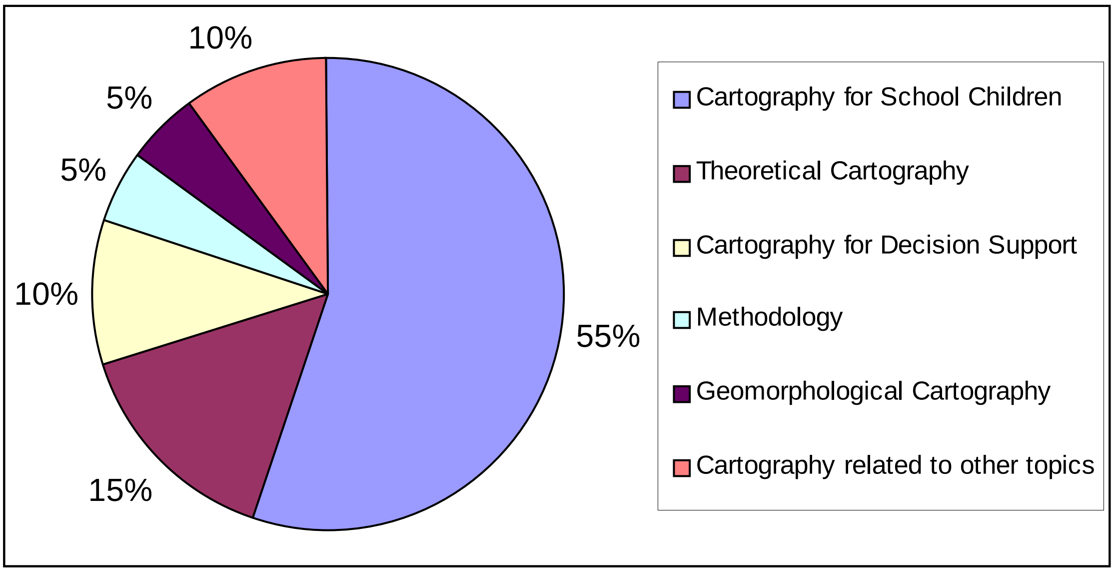


Figure 5-1. Thesis (MSc and PhD) focusing on Cartography in Brazil, divided by themes, from 1977 to 1997. Redrawn from Almeida (2005).

Generally speaking, research in Cartography for School Children in Brazil developed according to the following guiding principles:

- Students should be introduced to cartographic literacy in initial grades of primary school, with an aim to develop graphic skills that will be the basis of future activities in more advanced grades;
- Develop location and critical thinking skills by developing different method for how maps are used in schools. In other words, instead of using existing maps the student was encouraged to become a mapmaker, improving their graphic skills and expanding their critical understanding of geographic space; and
- Use the student's reality to work with geographic concepts, starting from the classroom, the school, the way from school to their house, the suburb, the city, the state, the country, the continent and the planet. In this way the main idea is to work gradually from local to global scale.

The concepts developed in the field were incorporated, in 1998, into Brazilian guidelines for primary education in geography, the National Curricular Parameters (*Parâmetros Curriculares Nacionais – PCNs*). This official publication established the guiding principles for teaching geography in primary schools and recognised the importance of cartography in the process. According to the document (MEC 1998), cartography in primary schools is seen as follows:

> *"Cartography has become a fundamental resource to teaching and researching. It makes it feasible to represent different spatial contexts in different scales. In Geography it is necessary to go beyond written and verbal language; geographical information has to be presented in form of maps by using proper graphic/cartographic language."* (MEC, 1998, p. 76)

It is important to note that this was a result of years of research and publications in the field of Cartography for Children in Brazil.

Several supporting materials can be used for geographical education in primary schools, amongst them tri-dimensional models, text books, videos and atlases (Fuckner and Loch 2005). A research trend that was established in Brazil during the nineties was the development of local school atlases for early geographical education. However, as emphasised by Sann *et al* (2002) a research trend in developing school atlases was also verified in other countries such as Germany;

Argentina; Bulgaria; Canada; Hungary; England; Poland; Russia; Switzerland; Turkey; and the United States.

Local Brazilian school atlases are the result, most of the time, of partnerships between public universities and municipal administrations. The main idea behind these products was to develop mapmaking and critical reading skills, working with the student's reality. Fuckner and Loch (2005) identified the distribution of local atlases for early geographical education published in Brazil by 2003 (Figure 5-2).

In figure 5-2 it can be seen that most of school atlases produced were developed for cities located in south/south-east states of Brazil. With exception of one product developed in the northerly state of Acre, in the Amazon region.

Figure 5-2. School Atlases published in Brazil, updated from Fuckner and Loch (2005).

These atlases were published on paper for free distribution in public primary schools and, therefore, have to be re-printed regularly. However, some were result of partnerships with local councils, and thus there is no guarantee that a new council would support a re-print of an atlas that was sponsored by their opposition.

In the same way, when the atlases are published primarily using research funds there will be no reprint, because those funds are allocated for limited research and not for re-printing these materials. Therefore, the Internet was seen as a natural solution for the impasse of re-printing local school atlases.

5.3 Case Study – The *School Atlas of Rio Claro*

Within the scope of this research the *School Atlas of Rio Claro* (Sao Paulo state) was chosen to provide a model for publishing local school atlases on the Internet using Open Standard Technologies.

The *School Atlas of Rio Claro* was developed by a research group based in the Department of Education, in the State University of Sao Paulo (UNESP), Rio Claro campus. It focuses on students from the 1st to the 4th grade (seven to ten-year-old). The atlas was produced with funds provided by the State of Sao Paulo Research Foundation (FAPESP) and the Rio Claro City Council. All copies of the first edition, published in 2002, were distributed to students in public schools; a re-print is already needed.

The atlas comprises a variety of topics, which are divided as follows:

- Orientation and Location - in this section the student was also introduced to the concept of scale so as to understand that the city where they live is part of a State, country and continent;
- Local history and archaeology - in this part the focus was on exploring archaeological evidence of previous indigenous population living in the area. This section also aims to locate the history of the city within a regional and national context;
- Geography - this section focuses on transportation, relief and Urban Infrastructure and public facilities. It introduces the partition of the urban area into different sectors and these sectors are used to analyse the infrastructure in suburban areas;
- Heritage and Environment - in this part the State Park "*Floresta Estadual Edmundo Navarro de Andrade"* and the former hydroelectric power plant are analysed. The State park was particularly important in the city's identity because it was nationally famous for being the place where the first Australian

gum trees were planted in Brazil and some of them are now more than a hundred years old;

- Water resources - this section focuses on the rivers and creeks within the city. It shows that the rivers are part of a major watershed, and it explains the water dynamics in urban areas, from flooding to sewage; and
- Remote sensing - this section introduces the use of aerial photographs and satellite images for understanding Rio Claro's urban area.

Almeida (2001a) and Carneiro (2003) emphasised that the research group that developed the atlas comprised mainly of teachers. Almeida (2003) highlighted that usually atlases are developed by geographers and cartographers. However in this project it was decided on the use of a collaborative research methodology, the teachers were been trained in new skills and at the same time providing valuable feedback to academic researchers within the group. In the end, the final product, the *School Atlas of Rio Claro*, would be the result of interaction between teachers, researchers and primary school children, the users.

The group started working in the project in 1996, researching new approaches for teaching geography in primary schools, and gathering the necessary information for the contents of the atlas. Almeida (2003) reported a series of difficulties related to the expectations of the teachers towards the university in the initial stages of the research; she summarised those conflicts as follows:

> *"During the first year, there were relationship conflicts between members of the working group. Nevertheless, some teachers had approached us asking for help to produce the product; they did not imagine that this initiative would require a more extensive commitment. In fact we suppose they expected somehow that the 'university' would provide them with the product they were looking for, teaching them how to use it.*" (Almeida 2003, p. 151 - translated from Portuguese)

These problems were slowly overcome as the first research results appeared. Working together with researchers from the university, the teachers prepared each page of the atlas, writing text and creating graphics.

In order to prepare the atlas contents the researchers first conducted a survey with primary school teachers in the city to address the questions: "*What is necessary for a primary school student to know about the place where they live?* " and "*What kind of supporting materials and procedures can help in acquiring that knowledge?"* (Almeida 2001a). The topics chosen (as listed previously) where selected from an extensive list gathered during the survey, considering the guidelines provided in the National Curricular Parameters.

One of the teachers involved in the Atlas project, Carneiro (2003), reported countless difficulties that had be overcome during the development of the product. She also revealed that every content page was submitted to extensive group scrutiny during the group's weekly meetings. After this initial assessment, the pages were then taken to classrooms to further assess their usability with groups of students. In this way the contents and the layout of the paper version of the atlas were extensively tested throughout the development period (from 1996 to the final publication in 2002).

The layout of the atlas was A4 in a landscape orientation. Every two pages comprised a different topic and, therefore, the contents were carefully summarised to fit in that area. The cadastral maps of the city were provided on paper by the city council and subsequently they were digitized using *Autocad* (Autodesk). The contents were prepared for printing using the *Freehand* (Macromedia). The desktop publishing was done by a third party company (paid from research funds) as well as undergraduate students undertaking internships.

When this research began the paper version of the atlas had been printed and was being used in public schools. The initial project, which aimed at creating the atlas, was finished and a secondary project, evaluating the paper atlas use, was underway. In that way the authors were working with undergraduate interns whose task is to observe the use of the atlas in classroom and take notes. The notes are discussed in weekly meetings held in the Education Department in the University of Sao Paulo State, Rio Claro Campus (figure 5-3).

Figure 5-3. A meeting of the authors of the atlas with undergraduate interns, where the use of the paper atlas in classroom was analysed (Ramos,2005).

Selected pages of the paper version of the *School Atlas of Rio Claro* are provided in the attachments, at the end of this document.

5.4 A brief portrait of education in Brazil

Before starting with the development and implementation of the proposed model for publishing local school atlases on the Internet additional questions need to be addressed.

A reader who is unfamiliar with the education system in Brazil might ask if Brazilian school students can access Web atlases. Therefore, a brief portrait of the educational system in Brazil, and specifically in Rio Claro (Sao Paulo State) is provided.

Education in Brazil is divided intro three levels:

- *Ensino Fundamental* – comprises eight years of study, starting at seven years of age. Attendance is compulsory for all Brazilian children and parents that fail to send their children to fundamental education can incur penalties.
- *Ensino Médio* – three years of study. Attendance at this level is not compulsory.

- *Ensino Superior* – Tertiary education; the duration of the course depends on the field of study.

The delivery of fundamental education is the responsibility of State governments. However, in Sao Paulo the State government is slowly handing over this commitment to municipal governments. Therefore local councils will ultimately inherit public schools facilities and education staff. This transition has not been well accepted in many cities that struggle with budget restrictions. The State government, alternatively, has made a commitment to support local councils by continuously increasing education-related funds. Table 5-1 illustrates the number of enrolments in public and private schools in Sao Paulo State for 2002 and 2004, by categories of school.

Type of School	Number of Students Enrolled in Fundamental Education					
	Total		1st to 4th Grade		5th to 8th Grade	
	2002	2004	2002	2004	2002	2004
Public (State)	3,285,418	3,001,513	1,229,390	1,104,762	2,056,028	1,896,751
Public (Federal)	194	187	194	187	0	0
Public (Municipal)	1,935,101	2,039,424	1,437,119	1,504,448	497,982	534,976
Private	773,172	783,955	375,708	389,819	397,464	394,136
Total	5,993,885	5,825,079	3,042,411	2,999,216	2,951,474	2,825,863

Table 5-1. Number of students enrolled in fundamental schools in Sao Paulo State in 2002 and 2004.

Source. INEP (2005)

As can be seen in table 5-1, the total number of students enrolled in primary schools in Sao Paulo State declined in this period. This may be caused by regional migration, school evasion as well as declining fertility rates. Brazil's fertility rate declined significantly over the last three decades, dropping from around 6 children per woman in the early 1970's to estimated 1.93 children per woman in 2005 (IBGE 2005).

Opposing the general trend, the number of students enrolled in municipal schools increased in this period. By comparison, in State schools the number of students declined. This is a direct result of the State's policy on fundamental education as highlighted previously.

In Rio Claro the situation is the same. Table 5-2 shows Rio Claro's statistics on primary education for the same period.

Type of School	Number of Students					
	Total		1st to 4th Grade		5th to 8th Grade	
	2002	2004	2002	2004	2002	2004
Public (State)	16,299	15,293	6,984	6,478	9,315	8,815
Public (Federal)	0	0	0	0	0	0
Public (Municipal)	3,259	3,499	3,016	3,281	243	218
Private	4,258	4,312	1,919	1,951	2,339	2,361
Total	23,816	23,104	11,919	11,710	11,897	11,394

Table 5-2. Number of students enrolled in fundamental schools in Rio Claro in 2002 and 2004.

Source. INEP (2005)

Considering that the *School Atlas of Rio Claro* focuses on first-to-fourth grade students its potential user group is about twelve thousand students (table 5-2).

Table 5-1 and 5-2 show the number of students enrolled in fundamental schools. The data was divided into 1st to 4th grade and 5th to 8th grade as, in public schools, first-to-fourth grade students and fifth-to-eighth-grade students do not share the same facilities. In other words, there are separate first-to-fourth grade schools and fifth-to-eighth-grade schools.

Regarding the use of computers in the classroom, information collected on a field trip to Rio Claro in 2005 indicated that all first-to-fourth grade schools were equipped with at least one computer laboratory for didactic purposes. Those computers were provided by the State government since 1997; thus the computer labs were comprised of a combination of old and new computers. With regards to Internet connection, not all computers may be connected to the Internet and the connection can vary from dial-up to broadband. However, all computers were equipped with CD-ROM drives. According the State Department of Education all public primary and secondary schools in Sao Paulo state would be equipped with at least one computer laboratory for didactic purposes by March, 2005 (Paulo 2004).

It can be argued that this number of computers per class is not still sufficient, considering that the average number of students per classroom is thirty or more. However, it is believed all levels of the Brazilian Government are aware of the importance of using new technologies for education, particularly early education, and the number of computers available for public schools tend to increase (Paulo 2004; Proinfo 2006).

Additionally, teachers have been continuously trained on the use of computers and the State Government has successfully implemented projects that aim to promote digital empowerment of teachers. Teachers are trained in computer skills (for those inexperienced with computers) as well as trained to improve their computer literacy. The use of computers in the classroom is always encouraged. One hundred thousand teachers in Sao Paulo State bought State-subsidised computers (Paulo 2004).

5.5 Producing multimedia-based tools for education: pros and cons

According to Banerji and Scales (2004), many technological innovations in the past were believed to revolutionise education once introduced in the classroom. Obviously, the introduction of radio and television provided additional capabilities to traditional teaching materials. However the expected revolution did not happen (Banerji and Scales 2004).

In a similar fashion, Banerji and Scales (2004) believed that these high expectations were based on the use of interactive multimedia and the Internet. They emphasised that these expectations could not be met if too much focus was placed on technology rather than cognition.

Freundschuh and Helleviks (1999) highlighted the use of multimedia for geographical education. About the advantages of multimedia applications for education, Freundschuh and Helleviks (1999, p. 272) had this to say:

> "*multimedia presentations are user friendly, can be adapted to self-paced instruction, offer 24-hour access to educational materials, offer a constantly revised educational resource, allow for distance education opportunities, are easily linked to the Internet and the World Wide Web, can easily incorporate latest research findings, and can augment classroom instruction.*"

Freundschuh and Helleviks (1999) also emphasised that with diminishing funds for education and larger student-to-instructor ratios, the use of multimedia (and also Web-delivered multimedia) would create a one-to-one learning environment. An environment that could *potentially* enhance learning.

However, Freundschuh and Helleviks (1999) did not advocate the use of computers in the classroom just for the sake of it. They stated that more extensive research in the application of multimedia-based applications for educational purposes was needed.

Torrisi-Steele (2004) claimed that multimedia and the Web were only two options in a wider range of tools available for education. The complete tool set of technologies that can be applied in a learning context comprised: textbook and other printed materials; video; face-to-face teaching; multimedia; and World Wide Web (plus other Internet-based technologies). Torrisi-Steele (2004) highlighted that the use of the Web in conjunction with other education tools have to be carefully chosen, depending on the teaching method applied.

In addition to the concerns of over-estimating the impact of the use of technology within the actual learning process as observed by Banerji and Scales (2004), Torrisi-Steele (2004) summarised the advantages and disadvantages of different tools used in education. Since this research proposes the use of the Internet to distribute educational support materials (a local school atlas), her view on the World Wide Web is shown in table 5-3.

Advantages	**Disadvantages**
Increasingly supporting multimodal presentation – text, images, sound, video and higher levels of interactive possibilities; access to up-to-date information; potential for collaborative learning with learners in multiple locations (e.g. chat, videoconferencing); potential for anytime, anyplace; highly motivational; updating of information relatively easy Wealth of up-to-date information available along with nonlinear nature, interactivity and multimodal presentation can support discovery oriented strategies	Requires costly technical infrastructure (networks, workstations, videoconferencing facilities) Development of own online materials: complex requiring expertise; can be costly and time-consuming; involves a high level of commitment Updating Web materials can be difficult/frustrating if not technically competent to some degree Sophistication of Web materials available to students is limited by access factors such as bandwidth, modem capabilities Not all educators are familiar with/comfortable with the new media technologies – steep learning curve both in technical understanding and implementation strategies; lack of awareness of the issues is one of the greatest pitfalls in adopting multimedia technologies; **as technology capabilities increase, so do complexity, commitment required, and the potential of "things not working"**

Table 5-3. Advantages and disadvantages of using the World Wide Web for teaching and learning (Torrisi-Steele 2004, p. 37).

The disadvantages for using Web-delivered education products (Torrisi-Steele 2004) raise a series of issues that should be addressed so as to optimise the final product and guarantee that it will be really useful for teachers. It is believed that if the teacher does not engage with the product, they will be very unlikely to adopt it in their practices.

Table 5-4 summarises how the issues raised by Torrisi-Steele (2004) are to be addressed in this research.

Issue	Approach adopted to address it
Requires costly technical infrastructure	The Brazilian Government, both at Federal and State levels have provided computer laboratories for public schools. It is fact that the computer labs in Rio Claro, the case study are not in sufficient numbers and the technology may be out-of-date. However, aiming to provide a product that could be used in any computer lab of public schools the technological requirements for using the product have to be low (e.g. using a lower resolution monitor and small files for low Internet connection).
Development of own online materials is hard and costly	The main goal of this research is exactly to provide a low cost solution for publishing own online material. The use of open standard technologies solve the problem because the source code is opened and can be adapted specific needs. The use of the technology does require technical expertise, to solve this problem a set of template files is proposed, those templates are extensively commented to provide the developer with all necessary information in order to publish their own local atlases.
Updating Web materials can be difficult	As mentioned above, because applications developed using the proposed templates will follow an extensive commented code, updating the materials online should not be a painstaking task.
Sophistication of Web materials is limited by Internet connection speed	To solve this problem the use of images was minimized. SVG files are text files and, therefore, their size is considerably small. In this way, the can be quickly downloaded even in dial-up connection.
Educators not familiar with new technologies tend to avoid it	The State of Sao Paulo has addressed this issue by continuously training public school teachers on the use of computers for education. Since 1997 all teachers have been trained first on the use of operational systems and common office applications and then in using educational software.

Table 5-4. Addressing the issues raised by Torrisi-Steele (2004) with regards to the use of Web-delivered educational products.

However, Torrisi-Steele (2004) analyses the disadvantages of producing educational products for the Web. When producing a product such as an atlas to be broadcast over the Internet additional issues have to be considered.

In this case, primary school teachers were the authors of the contents within the atlas, including the maps. Some premises are therefore assumed so as to establish their profile:

- They are not computer specialists, but rather they are specialised in their field of activity. In other words, the history teacher is a specialist in history, the geography teacher is a specialist in geography and so on;
- The project has budget limitations for buying equipments, software and paying extra staff for specialist tasks;
- The authors are not GIS specialists and/or GIS users, therefore they are unlikely to produce GIS-based products;
- The primarily source of materials for the atlases, maps and digital files is provided by local councils, and they are unlikely to be accurate or georeferenced. They also can be out of date; and
- Their computer skills are expected to be on the average, considering that the State government trained them to be users, not as specialists.

It is important to identify the profile of the atlas authors because they will be primarily the users of the templates developed. Since it is assumed that the authors are average computer users, it is also assumed that they will pass on the task of actually producing the digital files to university students from education and/or geography courses. This was the case with the paper version of the *School Atlas of Rio Claro*; the maps were digitized by university students working for the project (Carneiro 2003).

Fuckner and Loch (2005) identified the general profile of a school atlas developer in Brazil. They listed the obstacles for producing digital atlases in Brazil, the difficulties identified by Fuckner and Loch (2005), as well as proposed solutions, are shown in table 5-5.

Dificulties	**Possible solutions**
The target audience is still limited because just a percentage of the population has access to computers	In fact the number of computers classrooms available in Sao Paulo State is still insufficient, however it tends to increase.

There are numerous difficulties in using development software, and particularly Geographic Information Systems, by researchers and teachers, as well as the population in general	The developers do not use GIS, therefore difficulties in using such programs are not an issue here. The technology proposed for developing the atlases is open source and free of cost. Some technical knowledge is necessary in order to develop the final product, however the need for extensive technical knowledge should be minimised in order to reduce production costs.
Problems related to contents of the atlas such as lack of reliable georeferenced maps and other specific contents for GIS-based products	This problem is quite common in geospatial information provided by Brazilian city councils. As SVG is not a geospatial technology, it can be used in this situation.
Lack of professionals able to develop such products	It is assumed that the developers are primary school teachers, university researchers (from education and geographical education backgrounds) and university students. Those professionals could experience some problems in developing the application due to the lack of technical knowledge in publishing in digital media; this drawback is to be overcome by extensively commenting the code with instructions.
Lack of culture in the area of Cartography in Brazil of developing digital atlases	This scenario tends to change. The analysis of papers published in the five conferences on Cartography for Children indicate an increasing research interest on the production of digital educational products.

Table 5-5. Problems for producing local digital atlases for education in Brazil and possible solutions. After Fuckner and Loch (2005).

5.6 Developing SVG templates for Web-map publishing

Following the same guiding principle of the paper version of the atlas, the main objective of this research is to develop and evaluate a publishing methodology that will provide school atlases developers (teachers and researchers from geography and education departments of Brazilian universities) with a sound technology for publishing contents directly to the Internet.

The idea behind the proposed methodology is to change Brazilian atlas developers work methodology as little as possible. In the same way they planed the design for A4 paper format, it is suggested here that they work with 800x600 pixels screen resolution. They could develop their maps to a suitable size to fit into the screen format proposed. Additionally, since the templates cover a range of four different interactive situations, atlas developers could either create their interactive contents within the limitations of the templates proposed, or they could use the templates as a starting point and develop interactive atlas products that will encompass interactive functionalities beyond what is available in the templates. The approach to be adopted will depend on the budget of their projects, the timeframe and the profile of the development team.

What is important to highlight that the methodology developed here is not meant to establish limits and determine what an SVG-based Web atlas should be, but rather it is meant to show Brazilian atlas developers a path to follow, providing them an inexpensive option to publish their products on the Internet and, by doing so, give them freedom to go further, beyond the scope covered in the templates proposed here.

The methodology proposed should follow the guidelines highlighted in table 5-6.

Layout and Interface Design
Analyse the layout and contents of the paper version of the atlas to determine the ideal layout for the digital version
The interface has to be clean and easy to understand
The interface design should be flexible and adaptable
Code
The code should be easy-to-understand
Interactivity should be easy to implement
There should be an easy way of converting the existing maps to SVG format
The SVG maps should be easily incorporated into the templates
Files should be compact to be quickly downloaded in old computers and/or slow Internet connection
Interactive functionalities
The interactivity has to complement the information provided rather than divert the student's attention
Similarly to the paper version, the functionality, as well as the page design has to follow patterns. In this way pages with historical contents should have similar interactive functionalities.

Table 5-6. Guidelines adopted for proposing a methodology for publishing Brazilian local school atlases.

The guidelines highlighted in table 5-6 are explained in the following sections.

5.6.1 Layout and Interface Design

A number of aspects need to be considered when developing a layout for a Web application. The ideal display resolution is one of them. According to the W3 Schools Web site (2005) about 25% of the computers connected to the Internet use a display resolution of 800x600 pixels. Although there are no statistics available about the display resolution adopted amongst Brazilian Internet users, information collected during the field trip indicated that computer laboratories available for use in public primary schools comprised recent as well as old displays (some computer labs were created in the late nineties and have not been updated since). Therefore, it is believed that computers used in Brazilian might mostly adopt a display resolution of 800x600 pixels.

Therefore, in order to assure that the proposed template would be designed for viewing on most computer displays used in public schools an 800x600 display resolution was adopted.

The topics within the atlas were summarised so as to create an optimised navigation menu. It was established so that the menu would be located at the top of each page. The layout chosen for each page is shown in figure 5-4.

Figure 5-4. Proposed layout for the atlas.

After some tests with design, it was decided that the contents would be categorised into five options that should appear in the fixed menu as follows:

- *Início* (home);
- *Onde Estamos?* (location and orientation);
- *História* (comprising archaeology and history);
- *Patrimônio Ambiental e Cultural* (comprising heritage and environment); and

- *A Cidade* (comprising geography contents and urban sectors).

The overall design should follow the same guidelines used for the paper version. The design of the pages of the *School Atlas of Rio Claro* is very simple. There are no childish-like characters or intense use of colours, which are quite common characteristics of publications that target youngsters. Oppositely, the design could be described as ‘sober’. The adoption of this design can be explained by budgeting restrictions, as well as the intention of focusing the student’s attention on the contents of the publication rather than on its appearance.

The analysis of different interface designs adopted in Internet School Atlases indicated that the use of elaborate design is not uncommon. The examples illustrated previously are amalgamated in figure 5-5. This figure shows the use of common resources in interface design for children. Figure 5-5 A and B (both part of the same application) use contrasting colours and the design resembles an amusement park. The clear intention in this case is to foster the child to interact with the application the same way as they would interact and explore an amusement park in real life.

Figure 5-5C also explores the use of contrasting colours. The interface metaphor adopted here is a bedroom with toys. It seems that the purpose is the same as Figures 5-5A and B, to encourage the child to explore the site in the same manner as they explore any environment with which they are familiar. Figure 5-5D shows a different interface design. Although the contrasting colours are also employed, this is a more conventional interface, with a navigation bar located on the left of the screen.

Figure 5-5E and F use a character that works as an assistant when using the application. The characters are located in the bottom right corner in figure 5-5E and in the bottom right corner in figure 5-5F. Both applications also employ contrasting colours.

The proposed design followed the same guiding principles of the paper atlas. Therefore the interface should be simple, based in simple shapes. Contrasting colours were used. However there should be a pattern in use of colours, for example a blue bar with a question mark in lighter blue should be used to provide students with information about the section of the atlas they have on the screen, and so on.

A

B

Source: http://www.mapzone.co.uk/index.htm

C

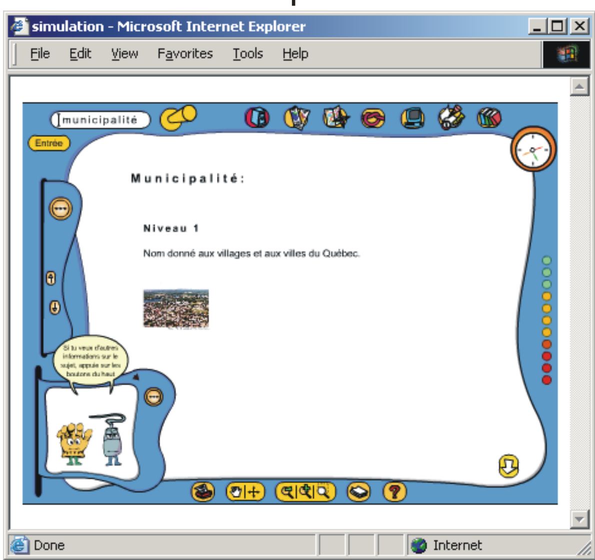
D

Source: http://www.mapzone.co.uk/pageshomework help/index.htm

Source: http://www.ibge.org.br

E

F



Source: http://tirolatlas.uibk.ac.at/kids/modules/memory/beznt/?page=2&lang=de&mode=2

Source: http://atlasduquebec.qc.ca/scolaire/

Figure 5-5. Different interface design used in geographical educational products.

It is believed that such design would focus the student's attention on the contents, as well as the paper version, and this design could easily be reproduced or changed by other developers (users of the templates) to suit their respective projects. Since it is believed that the prospective user of the templates is unlikely to be an experienced Web publisher, with budget restrictions, there will probably not be a professional designer in the developing team. Therefore the graphical interface proposed has to be simple, intuitive and effective.

After testing different interface designs, it was decided that an approach would be that Brazilian primary school students be invited to design the navigation bar for the atlas. The involvement of students in this stage was considered beneficial, because it not only engages students with the application but it also removes the need for the developing team to design the navigation bar.

The students were selected by their teachers from those already using the paper version of the atlas. Therefore they were familiar with the contents of the publication. Five students from the Fourth grade studying in three different classes in two different schools, with ages ranging from 9 to 10 years old, were invited to design the navigation bar for the atlas.

A letter was sent to selected teachers working in the second part of the main atlas project (assessing the use of the paper version of the atlas) containing instructions on the purpose of the request and some guidelines for the design. An example of a navigation bar (using a 'treasure map' metaphor) was provided to them (figure 5-6). The letter sent to the teachers is attached in the appendix.

Figure 5-6. A proposed 'treasure map' navigation menu.

It was thought that the example navigation bar provided for the teachers could 'contaminate' the final design proposed by the students, but that was not the case. Surprisingly, the students came up with completely different designs. In fact, the design proposed by the students showed that they had a deep identification with the contents of the atlas.

Instead of using the whole area provided in a single drawing, using the stickers with the titles of different items of the menu provided, they opted for designing single icons for each item proposed. The icons designed by the students are shown in figure 5-7.

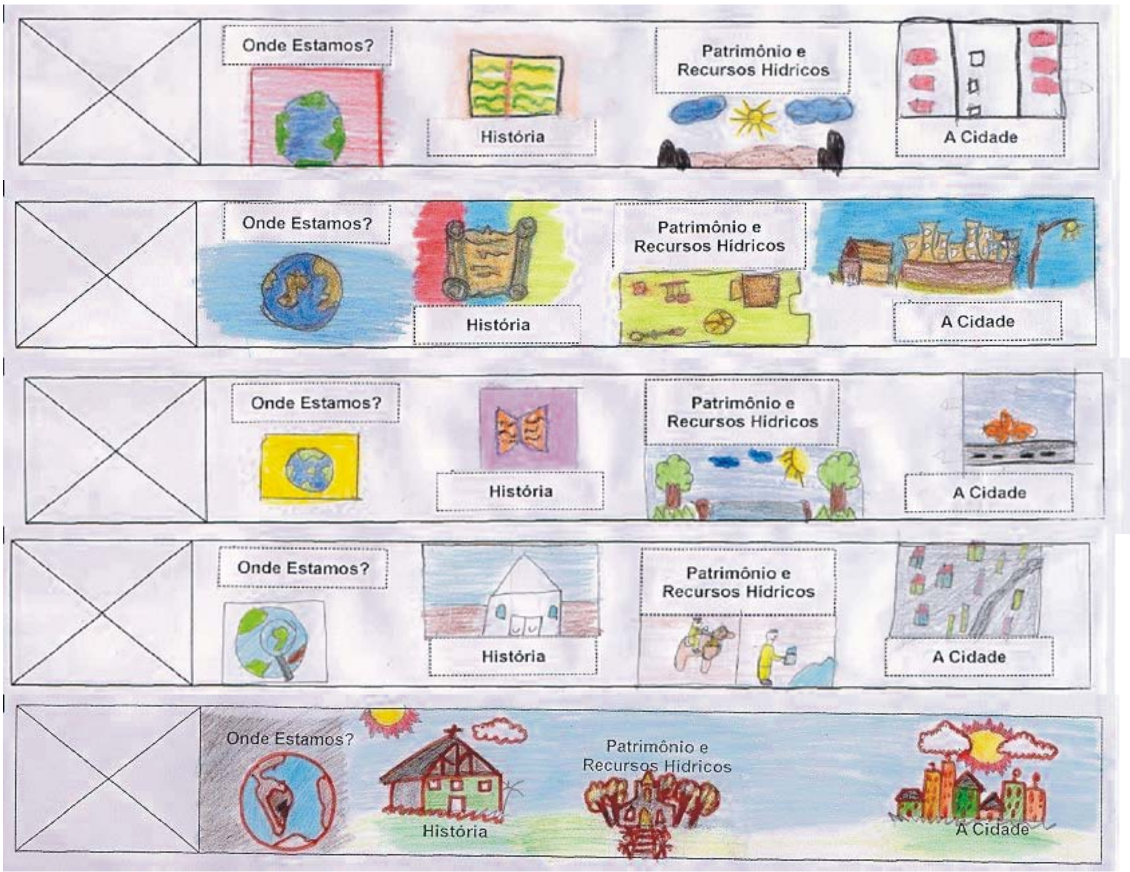


Figure 5-7. Navigation bars suggested by students.

Some interesting similarities can be identified in the student's drawings:

- All students proposed a navigation bar based in icons.
- All students designed a very similar icon for the item *Onde Estamos?* (location and orientation). The students decided to represent this topic with a globe; student number four (the forth drawing in figure 5-7) added a magnifying glass to the icon. This design is the cover of the *School Atlas of Rio Claro*. It is important to highlight the issue of scale at this point because the label provided in Portuguese for this topic "*Onde Estamos?*" can be translated as

"Where are we?", normally such question would remind immediate location. The expected graphic answer would be "We are at school" or "We are in Rio Claro", however the graphic answer for all the students was "We are in Planet Earth".

- For the item 'History' there were two groups of icons. Three students drew old books and/or publications (student number two drew a papyrus); the other two students decided to draw historical buildings to represent the topic. Historical buildings and churches are still quite common in Rio Claro, despite some significant buildings being recently demolished. The paper version of the atlas extensively explores the topic of historical sites and new developments, thus it is believed that the students tried to express graphically their knowledge about the subject based on the atlas contents.
- The icon that represents Environment and Heritage (*Patrimônio Ambiental e Cultural*) was the most diverse of all. Students one, three and five drew landscapes to represent the topic; student number five drew in detail a particularly recognisable image of an historical church located inside the State Forest. Student number two drew random objects, a ball and handcuffs amongst other objects. It is believed that student number two drew handcuffs in an attempt to link the icon to a significant fact in Rio Claro's history. Rio Claro was the first place in Brazil where slavery was legally banned. Student number four made a very interesting reading of the topic and proposed a split icon, on the left there is a man riding what seems to be a donkey, the man is carrying bags with supplies. This appears to be an attempt to connect the icon with the history of the city. Rio Claro was first established as a stop over for merchants and the early explorers travelling Brazilian's countryside. On the other part of the drawing made by student number four, a man takes some water from a river. All the pieces of information provided indicated that the students were very familiar with the contents of the atlas and tried to express their knowledge in their drawings.
- For the icon dedicated to the city the students drew different views of the urban area. Student number four opted for a bird's eye view, whilst the others portrayed a parallel view, emphasizing high-rise buildings in the skyline. The

only exception was student number three, who decided to draw a road and a car.

The icons chosen to comprise the navigation bar are shown in table 5-7.

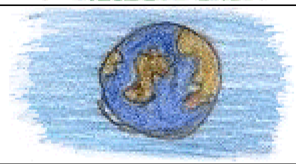
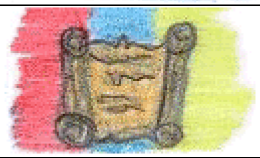
Icon	Title
	*Início*
	*Onde Estamos?*
	*História*
	*Patrimônio Ambiental e Cultural*
	*A Cidade*

Table 5-7. The icons in the navigation bar proposed.

After defining what icons would be part of the navigation menu, the next step was the analysis of the layout adopted for the paper version of the atlas in order to establish the best way of adapting the contents to the computer screen. The following sections focus on the analysis of the pages of the *School Atlas of Rio Claro* and the specification adopted for the Web design.

5.6.1.1 Interface Design – Template 1

Template number one focuses on information presented in a linear fashion. Sample pages of the *School Atlas of Rio Claro* that use this kind of information architecture are provided in figure 5-8.

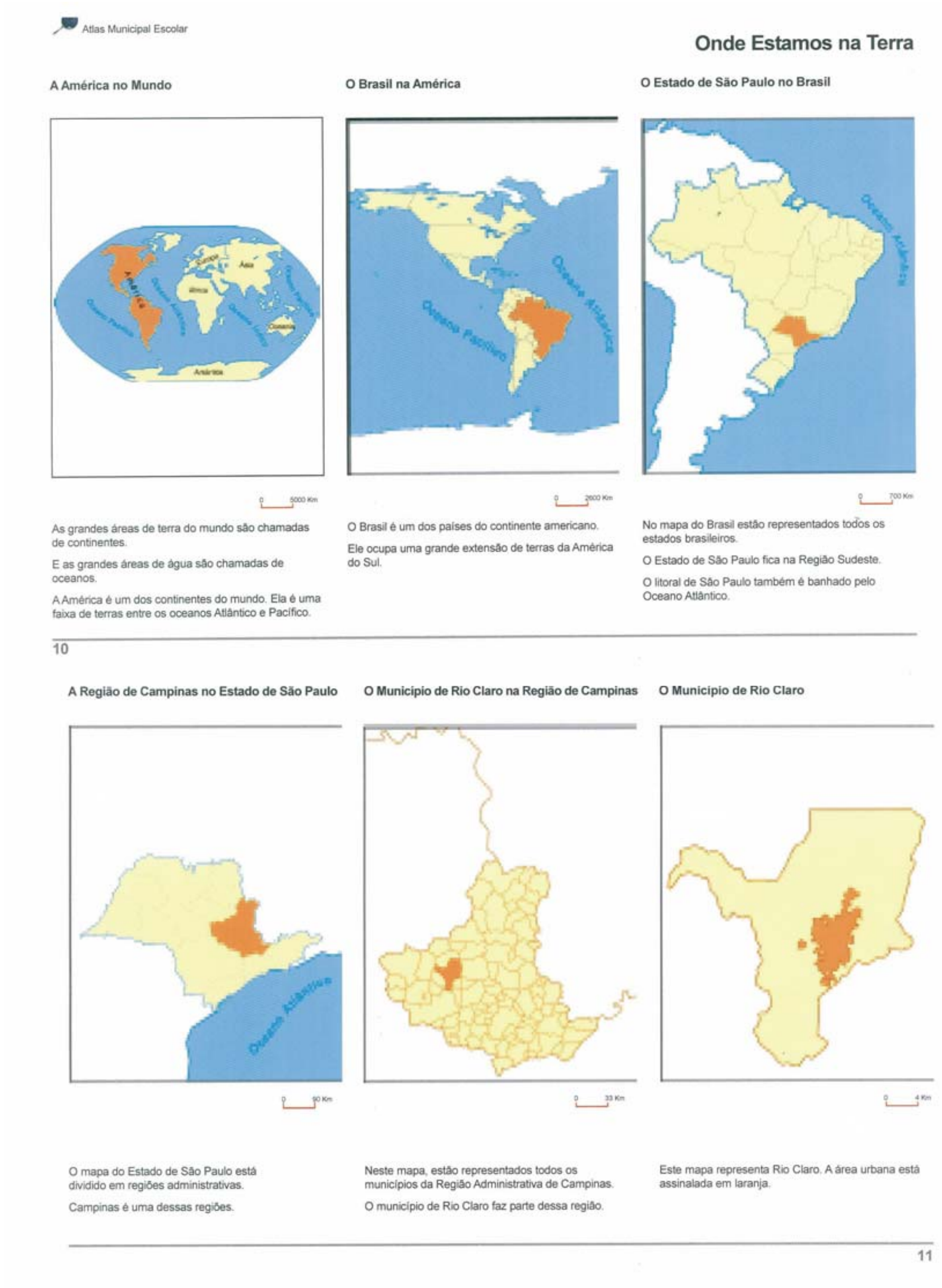


Figure 5-8. Pages 10 and 11 of the *School Atlas of Rio Claro*.

Figure 5-8 shows pages 10 and 11 of the atlas, exploring orientation and location. From the left on page 10 to the right in page 11 the student 'zooms-in' on the map. From global scale to the city of Rio Claro (highlighting urban and rural areas).

The information architecture in this topic is just linear and the student is invited to explore (from the left - the globe - to the right - the city) the area of study using different scales. This kind of architecture of information is quite common and, therefore, the first template proposed aimed to deal with linear presentations.

The design adopted for the first template is shown in figure 5-9. Some changes in the design were necessary in order to adapt the contents of the pages shown in figure 5-8 to the computer screen. Firstly, each map was shown in a separate screen. The student was invited to navigate between screens by clicking on the arrows located at the bottom of the screen or by following the clues provided. For example, in the first map, the map of the world, the student was asked to click in the American continent to move forward to the next map.

Question marks were placed in the continents, every time the student moved the mouse over a question mark the name of the continent was shown in the response area located on the top of the map.

A help box was located at the bottom of the screen (the blue bar with a question mark in the left). The help box provided the user the necessary information for navigation.

Another necessary change in the interface design was introduced in screens four and five. In those screens an inset map was located on the top right corner of the main maps. The inset map reproduced the previous map shown, in this way screen four showed Sao Paulo State and the inset map showed the Brazilian map; in screen number five the main map portrayed Campinas Administrative Region and the inset map showed its location in Sao Paulo State. The changes were introduced because it was believed that students are not familiar with some political and administrative subdivisions of Brazilian territory.

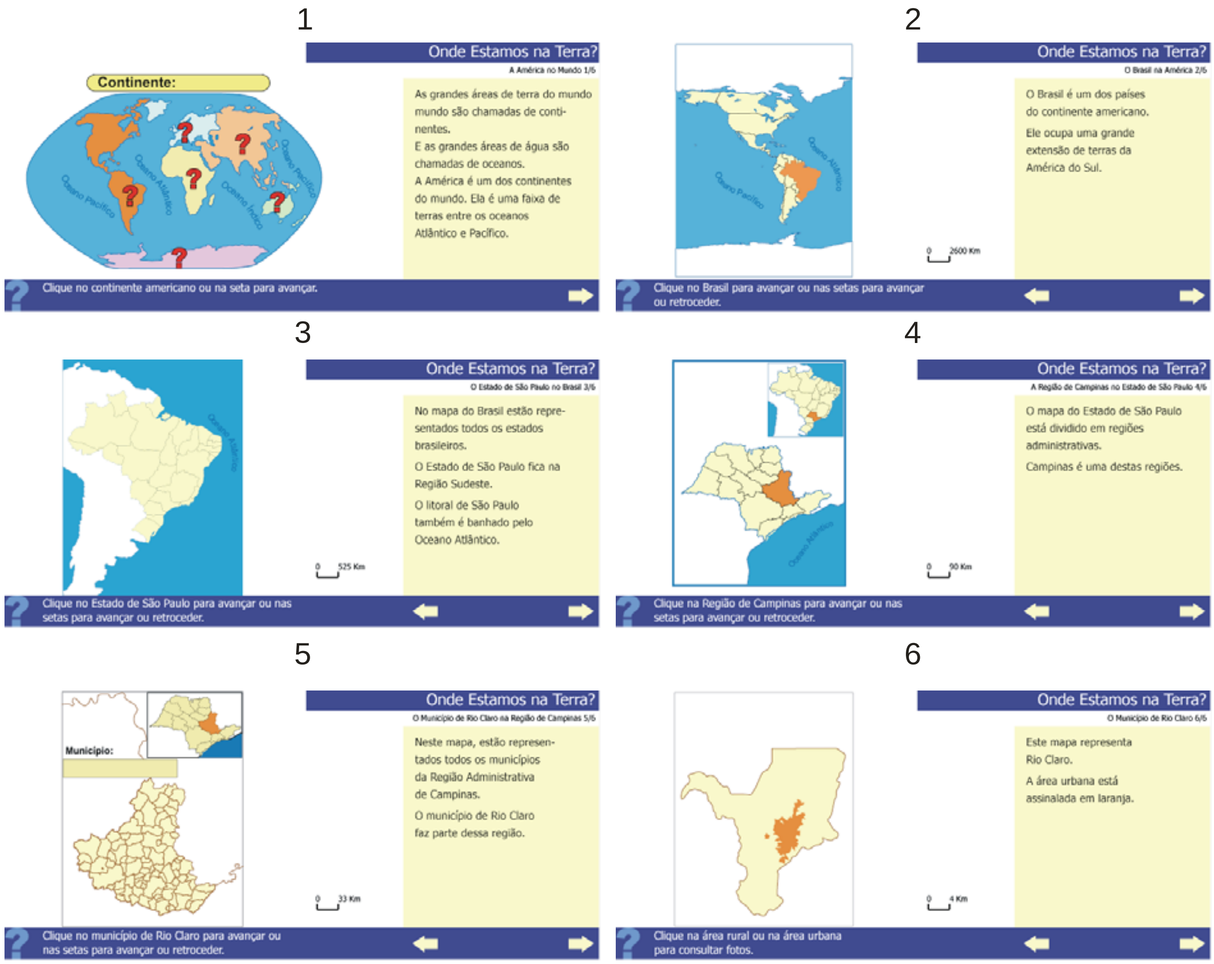


Figure 5-9. Interface design adopted in Template 1.

Table 5-8 illustrates the specifications adopted for designing Template number 1.

Filling colours for graphic components			
Colour	**Web Safe Code**	**RGB**	**Comments**
	66CCFF	102,204,255	Fill – Oceans and seas
	FFFFCC	255,255,204	Fill – Africa, text box, navigation arrows and all maps on screens 2, 3, 4, 5 and 6.
	FF9933	255,153,51	Fill – America, urban areas and highlighting colour for mouse over effects
	CCFFCC	204,255,204	Fill - Oceania
	FFCC99	255,204,153	Fill - Asia
	CCFFFF	204,255,255	Fill - Europe
	FFCCFF	255,204,255	Fill - Antarctica
	FFFF99	255,255,153	Fill – Response Area
	3333CC	51,51,204	Fill – Title Bar and Help Box
	6699FF	102,153,255	Fill – Question mark in Help Box
	FFFF00	255,0,0	Fill – Question marks within the map

Text specifications					
Font-Family	Font-Size	Font-Weight	Stroke	Colour	Comments
Arial	8	Normal	none	3333FF 51,51,255	Ocean names
Tahoma	20	Normal	none	FFFFFF 255,255,255	Title

Tahoma	10	Normal	none	000000 0,0,0	Navigation text and scale text
Tahoma	14	Normal	none	000000 0,0,0	Contents text box
Tahoma	14	Normal	none	FFFFFF 255,255,255	Help text
Arial	18	Bold	none	000000 0,0,0	“Continente” label in screen 1
Arial	18	Normal	none	000000 0,0,0	Response text in screen 1
Arial	13	Bold	none	000000 0,0,0	“Município” label in screen 5
Arial	13	Normal	none	000000 0,0,0	Response text in screen 5

Line work specifications

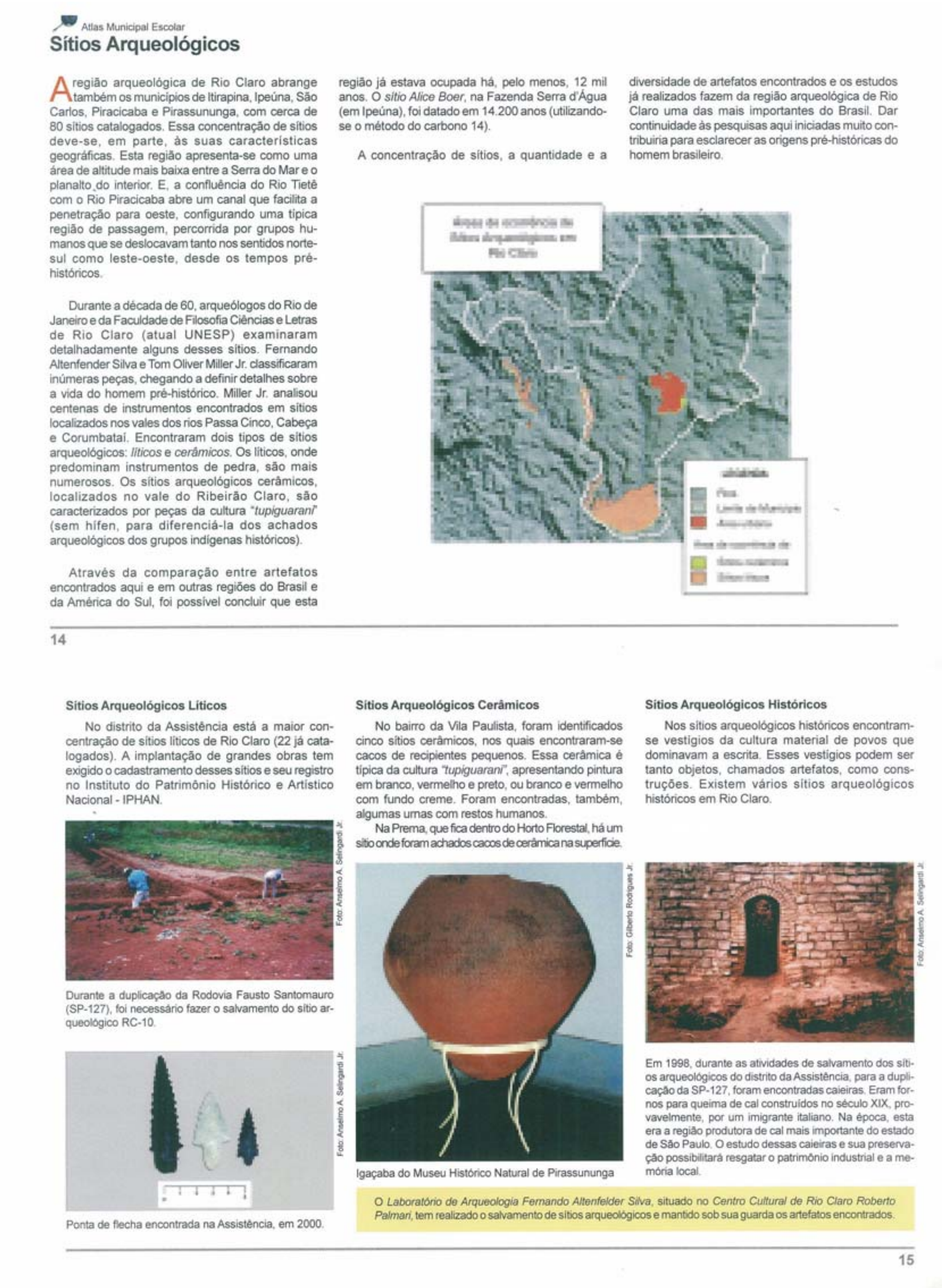
Colour	Web Safe Code	RGB	Stroke-Width	Comments
	000000	0,0,0	7	Border of response area and red question marks
	0066CC	0,102,204	7	Border of continents
	3333CC	51,51,204	2	Border of navigation arrows
	000000	0,0,0	2	Scale bar
	000000	0,0,0	7	Stroke-dasharray:10 5 Used for international borders (screen 2)
	000000	0,0,0	2	Stroke-dasharray:5 7 Used for state borders (screen 3)
	000000	0,0,0	10 5	Stroke-dasharray:20 10 Used for political borders in screen 4 and 5
	996633	153,102,51	1	Internal borders in screen 5 and 6

Table 5-8. Specifications adopted in Template 1.

5.6.1.2 Interface Design – Template 2

Template number 2 focuses on the use of clickable maps. Figure 5-10 illustrates a section of the *School Atlas of Rio Claro* where this architecture of information can be employed.

Figure 5-10 illustrates pages 14 and 15 of the paper *School Atlas of Rio Claro* exploring the topic of archaeology. The page at the left (page 14) shows a map of the city with different archaeological sites highlighted. The following page explores those sites in detail.



Atlas Municipal Escolar

Sítios Arqueológicos

A região arqueológica de Rio Claro abrange também os municípios de Itirapina, Ipeúna, São Carlos, Piracicaba e Pirassununga, com cerca de 80 sítios catalogados. Essa concentração de sítios deve-se, em parte, às suas características geográficas. Esta região apresenta-se como uma área de altitude mais baixa entre a Serra do Mar e o planalto do interior. E, a confluência do Rio Tietê com o Rio Piracicaba abre um canal que facilita a penetração para oeste, configurando uma típica região de passagem, percorrida por grupos humanos que se deslocavam tanto nos sentidos norte-sul como leste-oeste, desde os tempos pré-históricos.

Durante a década de 60, arqueólogos do Rio de Janeiro e da Faculdade de Filosofia Ciências e Letras de Rio Claro (atual UNESP) examinaram detalhadamente alguns desses sítios. Fernando Altenfender Silva e Tom Oliver Miller Jr. classificaram inúmeras peças, chegando a definir detalhes sobre a vida do homem pré-histórico. Miller Jr. analisou centenas de instrumentos encontrados em sítios localizados nos vales dos rios Passa Cinco, Cabeça e Corumbataí. Encontraram dois tipos de sítios arqueológicos: *líticos* e *cerâmicos*. Os líticos, onde predominam instrumentos de pedra, são mais numerosos. Os sítios arqueológicos cerâmicos, localizados no vale do Ribeirão Claro, são caracterizados por peças da cultura *"tupiguarani"* (sem hífen, para diferenciá-la dos achados arqueológicos dos grupos indígenas históricos).

Através da comparação entre artefatos encontrados aqui e em outras regiões do Brasil e da América do Sul, foi possível concluir que esta região já estava ocupada há, pelo menos, 12 mil anos. O *sítio Alice Boer*, na Fazenda Serra d'Água (em Ipeúna), foi datado em 14.200 anos (utilizando-se o método do carbono 14).

A concentração de sítios, a quantidade e a diversidade de artefatos encontrados e os estudos já realizados fazem da região arqueológica de Rio Claro uma das mais importantes do Brasil. Dar continuidade às pesquisas aqui iniciadas muito contribuiria para esclarecer as origens pré-históricas do homem brasileiro.

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Sítios Arqueológicos Líticos

No distrito da Assistência está a maior concentração de sítios líticos de Rio Claro (22 já catalogados). A implantação de grandes obras tem exigido o cadastramento desses sítios e seu registro no Instituto do Patrimônio Histórico e Artístico Nacional - IPHAN.

Foto: Anselmo A. Selingardi Jr.

Durante a duplicação da Rodovia Fausto Santomauro (SP-127), foi necessário fazer o salvamento do sítio arqueológico RC-10.

Foto: Anselmo A. Selingardi Jr.

Ponta de flecha encontrada na Assistência, em 2000.

Sítios Arqueológicos Cerâmicos

No bairro da Vila Paulista, foram identificados cinco sítios cerâmicos, nos quais encontraram-se cacos de recipientes pequenos. Essa cerâmica é típica da cultura *"tupiguarani"*, apresentando pintura em branco, vermelho e preto, ou branco e vermelho com fundo creme. Foram encontradas, também, algumas urnas com restos humanos.

Na Prema, que fica dentro do Horto Florestal, há um sítio onde foram achados cacos de cerâmica na superfície.

Foto: Gilberto Rodrigues Jr.

Igaçaba do Museu Histórico Natural de Pirassununga

Sítios Arqueológicos Históricos

Nos sítios arqueológicos históricos encontram-se vestígios da cultura material de povos que dominavam a escrita. Esses vestígios podem ser tanto objetos, chamados artefatos, como construções. Existem vários sítios arqueológicos históricos em Rio Claro.

Foto: Anselmo A. Selingardi Jr.

Em 1998, durante as atividades de salvamento dos sítios arqueológicos do distrito da Assistência, para a duplicação da SP-127, foram encontradas caieiras. Eram fornos para queima de cal construídos no século XIX, provavelmente, por um imigrante italiano. Na época, esta era a região produtora de cal mais importante do estado de São Paulo. O estudo dessas caieiras e sua preservação possibilitará resgatar o patrimônio industrial e a memória local.

O *Laboratório de Arqueologia Fernando Altenfelder Silva*, situado no *Centro Cultural de Rio Claro Roberto Palmari*, tem realizado o salvamento de sítios arqueológicos e mantido sob sua guarda os artefatos encontrados.

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Figure 5-10. Pages 14 and 15 of the paper *School Atlas of Rio Claro*.

The information architecture that can be adopted for this topic is a hierarchical one. In this way a clickable map can be provided. When the student clicks in one part of the map, the information related to the feature chosen is displayed. Therefore, a template dealing with clickable maps was proposed.

The design adopted for the second template is shown in figure 5-11. Once again, some changes in the design were necessary so as to adapt the contents of the pages to the screen. Because there was much of text and images in the page, it was decided that the main map would be visible all the time in the left of the screen and the contents on the right would change according to the choice made by the user. Initially, the text of page 14 is shown (figure 5-11).

Considering that the text in page 14 is long, there would be no space to show the complete text and the help box (in blue) located at the bottom of the page. It was considered that the help box would provide navigation information to the user and therefore should be visible all the time. The solution found was to create a 'slider' object (in grey and red) at the right of the text because this kind of scrolling bar is a metaphor extensively used in *Windows* applications.

When the user clicks in one of the two archaeological sites, the main text box is replaced with a second text box, in yellow. Clicking on the navigation arrows (in orange) or in other area of the map, will change the text box to different content.

Figure 5-11 portrayed the interface design and the links between the screens in Template 2.

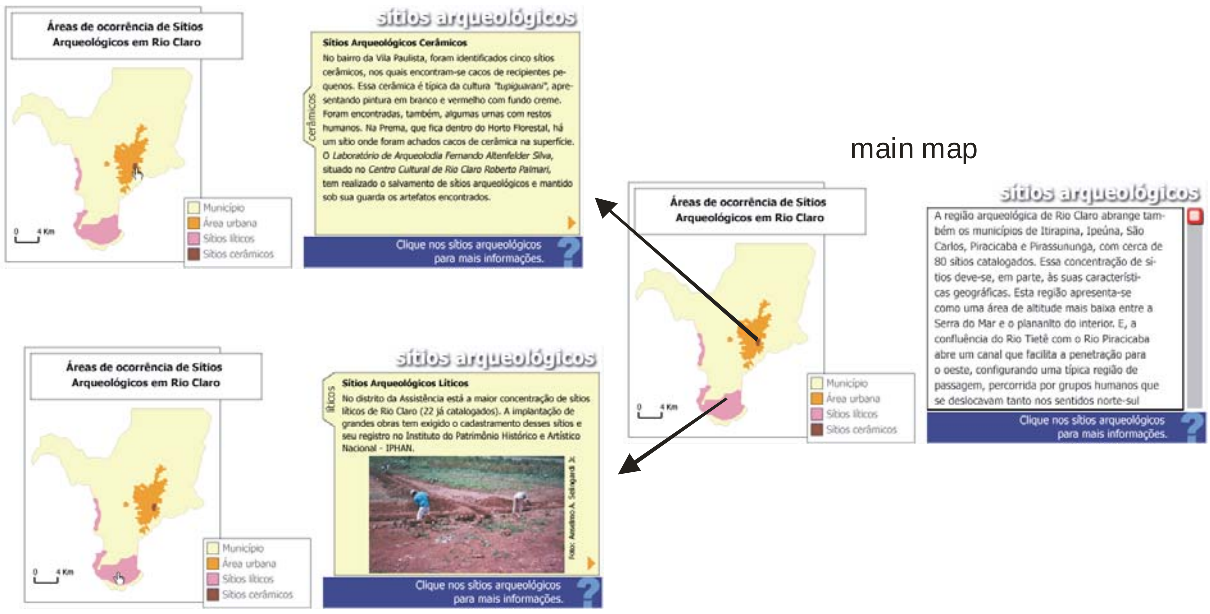


Figure 5-11. Interface design and links adopted in Template 2.

As can be seen in figure 5-11 the main map was digitised. The original file provided by the developers was the image shown in figure 5-10, however the quality of the image was not ideal and, therefore, the need for digitisation. Given that SVG is a vector standard, future users of the templates provided would be strongly encouraged to use vector maps.

Table 5-9 shows the specifications adopted for designing Template number 2.

Filling colours for graphic components			
Colour	**Web Safe Code**	**RGB**	**Comments**
	FFFFCC	255,255,204	Fill – City and additional text boxes.
	FF9933	255,153,51	Fill – Urban Area and navigation arrows
	996633	153,102,51	Fill – Ceramic archaeological site
	FF99CC	255,153,204	Fill – Lithic archaeological site
	3333CC	51,51,204	Fill – Title Bar and Help Box
	6699FF	102,153,255	Fill – Question mark in Help Box
	FFFF00	255,0,0	Fill – Scrolling button
	999999	153,153,153	Fill – Scroll bar

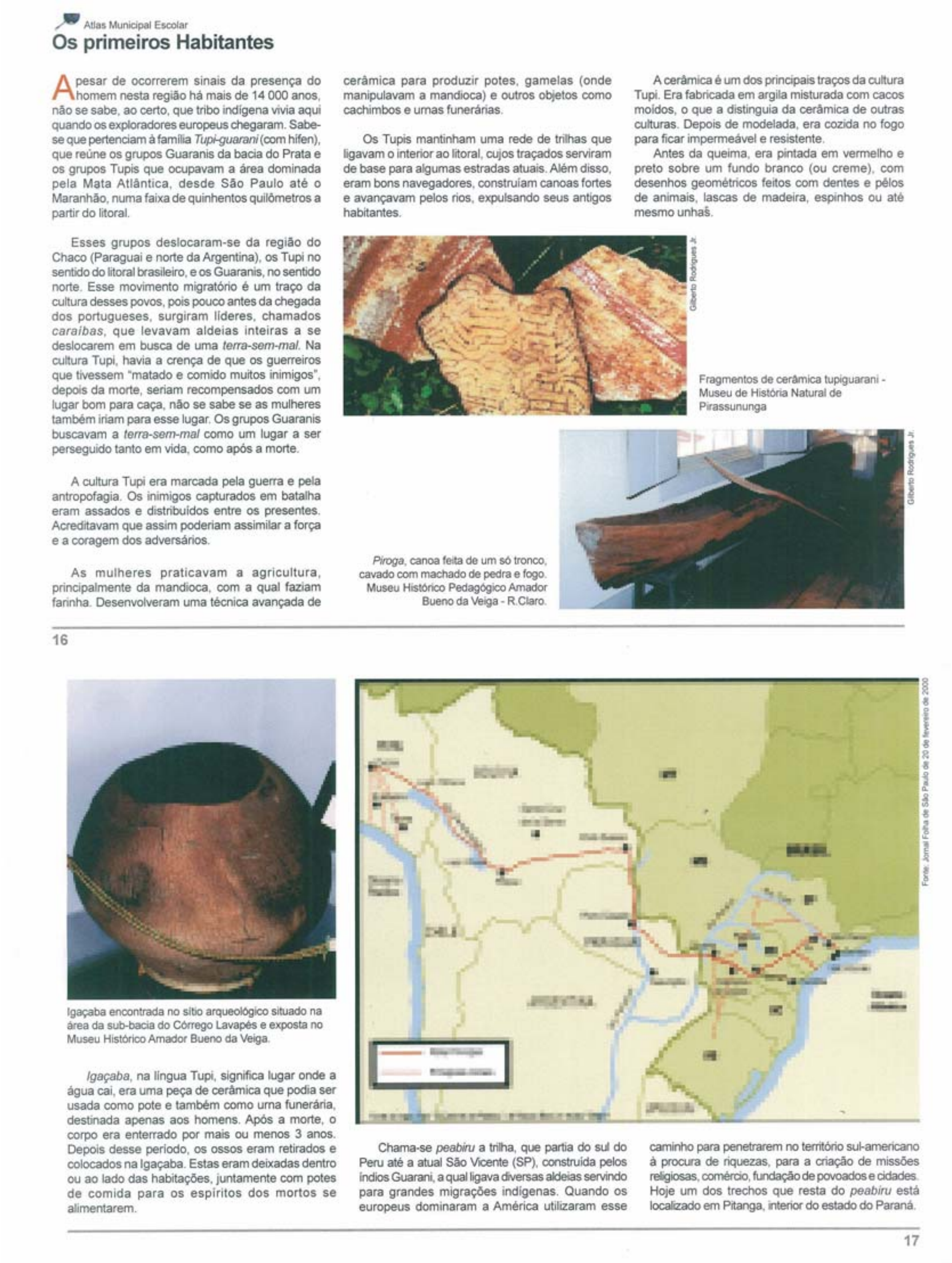
Text specifications					
Font-Family	Font-Size	Font-Weight	Stroke	Colour	Comments
Tahoma	26	Bold	none	FFFFFF 255,255,255	Title
Tahoma	14	Normal	none	000000 0,0,0	Contents text box
Tahoma	14	Bold	none	000000 0,0,0	Map Title
Tahoma	12	Normal	none	000000 0,0,0	Text box – additional information
Tahoma	10	Normal	none	000000, 0,0,0	Scale text and photo legends
Tahoma	13	Normal	none	999999 153,153,153	Map legend text
Tahoma	14	Normal	none	FFFFFF 255,255,255	Help Text Box

Line work specifications				
Colour	**Web Safe Code**	**RGB**	**Stroke-Width**	**Comments**
	000000	0,0,0	2	Border of text box, legend and map frame
	000000	0,0,0	1	Border of map title, legend frame, legend entries and additional text boxes
	996633	153,102,51	1	City's borders

Table 5-9. Specifications adopted in Template 2.

5.6.1.3 Interface Design – Template 3

In both Templates 1 and 2 the main focus of attention was the map. In Template 1 maps are displayed in a linear fashion. In Template 2 the clickable map is the interface for navigation. However, there is a third situation there needs to be considered, when the text is the main focus of attention and maps and figures are employed rather as complementary information. Figure 5-12 illustrates a section of the *School Atlas of Rio Claro* that fits this situation.



Atlas Municipal Escolar

Os primeiros Habitantes

Apesar de ocorrerem sinais da presença do homem nesta região há mais de 14 000 anos, não se sabe, ao certo, que tribo indígena vivia aqui quando os exploradores europeus chegaram. Sabe-se que pertenciam à família *Tupi-guarani* (com hífen), que reúne os grupos Guaranis da bacia do Prata e os grupos Tupis que ocupavam a área dominada pela Mata Atlântica, desde São Paulo até o Maranhão, numa faixa de quinhentos quilômetros a partir do litoral.

Esses grupos deslocaram-se da região do Chaco (Paraguai e norte da Argentina), os Tupi no sentido do litoral brasileiro, e os Guaranis, no sentido norte. Esse movimento migratório é um traço da cultura desses povos, pois pouco antes da chegada dos portugueses, surgiram líderes, chamados *caraíbas*, que levavam aldeias inteiras a se deslocarem em busca de uma *terra-sem-mal*. Na cultura Tupi, havia a crença de que os guerreiros que tivessem "matado e comido muitos inimigos", depois da morte, seriam recompensados com um lugar bom para caça, não se sabe se as mulheres também iriam para esse lugar. Os grupos Guaranis buscavam a *terra-sem-mal* como um lugar a ser perseguido tanto em vida, como após a morte.

A cultura Tupi era marcada pela guerra e pela antropofagia. Os inimigos capturados em batalha eram assados e distribuídos entre os presentes. Acreditavam que assim poderiam assimilar a força e a coragem dos adversários.

As mulheres praticavam a agricultura, principalmente da mandioca, com a qual faziam farinha. Desenvolveram uma técnica avançada de cerâmica para produzir potes, gamelas (onde manipulavam a mandioca) e outros objetos como cachimbos e urnas funerárias.

Os Tupis mantinham uma rede de trilhas que ligavam o interior ao litoral, cujos traçados serviram de base para algumas estradas atuais. Além disso, eram bons navegadores, construíam canoas fortes e avançavam pelos rios, expulsando seus antigos habitantes.

A cerâmica é um dos principais traços da cultura Tupi. Era fabricada em argila misturada com cacos moídos, o que a distinguia da cerâmica de outras culturas. Depois de modelada, era cozida no fogo para ficar impermeável e resistente.

Antes da queima, era pintada em vermelho e preto sobre um fundo branco (ou creme), com desenhos geométricos feitos com dentes e pêlos de animais, lascas de madeira, espinhos ou até mesmo unhas.

Gilberto Rodrigues Jr.

Fragmentos de cerâmica tupiguarani - Museu de História Natural de Pirassununga

Gilberto Rodrigues Jr.

Piroga, canoa feita de um só tronco, cavado com machado de pedra e fogo. Museu Histórico Pedagógico Amador Bueno da Veiga - R.Claro.

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Igaçaba encontrada no sítio arqueológico situado na área da sub-bacia do Córrego Lavapés e exposta no Museu Histórico Amador Bueno da Veiga.

Igaçaba, na língua Tupi, significa lugar onde a água cai, era uma peça de cerâmica que podia ser usada como pote e também como urna funerária, destinada apenas aos homens. Após a morte, o corpo era enterrado por mais ou menos 3 anos. Depois desse período, os ossos eram retirados e colocados na Igaçaba. Estas eram deixadas dentro ou ao lado das habitações, juntamente com potes de comida para os espíritos dos mortos se alimentarem.

Chama-se *peabiru* a trilha, que partia do sul do Peru até a atual São Vicente (SP), construída pelos índios Guarani, a qual ligava diversas aldeias servindo para grandes migrações indígenas. Quando os europeus dominaram a América utilizaram esse caminho para penetrarem no território sul-americano à procura de riquezas, para a criação de missões religiosas, comércio, fundação de povoados e cidades. Hoje um dos trechos que resta do *peabiru* está localizado em Pitanga, interior do estado do Paraná.

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Figure 5-12. Pages 16 and 17 of the *School Atlas of Rio Claro*.

This section of the publication is an example of design adopted in several other pages. Here the text is considered to be the main focus of attention and, therefore, it has to be on the screen all the time. The images and maps illustrate concepts within the text and, therefore, they had to be linked to it. The interface design adopted in this template is shown in figure 5-13.

Figure 5-13. Interface design adopted in Template 3.

Following the guidelines established in Template 2, the text was placed on the right side of the screen. Due to restrictions in space, a scroll bar was created. On the left side, the standard help box (in blue) was placed on the bottom of the page.

The orange box offers the user links related to the text content (the same links can be found within the text). The yellow box (colour used here for additional information) allows the users to navigate within the pictures related to the topic using the orange navigation arrows. The navigation was implemented in a linear fashion, in a similar way to template number one. The difference here was that all contents were presented in one single file (as opposed to Template 1, where the contents were split into separate files).

The map located in page 17 (on the left in figure 5-12) could not fit inn the screen; therefore the solution was to overlap it into the main screen. In this way the map is opened in a separate window (a pop-up window) the user can then alternate the view between the main text and the additional map. This map was implemented in a separate template.

Table 5-10 illustrates the design specifications adopted in Template 3.

Filling colours for graphic components			
Colour	**Web Safe Code**	**RGB**	**Comments**
	FFFFCC	255,255,204	Fill – Photo's area.
	FF9933	255,153,51	Fill – Additional information box and navigation arrows
	3333CC	51,51,204	Fill – Help Box
	6699FF	102,153,255	Fill – Question mark in Help Box
	FFFF00	255,0,0	Fill – Scrolling button
	999999	153,153,153	Fill – Scroll bar

Text specifications					
Font-Family	Font-Size	Font-Weight	Stroke	Colour	Comments
Tahoma	26	Bold	none	FFFFFF 255,255,255	Title
Tahoma	14	Normal	none	000000 0,0,0	Contents text box
Tahoma	12	Normal	none	0000FF 0,0,255	Additional information (hyperlinks)
Tahoma	12	Normal	none	000000 0,0,0	Legend of photos
Tahoma	14	Bold	none	000000 0,0,0	Additional Information - titles
Tahoma	10	Normal	none	000000 0,0,0	Credit of photos
Tahoma	14	Normal	none	FFFFFF 255,255,255	Help Text Box

Line work specifications				
Colour	**Web Safe Code**	**RGB**	**Stroke-Width**	**Comments**
	000000	0,0,0	2	Border of text box, legend and map frame

Table 5-10. Design specifications adopted in Template 3.

5.6.1.4 Interface Design – Template 4

The final template proposed focuses on the implementation of a map with an interactive legend and a navigation map for interactive zoom and pan functions. Due to the high level of JavaScript coding necessary to develop this kind of template it was decided that this kind of map would be always available in a separate window (pop-up). Therefore the developer should not be concerned about any other contents but the map itself.

The design proposed for Template 4 is shown in figure 5-14.

Figure 5-14. Interface design proposed for Template 4.

In this template, the emphasis was placed on four elements. The first is the map itself. As the original map was provided as a vector file (*Freehand* format) it could be converted into SVG. In this way separate graphic elements within the map could be manipulated in by using an interactive legend.

The interactive legend, placed on the top right corner of the main map, allowed the user to make the layers of information invisible. Another interactive legend allowed the user to control zoom and pan in the main map. This legend was located inside the main map's frame so that an additional text box could be placed to the right. This location is not essential and this navigation map could be placed out of the main map's area as required by the developer.

The final important element in the interface design is the help box, in blue, located on the bottom right corner of the window. The text was this box, also seen in other templates, changed according to the mouse position on the screen.

Table 5-11 illustrates the design specifications adopted in Template 4.

Filling colours for graphic components			
Colour	**Web Safe Code**	**RGB**	**Comments**
	FFFFCC	255,255,204	Window's background colour and South America countries (except Brazil)
	996633	153,102,51	Brazilian States not connected to the topic
	CCCC99	204,204,153	Brazilian States connected to the topic
	3333CC	51,51,204	Fill – Help Box
	6699FF	102,153,255	Fill – Question mark in Help Box
	66CCCC	102,204,204	Fill – Interactive zoom and pan object
	66CCFF	102,204,255	Fill – Oceans
	FFFFFF	255,255,255	Fill – Text boxes and legends

Text specifications					
Font-Family	Font-Size	Font-Weight	Stroke	Colour	Comments
Tahoma	28	Bold	none	FFFFFF 255,255,255	Title
Tahoma	18	Normal	none	666666 102,102,102	Navigation Map title
Tahoma	12	Normal	none	000000 0,0,0	Contents of text box
Tahoma	9	Normal	none	000000 0,0,0	Credit of map
Arial	19	Bold	none	000000 0,0,0	Brazilian State's acronyms
Arial	14	Normal	none	000000 0,0,0	Country's names
Arial	14	Bold	none	000000 0,0,0	Ocean's names
Arial	8	Normal	none	000000 0,0,0	River's names
Arial	10	Normal	none	000000 0,0,0	City's names
Tahoma	13	Normal	none	FFFFFF 255,255,255	Help Text Box

Line work specifications				
Colour	**Web Safe Code**	**RGB**	**Stroke-Width**	**Comments**
	000000	0,0,0	3	Map frame
	333300	51,51,0	1.5	International borders (except Brazilian borders) and State borders
	333300	51,51,0	4	Brazilian borders
	FF0000	255,0,0	4	Main route
	FF0000	255,0,0	4	Stroke-dasharray:8 4 Secondary route

Table 5-11. Design specifications adopted in Template 4.

5.6.2 Using the Code

Considering that the atlas developers were expected to have little or no previous knowledge in digital publishing, the proposed solution was to provide a number of templates, prepared according to the structure of the different parts of the atlas. Those templates should be extensively documented to make them easier to be used.

Additionally, instructions on how to optimize SVG files should be provided in order to create more compact files.

The developers need to be provided with instructions on how to transfer their existing content to digital media. In the case of the *School Atlas of Rio Claro*, the contents provided by the developers were mainly in the following formats:

- Vector files: maps and timelines in *Freehand* (Macromedia); and
- Raster files: images in TIF format, comprising photographs and some scanned maps.

Those files were produced by a printing bureau for final publishing. In an interview conducted during the field trip it was noted that the printing bureau received the original maps from the atlas' developers as *Autocad* (Autodesk) and *Corel Draw* files. They also received printed photographs that had been scanned according to printing requirements.

In chapter 4, section 4.7.2., two different approaches for publishing SVG maps for the Web were illustrated: client-side SVG and server-side SVG. In the scope of this research the client-side approach was used. It is important to emphasise that this choice was due to two basic reasons:

- The lack of technical knowledge by atlas developers in regards to working with server-side architecture. In order to use this architecture it would be necessary to hire technical staff, which would increase significantly development costs; and
- The lack of physical infrastructure (a Web server), and lack of resources to maintain the server running after the project is over.

In this way the atlas should be developed to still run after the research is completed, with no need for maintenance. Therefore client-side architecture was chosen for this research.

The following methodology was proposed to for the use of the templates (figure 5-15).

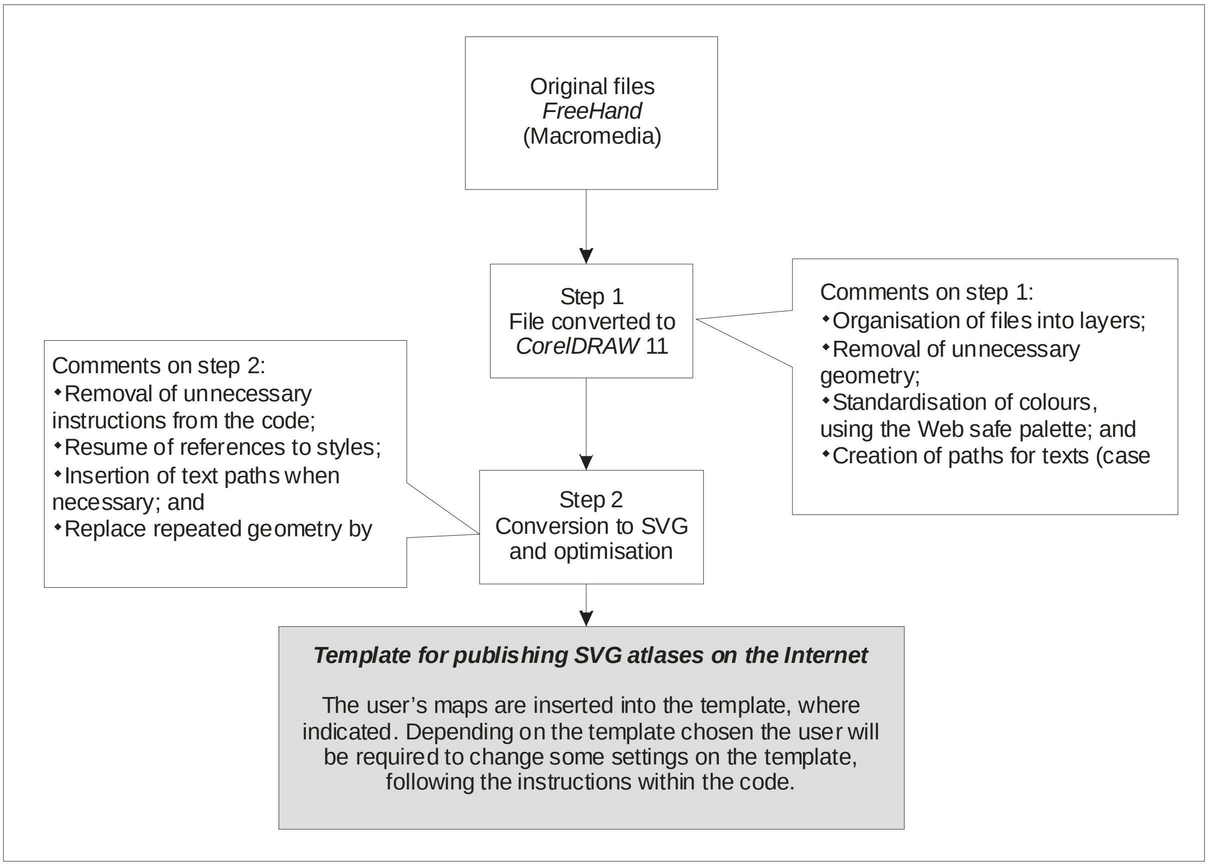

Figure 5-15. Methodology to be followed on the use of the templates.

5.6.2.1 Considerations on Step 1: using *Corel Draw* 11 to create SVG maps

Prospective atlas developers should fit into two categories: they will transpose the contents of an existing paper atlas to the Web; or they will develop their files directly for Web publishing. Either way, it is believed that graphic files will be created with a major drawing application. The most common commercial applications in this category available in the market are *Freehand* (Macromedia), *Illustrator* (Adobe) and *Corel Draw* (Corel).

Within this research the original atlas had been already published and therefore, the first step was to convert the original *Freehand* files into SVG. In order to identify the most suitable software to create SVG files a series of common graphic packages were tested.

Other software could be used to generate SVG files, but, as stated previously, one of the premises in this research was that the user would have little experience with computer graphics, and it was assumed that the developers would more likely have access to a commercial package.

The testing was done by exporting a map (a political world map) from popular proprietary graphics formats to SVG. The findings are shown in table 5-12.

Package	Company	SVG	Size of SVG File	Comments
FreeHand 10	Macromedia			
FreeHand MX 11.0.2	Macromedia			
Illustrator 10	Adobe	✓	153 kb	Files exported from *Illustrator* are too big. In addition they are not easy to understand.
Corel Draw 10	Corel	✓	43 kb	The resulting files are reasonably small, compared to the others. On the other hand, the coordinate system can be confusing because the zero is not located on the top left corner of the file, but in the centre.
Corel Draw 11	Corel	✓	30 kb using 1:10 54 kb using 1:100 67 kb using 1:1000	When saving as SVG the user is offered different drawing precisions, from 1:1 to 1:100000 units. However, the higher the precision, the bigger the resulting file. The problem with the coordinate system in the previous version was solved; zero is located in the top left corner as a default.
Corel Draw 12	Corel	✓	121 kb	The resulting file is too large and it is not possible to change the drawing precision.

Table 5-12. Comparison of SVG files obtained from different graphic packages.

From all graphics packages analysed, just the Macromedia products did not offer an option to export their files to SVG. It is worth commenting that Macromedia produces *Flash*, the most popular application for developing interactive vector graphics for the Web.

Consequently, from all products analysed, just Corel and Adobe provided an option to export their files to SVG. Considering the information shown in table 5-12, *Corel Draw* 11 was selected to create the SVG files. SVG files created by *Corel Draw* 11 were reasonably easy to understand and to optimise.

The drawing precision chosen was 1:100 units, as it provides a good definition and results in fairly small SVG files. However, the resulting files have to be optimised to eliminate unnecessary information that *Corel Draw's* export engine inserts into the SVG code.

Dahinden *et al* (2004) used Adobe *Illustrator* to generate SVG files from original *FreeHand* files. The authors described the procedures adopted and indicated some drawbacks, amongst them the size of the resulting file and also the fact that graphic objects, such as symbols and dashed lines, were transformed into polygons. In addition, text that was based on paths was exported letter-by-letter in different rotations. It is important to stress that some of these problems can be found in SVG files exported from *Corel Draw* as well, therefore some knowledge about SVG is still needed to optimise the files.

FreeHand files cannot be directly imported into *Corel Draw* 11. Therefore, there are two options for inserting *FreeHand* graphics into *Corel Draw*: the first is to use another vector format as a 'bridge', where the original *FreeHand* file is exported as a diverse vector format and then imported into *Corel Draw* 11; and the second option is simply 'cut-and-paste' using the clipboard. One could just copy the graphics from *FreeHand* and then paste it into *Corel Draw*.

Since one of the cornerstone concepts in this research was that the user will have little experience with developing graphics applications, it is believed that the second option was to be the most likely to be used, therefore all the maps in this research were inserted into *Corel Draw* using the clipboard method.

The user then needs to change the drawing units to pixels and specify a resolution of 72 dpi. This is important because the *Corel Draw's* SVG exporting engine will use the specified paper size as the final SVG file size, therefore if just one part of the map is intended to be saved as SVG it should be transferred to another file in a different paper size.

After the paper size is set, the file has to be organised into layers. The layers are exported to SVG, which saves much further work. In addition, if necessary objects such as lines and polygons can be named, this information will also be exported to SVG, text paths have to the exported to SVG as well, with proper identification.

The file also has to be cleaned before exported to SVG. This is necessary because, in this case, the original files were intended to be printed and sometimes some geometric information can be repeated and not deleted. When printed, this does not make any difference, however, overlapped geometry will be exported to SVG and, therefore, it is recommended that superfluous geometry be removed so as to create smaller SVG files.

5.6.2.2 Considerations on Step 2: preparing maps to insert into the SVG Atlas Template

Generally speaking, SVG files that are automatically generated by *Corel Draw* contain many unnecessary instructions that could be removed. Step 2 comprises the identification of these unnecessary pieces of code and optimization of the files. Although this stage could virtually be ignored, it is recommended that the user spends some time 'cleaning' the SVG files. This makes the files much smaller resulting in reduced download time.

In addition, it must be emphasised that the purpose of the template was to provide the means to produce atlases for school children and, therefore, it is believed that the smaller the download time, the least likely students are to get distracted when they are using the product.

References to CSS (Cascading Style Sheet) styles are fairly easy to optimize. *Corel Draw* refers to the style in the class property of every object. Objects that follow the same style could be grouped in 'g' tags referring to the CSS style just once.

It is also straightforward to optimize *Corel Draw's* SVG files using text paths. Text paths are very helpful when using text that is not in a straight line such as names of rivers, oceans, mountain ranges and so on. By default such text will be exported, letter-by-letter, with different rotations. A simple solution is to export a text path, in a different layer and insert it into the definitions section (using the 'defs' tag) on the SVG file, and to further refer to the text path within the map. Sample Code 6 illustrates an example of SVG code using text path.

Sample Code 6. Fragment of SVG code using text path.

```
<?xml version="1.0" encoding="iso-8859-1"?>
<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.0//EN" "http://www.w3.org/TR/2001/REC-SVG-20010904/DTD/svg10.dtd" >
<svg width="242" height="200" viewBox="0 0 2420 2000">
     <defs>
            <path id="textPath" d="M1950 747c70,180 266,243 307,391 35,115 39,245
            14,346" />
     </defs>
     <rect fill="lightblue" width="2420" height="2000" />
     <text font-size="115" font-family="Arial" fill="#0077B8" >
            <textPath xlink:href="#textPath">Oceano Atlântico</textPath>
     </text>
</svg>
```

Symbols are also important tools when optimising SVG files. It is recommended to use symbols when a particular geometry is used repeatedly. This is the case with pictorial maps and dot maps. Similarly, symbols should be used in proportional symbol maps, where the same symbol can be rendered within the file in different scales.

The use of symbols makes the file smaller and the rendering time shorter because the viewer does not need to interpret several instructions, but, on the contrary, it will repeat the same geometry, and just change the scale.

Sample Code 7 illustrates a piece of SVG code using symbols. The symbol is described in the definitions section (‘defs’ tag) and repeated in the code, as per lines 12 to 14.

Sample Code 7. Fragment of SVG code using symbols.

```
1.  <?xml version="1.0" encoding="iso-8859-1"?>
2.  <!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.0//EN" "http://www.w3.org/TR/2001/REC-SVG-20010904/DTD/svg10.dtd" >
3.  <svg width="242" height="200" viewBox="0 0 242 200">
4.       <defs>
5.              <symbol id="crop" stroke="#663300" stroke-width="2" fill="#66CC66"
                overflow="visible">
6.                     <path d="M9 0c32,22 31,49 20,60 -14,-2 -32,-24 -20,-60z"/>
7.                     <path d="M51 1c12,36 -6,57 -21,59 -10,-11 -11,-38 21,-59z"/>
8.              </symbol>
9.       </defs>
10.      <rect fill="lightyellow" width="242" height="200" />
11.      <g id="Farms" >
12.             <use x="40" y="30" xlink:href="#crop" />
13.             <use x="100" y="100" xlink:href="#crop" />
14.             <use x="170" y="30" xlink:href="#crop" />
15.      </g>
16. </svg>
```

Figure 5-16 shows how the pieces of SVG code portrait in Sample Code 6 and 7 are to be rendered in *Internet Explorer* (Microsoft).

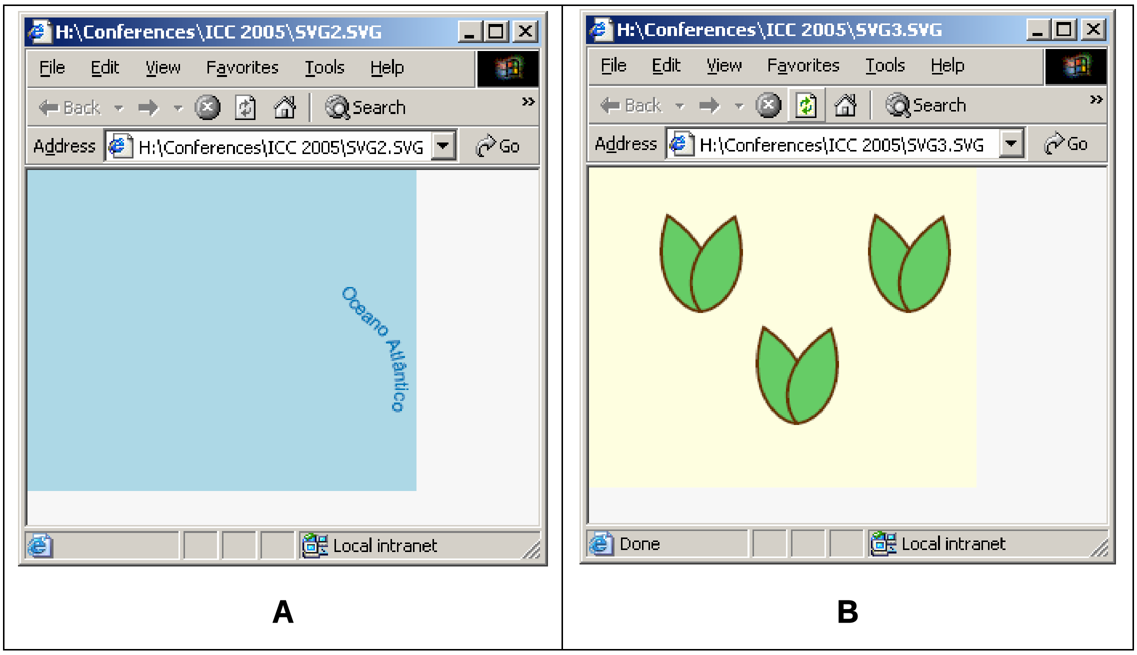

Figure 5-16. Rendering the SVG examples shown in Sample Code 6 (A) and 7 (B).

5.6.2.3 Inserting maps into the SVG Templates

The integration of the user's SVG maps into the template is one of the major concerns within this research. In order to make the process fairly straightforward the code needed to be self-explanatory, therefore the source code in the template provides extensive comments offering the user guidelines that explain where their map should be inserted and the settings that should be changed according to their particular maps used.

Figure 5-17 illustrates the rendering of a map created using Template 4. It can be seen that the main map differ from that presented in figure 5-14. The layout was also changed, as highlighted previously; the navigation map was placed outside the map frame in this case.

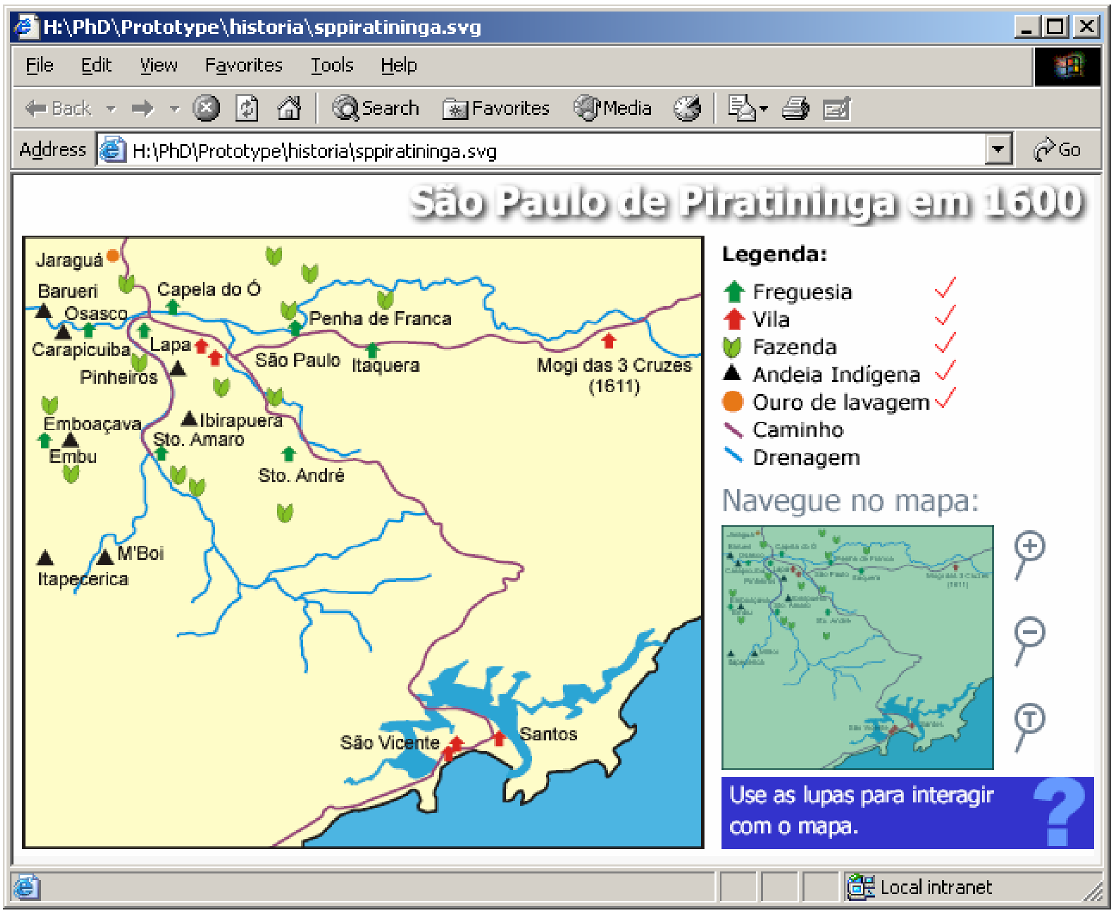

Figure 5-17. Example of Web-map implemented using Template 4.

All the symbols that can be seen in the legend (on the right of the main map) were inserted as SVG symbols, following the procedure demonstrated in Sample Code 7.

The main map on the left side can be replaced with the user's map, the code is annotated throughout so as to identify the pieces of code that must be replaced. An example of these comments is provided in Sample Code 8.

Sample Code 8. Example of comments provided into the SVG Templates.

```
<!-- *********************************************************************
*****************************  M A I N  M A P  ***************************************
*************************************************************************************
* This part of the code should be replaced with your map, the id "main_map" must be *
* kept and all graphic elements must be grouped into the g tag named "complete_map" *
* References to CSS have to be updated into the CSS section earlier in this code    *
********************************************************************************* -->

<svg id="main_map" x="5" y="35" width="396" height="356" viewBox="0 0 2200 1980">
       <g id="complete_map">
(…)
       </g>
</svg>

<!-- *********************************************************************
***********************  E N D  O F  M A I N  M A P  *******************************
********************************************************************************* -->
```

Although the templates were functional when developed and applied to different parts of the *School Atlas of Rio Claro*, testing was necessary in order to verify if the comments provided were sufficient and if the templates could be functional when used by developers with the highlighted profile. The results of the testings conducted with Brazilian atlas developers are analysed in chapter 6.

5.6.3 Implementing Interaction

During the analysis of the contents in the *School Atlas of Rio Claro* it was decided that three types of interactive functions could be employed:

- **Mouse over effects:** this kind of effects could result in changing the colour of the feature to highlight an area of interest. In addition a text message could be displayed on mouse over effects. This kind of effect was employed in template 1.
- **Scroll bars:** This is one of the most used effects, because it is necessary to scroll text on the screen. Scrolling bars are implemented using JavaScript code and the level of difficulty is considered low, comments provided on the code help the developer to adapt the code to their needs.
- **Hyperlinks:** This is considered to be the easiest interactive functionality to be implemented. There are three kinds of hyperlinks suggested: 1 - a hyperlink that will lead the user to another piece of information within the SVG file itself; 2 - a hyperlink that will open a pop-up window; and 3 - a hyperlink that will load another html page in the same window.
- **Interactive zoom and pan:** This type of effect was used in Template 4. This kind of interactivity requires extensive use of JavaScript coding and, therefore, it is the most complex effect to implement. Comments added throughout the code aim to minimise the complexity of the code and make it possible for non-expert developers to apply this function to their maps.

Some interactive features can be implemented using just SVG functions; others need to be implemented with JavaScript. In both cases comments were added to the code so as to guide the user about how to adapt the code to their needs. Examples of the implementation of interactive functions are provided in the following sections.

5.6.3.1 Interactive functions with Mouse over effects

The example used to illustrate the use of this kind of effect was presented in Template 1. It can be easily adapted and used in conjunction with other templates. Figure 5-18 illustrates the effect.

A B

Figure 5-18. Example of mouse over effect.

In the example above, figure 5-18A portrayed the map as it is originally presented to the user. When the user moves the mouse pointer over the polygons in the main map a JavaScript function is called. This function will change the polygon's colour and show the name of the city highlighted in the response area (figure 5-18B). There is no need to change the JavaScript code, as emphasised in the comments provided in Sample Code 9, and the user has to change the main map and identify the polygons that need to be highlighted with mouse over effects, as shown in Sample Code 9.

Sample Code 9. Example of comments provided for mouse over effects.

```
<!-- ***************************************************************************
************ G R A P H I C  E L E M E N T S  W I T H I N  T H E  M A P **********************
*******************************************************************************************
**  You should insert your map into the tag called "main_map", you can also change width   ***
**  and height of the SVG "main_map" according to the interface design you have chosen,    ***
**  however you should not change the viewBox (keep the original coordinates from your     ***
**  map). Every path element corresponds to one polygon in the map, the id will be         ***
**  shown in the mouseover effect, do not change the Java Script code, just name the       ***
**  polygons within your map and call the mouseover and mouseout functions as shown.       ***
****************************************************************************************-->

<svg id="main_map" width="232" height="300" viewBox="0 0 2470 3190" x="74" y="0" >
        <g id="Border">
                <rect class="fil10 str1" x="10" y="10" width="2450" height="3170"/>
        </g>

        <g id="Municipios" class="style1 str0">
                 <path id="Paulínea" onmouseover="changeColour(evt,'Paulínea')"
                 onmouseout="changeColour(evt,'Paulínea')" d="M1131 2500c-9,-4 -9,(…) />
                 <path id="Pedra Bela" onmouseover="changeColour(evt,'Pedra Bela')"
                 onmouseout="changeColour(evt,'Pedra Bela')" d="M1751 2477c-12, (…)/>

(…)
        </g>

<!-- ***************************************************************************
**************************** R E S P O N S E  A R E A ***************************************
*******************************************************************************************
** It is not necessary to change the code below, although you can change X and Y to, width  **
** and height                                                                               **
****************************************************************************************-->
        <g id="Resposta">
                <rect class="fil5 str3" x="20" y="920" width="1550" height="240"/>
        </g>

        <g id="groupShowCity">
                <g id="cityText" >
                        <text x="50" y="850" font-size="13">Município:</text>
                        <text id="varCity" x="50" y="1080" font-size="130"> </text>
                </g>
        </g>

</svg>

<!-- ***************************************************************************
******************************** E N D  O F  M A I N  M A P ********************************
****************************************************************************************-->
```

5.6.3.2 Interactive functions with Scroll Bar

The second type of interactive function, the use of scroll bars, requires the user to change some parameters in the JavaScript Code. If the user changes the position and size of the scrolling bar and scrolling button the code will not work properly and changes need to be made to the JavaScript function that controls the scrolling of the main text. In this way the changes are made in the Java Script code as shown in Sample Code 10 and 11.

Figure 5-19. Specifications of the scrolling bar object.

Figure 5-19 shows the interface and the size of the objects involved. The scrolling bar, in grey, is 305 pixels high. The scrolling button, in red, is a 20 pixel square. The SVG code provides guidelines for adapting the code as illustrated in the Sample Code provided below.

Sample Code 10. Instructions within the SVG Code.

```
<!-- ******************************************************************************
**************************** S C R O L L I N G  B A R ***************************
**********************************************************************************
***  Please note that if you change the y coordinate in the "main" svg document above you  ***
***  should also change the functions JavaScript SliderMove and SliderClick (above) refer  ***
***  to the functions for more instructions. In addition, if you change the size of the    ***
***  scrolling bar "track" and the "thumb" you will be required to make extra changes in   ***
***  the JavaScript. Your text is likely to be in a different length, look at the func-    ***
***  tions mentioned to make it scroll completely                                          ***
*********************************************************************************-->


      <g id="slider" transform="translate(373 0)" yoffset="0">
            <rect id="track" x="0" y="0" width="20" height="305" style="fill:#C0C0C0" />

            <g id="thumb" transform="translate(0 0)">
                  <rect width="20" height="20" filter="url(#button)" rx="5" ry="5"
                   style="fill:red; stroke:none"/>
            </g>
      </g>
```

Sample Code 10 illustrates the instructions provided within the SVG code; basically the developer is focused on the necessary changes to be made in the JavaScript code to adapt it to their interface design. Additional comments in the JavaScript section of the code were necessary and they are shown in Sample Code 11.

Sample Code 11. Comments within the JavaScript code.

```
         function SliderMove(event)
           {

           // change the final number according to the y coordinate of the "main" svg object
           // in this code y = 35, if you change to 25 then the final number in this equation
           // should also be reduced by 10, for instance

           var value = event.getClientY() - parseFloat(slider.getAttribute("yoffset")) - 45;
```

```
        // the final number - 1.8 - should be changed by you according to the size of the
        // text box. The higher the number the more text will scroll on the screen. You
        // should try different numbers until you find the one that better suits your
        // project

        var ytexto = parseFloat(animateable.getAttribute("yoffset")) - (value * 1.8);

        // In the following equation change the value 285
        // The number should be the height of the scrolling bar - height of red buttom

        if (sliderActive && value > 0 && value < 285)
              {

              thumb.setAttribute("transform", "translate(0 " + (value) + ")");
              SliderCallback(ytexto);
        }
    }
```

In Sample Code 11, extensive instructions on the necessary changes in the JavaScript function are explained. Basically three changes are necessary and will be explained in the same order as they are commented upon in the code. The first change is necessary if the user changes the ‘y’ coordinate of the text box and scrolling bar (they are grouped together in the code). The number that appears in the code should be reduced or increased at the same ratio as the y coordinate.

The second change, and the most likely, is related to the size of the text to scroll. The equation calculates the scrolling ratio based on a factor given at the end of the equation. That factor changes according to the size of the text and can, therefore, be higher of smaller. Even if the user does not alter the interface design (which would make all other modifications unnecessary) this change has to be done because a different text will be scrolled.

The third necessary change is related to the limit of the track object. Basically speaking, the equation determines how many pixels the button can move downwards. This number should be equal to the height of the scrolling bar minus the height of the scrolling button. In this case, as can be seen in figure 5-19, the number 285 is a result of 305 – 20 pixels.

5.6.3.3 Interactive functions with Hyperlinks

Hyperlinks are fairly easy to implement within SVG. However, as emphasised previously, there are three different types of hyperlinks that were considered in this research.

The first type of hyperlink leads the user to another part of the SVG code itself. Sample Code 12 shows how hyperlinks are defined in SVG.

Sample Code 12. The definition of an hyperlink in SVG.

```
<g id="photo1" >

      <image x="36" y="40" width="287" height="150" xlink:href="figuras\ceramica1.gif"/>

      <text class="smallText endText" transform="translate(333,40) rotate(270)">Foto: Gilberto
        Rodrigues Jr.</text>

      <text class="mediumText middleText">
            <tspan x="182" y="205">Fragmentos de cerâmica tupiguarani</tspan>
            <tspan x="182" y="220">Museu de História Natural de Pirassununga</tspan>

      </text>
      <a id="Forwards1">
            <g transform="translate(335,195)">
                  <path class="orange" d="M0,0 10,10 0,20z" />
            </g>
      </a>

</g>
```

In the piece of code presented in Sample Code 12, there is a picture, some text and an arrow (in orange) on the display. All elements described are grouped in a <g> tag named ‘photo1’. It is important to group all elements that will be displayed together into <g>tags and to name them accordingly.

The tag <a> defines the hyperlink. In the example above the hyperlink was named ‘Forwards1’. It is important to name the hyperlinks because in the case illustrated here, there are several pictures that will be displayed individually according to the link chosen. In this way, the second picture will be in a group called ‘photo2’ and the arrow will be called ‘Forwards2’, and so on.

Sample Code 13 illustrates how the interaction is implemented.

Sample Code 13. Controlling the interactive display of different parts of the code.

```
<!-- ******************************************************************************************
************************ C O N T R O L   O F   P I C T U R E S ********************************
***********************************************************************************************
***  The display property of efery <g> element containing pictures is controlled here, for ***
***  instance the group called "photo1" will be display on the event Backwards1.click or   ***
***  ceramica1.click and so on. On the other hand, it will be invisible on the event       ***
***  Forwards1.click or canoas.click. Change the names of the events here if you renamed   ***
***  them in the previous code                                                             ***
*******************************************************************************************-->

<set xlink:href="#photo1" attributeName="display" to="inline" begin="Backwards1.click;
    ceramica1.click;ceramica2.click;ceramica3.click" />
<set xlink:href="#photo1" attributeName="display" to="none" begin="Forwards1.click;
    canoas.click;canoas2.click" />
```

The first line of code portrait above tells the Web browser that the <g> element named ‘photo1’ (presented in Sample Code 12) will have the display property switched to ‘inline’ (visible) on the event Backwards1.click (‘Backwards1’ is another link within the code).

On the other hand the visible property of the same <g> object will be switched to ‘none’ (invisible) on the Forwards1.click event. The object named ‘Forwards1’ is also shown in Sample Code 12. What this line basically says is, switch of the current picture when the user clicks the arrow to go forward. In this way the user can navigate through a series of photos (or other content) using hyperlinks that will make visible and invisible different parts of the code. The result is shown in figure 5-20.

Figure 5-20. Changing contents in the additional contents box (in yellow).

The second consists of a hyperlink that will open a pop-up window. It is not possible to call a pop-up window from an SVG file, so the JavaScript code to open the pop-up window has to be inserted into the <head> section of the HTML page. However, the

SVG file can call the JavaScript function from the HTML page. Sample Code 14 shows the JavaScript function that has to be present into the HTML page in order to open the pop-up window.

Sample Code 14. Function that calls a pop-up window.

```
<SCRIPT type="text/javascript">
      function openWindow(url,width,height)
            {
            window.open(url,'','menubar=no,resizable=no,scrollbars=no,status=no,titlebar=no,
             toolbar=no,width=' + width + ',height=' + height + ',left=20,top=20');
      }
</script>
```

The function called ‘openWindow’ receives the parameters called url, width and height. The url parameter defines the name of the file to be opened, width and height define the size of the window. In addition the function determines the pop-up window will not have menu bar, scroll bars, status bar, title bar or tool bar; and it will be located on 20 pixels from the left of the screen and 20 pixels from the top.

The SVG code that calls the function illustrated above is presented in Sample Code 15.

Sample Code 15. Calling an external function from SVG code.

```
<a onclick="openWindow('peabiru_popup.htm','760','440')">
      <text class="mediumText hyperlink endText" x="345" y="50">trilhas: o caminho de
       peabiru</text>
</a>
```

In the piece of code described above, the function ‘openWindow’ is called. Additionally the contents 'peabiru_popup.htm', '760', '440' are passed to the function.

The third kind of hyperlink used loads another html page in the same window. This is the most straightforward of all the three kinds of hyperlinks. Sample Code 16 illustrates the use of this type of hyperlink from the SVG file.

Sample Code 16. Opening a new file in the main window.

```
<a xlink:href="slide2.htm" target="_main">
      <use id="arrowForward" x="720" y="308" xlink:href="#arrow" />
</a>
```

In the example illustrated above, from Template 1, the hyperlink object identified by the tag <a> calls a file named ‘slide2.htm’ to be open in the main window (target). There is no need to create any JavaScript function neither to insert any extra piece of code in the HTML page in this case.

5.6.3.4 Interactive functions with Zoom and Pan

This kind of interaction is present in Template 4. Interactive zoom and pan is the hardest type of interaction to implement and, therefore, the Template's code was extensively annotated in order to help the user apply this type of interactivity to their maps.

In Template 4 the following interactive functionalities are provided:

- Control of layers - different layers on the map legend can be turned on and off, in this way the student will be able to create several different compositions of maps by switching layers;
- Navigation map - a small navigation map is provided with interactive zoom controls next to it. The zoom symbols as well as the JavaScript used to handle them were adapted from cartonet <http://www.carto.net>. By manipulating the navigation map the student will be able to pan the main map and change its zoom as well; and
- Help bar: the help area is provided on the bottom right corner. Help messages change according to mouse move events over different objects, this is believed to be a valuable feedback to the students on how to interact with the map.

Firstly, the developer is advised to insert their map into the main map section of the code, following the same procedure present in Templates 1 and 2. The navigation map is a reduced version of the main map. The pieces of code that should be changed in order to make the navigation map and the interactive layers work are also extensively annotated, following the same standard used previously. Sample Code 17 illustrates the implementation of the navigation map within the SVG code.

Sample Code 17. Creating the navigation map.

```
<svg  id="referenceMap"  x="411"  y="203"  viewBox="0  0  2200  1980"  width="158"  height="142"
pointer-events="none">
      <use xlink:href="#complete_map" />
</svg>

<!-- *****************************************************************************************
*** This is the object that will control the zoom tool, it has to be the same size as the  ***
*** reference map and needs to overlap it. Therefore use the same width, hight, x and y as ***
*** the reference map. Do not change any other part of the code.                           ***
*****************************************************************************************-->

<rect   id="dragRectForRefMap"   class="dragRect"   x="411"   y="203"   width="158"   height="142"
onmousedown="myRefMapDragger.drag(evt)"            onmousemove="myRefMapDragger.drag(evt)"
```

```
onmouseup="myRefMapDragger.drag(evt);myMainMap.newViewBox('dragRectForRefMap','referenceMap')"
/>

<g id="navigatorElements">
      <text class="allText subTitleText" x="411" y="195">Navegue no mapa:</text>
      <use id="zoomIn" transform="translate(590,215)" xlink:href="#magnifyerZoomIn"
        onclick="zoomIt('in');" onmouseover="magnify(evt,1.2,'in');"
        onmouseout="magnify(evt,1,'in');" />
      <use id="zoomOut" transform="translate(590,265)" xlink:href="#magnifyerZoomOut"
        onclick="zoomIt('out');" onmouseover="magnify(evt,1.2,'out');"
        onmouseout="magnify(evt,1,'out');" />
      <use id="zoomFull" transform="translate(590,315)" xlink:href="#magnifyerFull"
        onclick="zoomIt('full');" onmouseover="magnify(evt,1.2,'full');"
        onmouseout="magnify(evt,1,'full');" />
</g>
```

The <svg> object named ‘referenceMap’ corresponds to a reduction of the developer’s map, called ‘complete_map’. The object called ‘dragRectForRefMap’ controls the interactive zoom and pan. The user is advised not to change the functions called on the events mousedown, mousemove and mouseup.

The <g> object called ‘navigatorElements’ comprises the interactive icons for zoom in, out and zoom to extent. The user can change x and y coordinates at their will. Sample Code 18 shows the changes that have to be done in the JavaScript code in order to implement the interactive zoom and pan tool.

Sample Code 18. Necessary changes in the JavaScript code.

```
function init(evt) {
      svgDoc = evt.target.ownerDocument;
      myMapApp.resetFactors();

      //In this line change the values.
      // 2200 is the bottom right coordinate of the navigation map (referenceMap)
      // 100 is the minimum zoom
      // 200 is the maximum zoom
      // 0.6 is how much the system will magnify the map each time the user clicks on
      // the magnifying icon

      myMainMap = new map("main_map",2200,100,200,0.6);

      // to adapt this line to your map:
      // 411 is the x coordinate of the top left corner on the navigation map
      // 569 is the x coordinate of the top right corner on the navigation map
      // that is (x coordinate + map width)
      // 203 is the top y coordinate on the navigation map
      // 345 is the bottom y coordinate on the navigation map (top y + map height)

      myRefMapDragger = new dragObj("dragRectForRefMap",411,569,203,345,"ul");

      actualzoom = 1;

      // the variable group_el stores the map object that will have the scale changed
      group_el = svgDoc.getElementById("main_map");

}
```

The only necessary changes to the code are noted in Sample Code 18. Many other functions are included into Template 4, however the user is advised not to change them, including the help messages that will be displayed according to the mouse move event.

The effectiveness of the comments provided for implemented interactivity was tested with a group of Brazilian researchers, the findings are analysed in the following chapter.

5.7 Chapter Summary

This chapter analysed the current state-of-the-art of research in the area of Cartography for Children in Brazil. A remarkable research trend in Brazil is the development of local school atlas for early geographical education. Twenty three atlases had been published up to 2003 and it is believed that more atlases are under development such as the *School Atlas of Sumaré* and the *School Atlas of São Bernardo do Campo*.

These atlases are mainly result of partnership between academics, undergraduate and post-graduate students, teachers and local councils. The research funds are usually scarce and it is believed that in most of the cases there are no funds available to re-print the atlases once they are out of print. This is the case of the paper *School Atlas of Rio Claro*, originally released in 2002, with five thousand copies; the product is already out of print. There is no perspective of any further reprints of the *School Atlas of Rio Claro* in the near future. A low cost solution for publishing those products is necessary otherwise quality educational resources like this atlas risk to vanish.

The Web is the proposed delivery medium for those atlases and the graphical open standard SVG is the technology for implementing the atlas. The public investment for providing computer laboratories to primary schools and the extensive training of teachers in the use of computers now make this solution feasible. Figures presented in this chapter show that, once online, the *School Atlas of Rio Claro* will provide current information about the city to a population of nearly twelve thousand primary students. This makes the digital atlas available to a much wider audience than the original paper version.

In addition this chapter outlined the procedures adopted for developing an SVG Atlas Template for publishing school atlases on the Internet. Firstly the prospective developers are advised not to be concerned about the layout of the navigation bar. It is suggested that the students could design it. This kind of design was tested during this research; the feedback from the students was extremely positive and the final design very satisfactory.

The contents of the atlas were analysed and four final templates were proposed, they are described as follows:

- **Template 1 –** applied to linear presentations;
- **Template 2 –** applied to clickable maps;
- **Template 3 –** applied when the text is the main source of information; and
- **Template 4 –** applied to interactive maps with zoom and pan tools.

The templates were analysed with regards to interface design; the use of the code and the implementation of interactive functions. The complete code of the templates is available in the CD-ROM accompanying this document.

The development of the templates shown in this chapter has provided some valuable lessons. However, testing was necessary in order to assess the viability of the templates proposed with actual Brazilian atlas developers.

Additional tests were carried out with Brazilian primary school teachers in order to assess the interface design proposed. Both testings are subject of analysis in the following chapter.

6 User Testing

6.1 Chapter Overview

This chapter focuses on testing the templates described in the previous chapter. The first test aimed at assessing the usability and efficiency of a hypothetical atlas based on the proposed templates. This test was conducted with primary school teachers. To achieve this goal part of the *School Atlas of Rio Claro* was published on the Web and had its usability tested by primary school teachers who already used its paper counterpart. They were given questionnaires that aimed firstly to identify the sample population and to determine their skills and computer usage habits. The next step was to assess key issues in the prototype atlas use, identifying difficulties they had using the atlas, as well as particular features that should be included. Finally, teachers were asked to produce an activity for students, on paper, based on the content provided by the Web prototype.

A second test was conducted with atlas developers. The purpose was to assess the effectiveness of the proposed templates as a publishing tool using SVG. In three weeks a group of graduate candidates from the University of Sao Paulo State, Rio Claro Campus, developed in three weeks a simple Web atlas of the University's Campus using the templates described in the previous chapter. The volunteers were also given questionnaires aiming at assessing their computer usage habits and identifying possible problems they had had when developing their product. A summary of the answers provided in both surveys is available in the appendix C, at the end of this document.

6.2 Sampling population

The initial point to conduct both surveys was to define a sampling population. In this particular stage of the research some restraints had to be considered:

- The research was conducted in Australia and the sampling population was located in Brazil;
- The survey would be conducted with volunteer, because there were no research funds allocated to pay interviewees; and
- Because the testings would be relatively time-consuming, particularly testing with developers, the sampling population would be contributing with this research during their working hours.

Considering these constraints, there was no possible control over the size of the sampling population for this research. Both testings were formatted as courses. It was assumed that this would foster volunteers to engage in the research.

There are numerous sampling methods (Chaudhuri and Stenger 1992; Thompson 2002). Generally speaking, sampling models can be divided into probability and non-probability sampling. In probability sampling, the population is viewed as a finite group and probability techniques are used to determine an ideal sample population considering the finite group (Thompson 2002). In non-probability sampling (or purposeful sampling), conversely, the sampling group is relatively small or even restricted to a single unit, however the sampling population is not selected by statistical methods, but rather *purposefully* (Patton 2002).

Regarding the differences between both approaches, Patton (2002, p. 230) claimed that:

> "*The logic and power of random sampling derive from statistical probability theory. A random statistically representative sample permits confident generalization from a sample to a larger population (...). The logic and power of purposeful sampling lie in selecting* information-rich *cases for study in depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the enquiry*."

Considering the constraints listed previously and the different sampling methods described, a qualitative approach using purposeful sampling (non-probability) was adopted in this research.

6.3 Test 1: Test Execution

The first test was conducted with primary school teachers from Rio Claro's public schools between May and June 2005. The test was set up as a formal course, promoted by the Planning Department of UNESP in partnership with the "Marcelo Schimidt" primary school.

A group of voluntary teachers worked with the prototype atlas developed using the templates outlined in chapter five. The course comprised two parts. The first part focused on theoretical concepts in multimedia cartography and visualisation. The teachers were introduced to a number of Brazilian digital atlases (mainly the Brazilian applications highlighted in chapter four) and their interactive functionalities. This part of the test was conducted in a public primary school in Rio Claro called “Marcelo Shimidt”. The computer laboratory was not yet available in this particular school, although it was being set up by the time of testing. Therefore the practical part of the course, the actual use of the prototype atlas, was conducted in the facilities of the University of Sao Paulo State (UNESP) Rio Claro Campus.

The practical part of the group was conducted in a laboratory with six computers. Those computers were mainly *Pentium IV* running *Windows 2000* and *Internet Explorer* version 5 or better. The initial motivation of the volunteers to undertake the test was that, because it was conducted as an official course and validated by the Department of Education, their attendance would count as a bonus for their careers. However, it was made clear from the start that there would be no formal assessment during the course and the volunteers would rather be contributors to a PhD research programme. It was observed that this information, instead of being merely students in a course they would be volunteers for testing the product developed by a PhD Candidate, increased the willingness of the group in contributing during the whole process. As a result, the group was always keen to interact with the PhD Candidate and the prototype product.

On the first day the group was provided with digital copies of the prototype product and it was observed that they really took the product to their homes and tested themselves and with their relatives (including primary school children). The feedback they provided was, therefore, beyond the expected.

6.3.1 User Profiles

The test group was comprised of fourteen teachers, all working in public primary schools. All of the volunteers were familiar with the content of the *School Atlas of Rio Claro* and had used the atlas previously in their teaching practice.

Regarding their academic background, ten teachers had finished tertiary education; three were undertaking their tertiary qualifications and one had finished secondary school. This difference is explained by a new policy on education introduced by the Brazilian government in the mid-1990s. Until then the minimum education requirement for a professional primary school teacher was secondary education, with a specialisation in teaching. After the new regulations were introduced primary school teachers were required to complete their tertiary education with an appropriate teaching qualification. Amongst those teachers that have completed tertiary education, four graduated in pedagogy, three in language studies (Portuguese); one had a degree in geography, one completed his/her degree in biology and one had a degree in social communication.

There are two levels in teaching career in Brazil. Teachers that are qualified to work with primary school students from grade one to four are identified as PI. Teachers that are qualified to teach from grade fifth to eighth in primary education and all grades in secondary school are identified as PII. The difference is that in the four initial grades the students spend all of their time with the same teacher and, therefore, the teacher has to teach a range of subjects to the pupils. From the fifth grade there are specialised teachers, therefore there will be different teachers for different subjects such as Portuguese, English, Mathematics, Geography, History, Biology, Chemistry, Physics, Arts, etc. In the group of volunteer teachers analysed here, ten were PI, one was qualified as PI and PII and one was qualified only as PII. In addition two teachers were performing administrative duties at their schools.

Regarding their work experience, two teachers (14% of the group) had worked for five years or less. Three teachers had worked from five to ten years. The majority of the group (51%) had worked as teachers from fifteen to twenty years and finally two teachers (14%) had more than twenty years of work experience in the profession (figure 6-1).

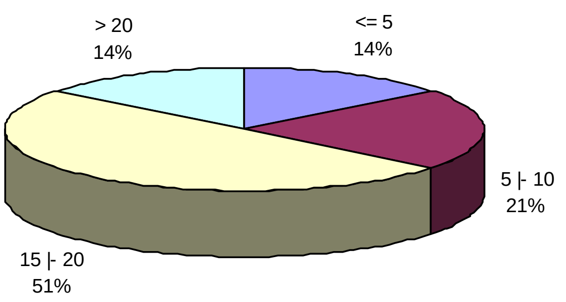

Figure 6-1. Volunteers' work experience (in years).

Considering their experience using computers, one teacher (7%) indicated that he/she had less than one year of experience and made an additional comment of "still learning". Six teachers declared that they had two to three years experience using computers, half declared two years and the other half three. Therefore 42% of all respondents fitted in this category. One teacher had used computers for four years, another for five years and five (37% of all respondents) had used computers for more than five years. In summary the group could be considered to be experienced computer users, 50% of them had used computers for four years or longer (figure 6-2).

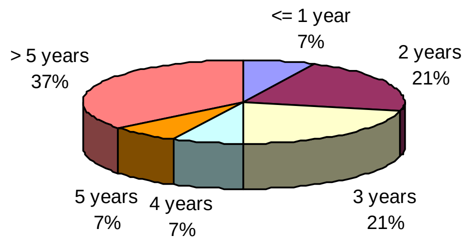

Figure 6-2. Volunteers' experience using computers (in years).

Regarding computer use, most of the respondents used computers for Internet access (13 answers), the second most common use was text editing with 11 answers. Seven teachers used computers for games and/or leisure also. Six used spreadsheet software, four used computers to prepare presentations and one used computers for image editing (figure 6-3).

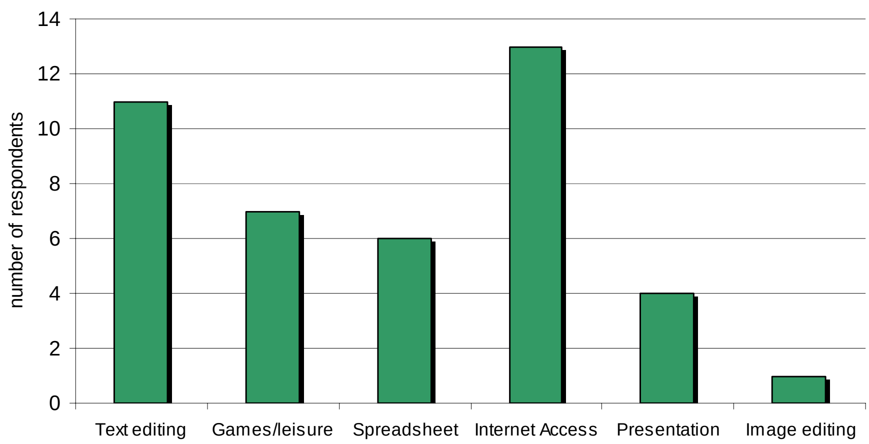

Figure 6-3. Computer usage habits amongst respondents

Considering Internet use (figure 6-4), the answers revealed different usage patterns. Most of respondents used search engines (mostly *Google*, *Yahoo* and the Brazilian *Cadê* – http://www.cade.com.br). Four respondents made comments about their Internet usage habits. One teacher, who did not use the Internet said that because he/she had just bought their first computer they still felt insecure connecting to the Internet. Another respondent said that because he/she did not have a personal computer their use was very restricted. Surprisingly two teachers said that they used the Internet very seldom because they had not been required to do so as part of their work duties.

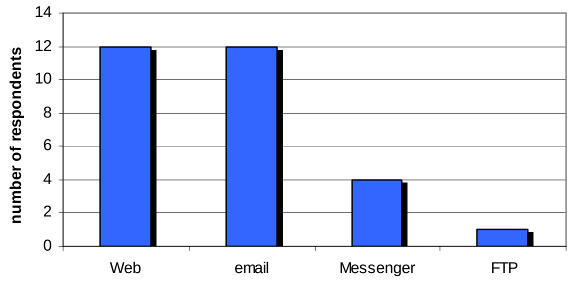

Figure 6-4. Internet usage habits amongst respondents.

Regarding Internet map use, six teachers used the Internet to access maps. It was therefore assumed that these teachers used the Internet to search specifically for geographical content at some stage. Amongst those who used Internet maps five had used Internet Atlases in the past.

The main problems highlighted by the respondents with regards to Internet map use was related to the low graphic quality of maps (two answers) and lack of relevant information (three answers). When the respondents indicated that the low graphic quality of online maps was a major drawback with Internet maps, their answers confirmed the remarks made by Peterson (2003, p. 6) that "*Many of the static maps available through the Internet have been scanned from paper maps (...) So little care is sometimes taken in the scanning process that the text on the back-side of the paper map will appear in the scanned version*". Many Internet maps are still published as low-quality raster images (Peterson 2003) and this is believed to be a major problem that undermines Internet map use.

Lack of relevant information, mentioned by three respondents as a problem for Internet map use, was considered to be a different problem. One possible reason is a probable conflict of interests between the atlas content the respondents expected to access and the content they actually found on the Web. However, this may have been caused by their lack of experience in using Internet search engines.

6.3.2 Issues in Internet Atlas use

In the second part of data collection, after interacting with the prototype, the volunteers were given a second questionnaire where they were asked to identify elements of interface design and interactive elements within the different topics implemented in the prototype. Eleven teachers (from the initial fourteen) completed the questionnaire.

The purpose here was to identify possible difficulties in atlas use and, more specifically, to detect possible differences between Internet atlas use and paper atlas use. These differences could be identified because, as stated previously, paper atlas use was extensively tested by the authors of the *School Atlas of Rio Claro* with teachers and students in a weekly basis (Almeida 2003).

6.3.2.1 Topic 'Location and Orientation' (*Onde Estamos na Terra*)

Initially, the respondents were asked to identify elements of the interface (regardless of whether the elements were interactive or not). They were given a blank space to fill in the questionnaire, the purpose was not to induce answers.

The topic 'Location and Orientation' (*Onde Estamos na Terra*) was developed based on Template 1. Template 1, as explained in the previous chapter, deals with linear presentations. The interface design of this topic can be seen in figure 6-5.

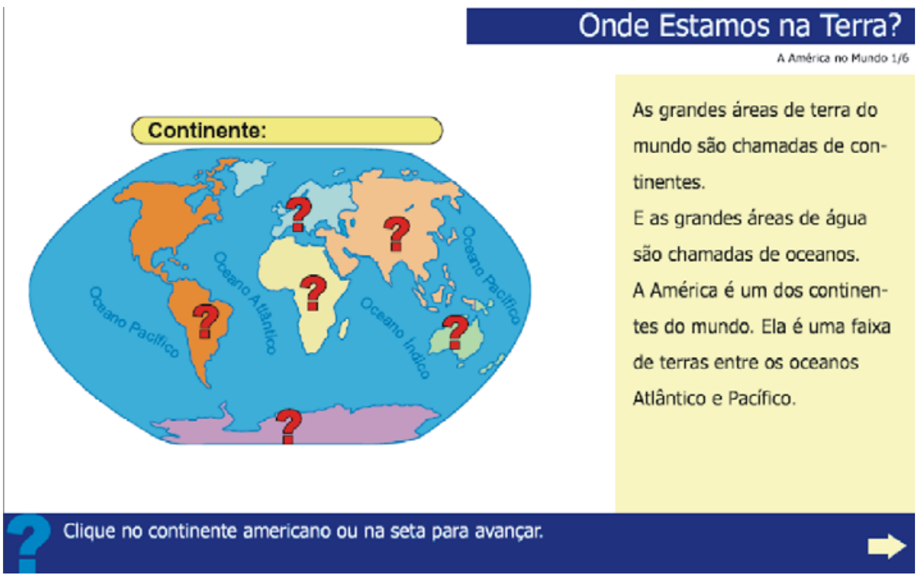

Figure 6-5. Interface of the topic Location and Orientation

Generally speaking, the interface comprises a text area (on the left in yellow), a title bar in blue on the top left corner of the screen, a help bar on the bottom of the page and navigation arrows on the bottom right corner of the screen. The maps are shown on the left of the screen, each page shows a different map and all the maps in the topic have interactive features.

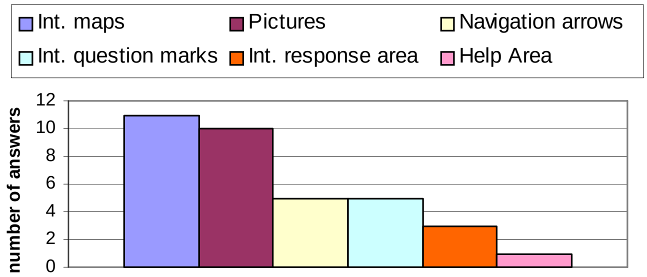

Figure 6-6. Interface features mentioned by respondents.

Out of all of the elements presented in the interface design, the most noticed were the maps. All members of the group mentioned maps (figure 6-6). The second most noticed element of interface design was pictures, cited by ten respondents. This is a considerable piece of information, considering that just the last map allow access to pictures (the map of the city of Rio Claro with pictures from the urban and rural areas). Two elements were the third most noticed feature in the interface, the navigation arrows and the interactive question marks (portrait in figure 6-5). These elements were mentioned by five respondents. The interactive response area (in yellow area at the top of the map in figure 6-5) was mentioned by three respondents. The least noticed element was the 'help' bar, cited by only one respondent.

It is also important to highlight that, regarding the interface features in 'Location and Orientation', not one teacher mentioned the graphic scale, the title bar or the text box. Graphic scales were provided in all maps except the initial world map. Another piece of information was the order in which the teachers mentioned the interface features in their questionnaires. This shows which element was more prominent from their point of view. In this case five respondents cited pictures first, five, on the other hand, cited maps first.

The second question was about the topic of 'Location and Orientation'. The respondents were asked to indicate which interactive effects they could identify. The answers are illustrated in figure 6-7.

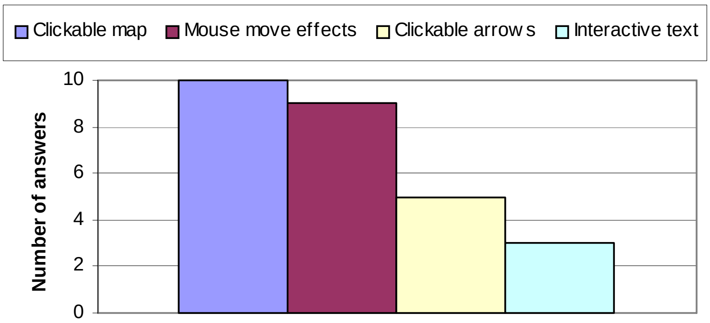

Figure 6-7. The interactive elements identified.

The most cited interactive feature was clickable maps, mentioned by ten teachers. They provided comments such as "clicking in different parts of the map triggers different actions" and "the little hand" on the map, which indicated a hyperlink and, therefore, a clickable feature.

The second most cited interactive feature was mouse over effects. There are basically three different kinds of mouse over effects in this topic: swapping colours of features in the map on mouse move; showing a text in an indicated text area on mouse move; and showing a particular label in different locations of the screen on mouse move. Nine teachers mentioned this interactive feature. Interactive navigation arrows were mentioned by five respondents and interactive text areas were mentioned by three respondents.

What can be summarised by the answers provided in the topic 'Location and Orientation' is that teachers tended to focus their attention more on interactive elements than non-interactive elements. Although maps were the most cited graphic element amongst all interface features, considering the order in which graphic elements were mentioned by respondents the group split their main attention between pictures and maps.

6.3.2.2 Topic 'Evidences of First Settlers' (*Sinais dos Primeiros Homens*)

'Evidences of the First Settlers' is one of the topics that deal with archaeological evidences of the primitive settlers of Rio Claro. In the *School Atlas of Rio Claro* this topic was explored in two pages covering a timeline was all archaeological evidence was located in chronological order.

The interface design for the interactive atlas (figure 6-8) is very similar to the paper atlas, however, due to limitations on screen size, the information is shown in interactive text boxes. This is shown according to the movement of the mouse pointer over the timeline and disappear when the user clicks on the close button (located on the top right corner of the text box).

Additionally, navigation arrows were located on the right and left side of the screen. They allow the user to scroll the timeline and its related landscape backwards and/or forward.

Figure 6-8. Two different screenshots of the interface design adopted in the topic ‘Evidences of the First Settlers’.

In this topic, where there are no maps or pictures, two features of the interface components shown in figure 6-8, were the most cited by the respondents - the navigation arrows and the timeline. All eleven respondents mentioned these features. The second most cited element was the 'back' option located on the top left corner of the screen (*voltar* in Portuguese), mentioned by six teachers. Curiously this element was included as a temporary measure as it was feared that the users would become confused with the menu bar on the top of the screen and therefore an 'emergency exit' would be necessary. Nevertheless, it was noticed that such a situation did not occur and the users were very confident using the navigation bar and navigated throughout the prototype without any significant problems.

The third element mentioned was landscape. The landscape image is located on the top of the timeline (in red) and illustrates how the vegetation might have been on the period indicated in the timeline. The image and the timeline scroll sideways on the screen when the navigation arrows are clicked. The image was also included in the printed version of the *School Atlas of Rio Claro*.

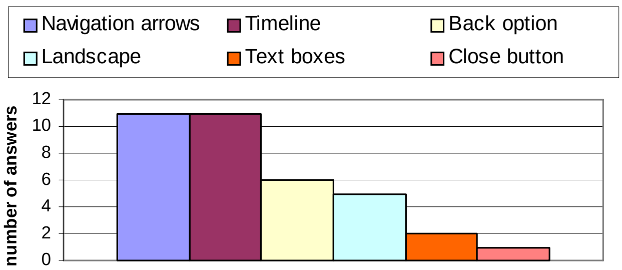

Figure 6-9. Interface features mentioned by respondents.

The fourth element the teachers mentioned was the interactive text boxes that provided additional contents. These were cited by two respondents. These are revealed by moving the mouse on the timeline. The last element cited was the 'close' button on the additional text box, mentioned by one respondent (figure 6-9).

When asked to indicate which interactive elements they could identify in this part of the prototype, the teachers were quite reserved in their answers. Most respondents indicated just one interactive feature. One respondent indicated

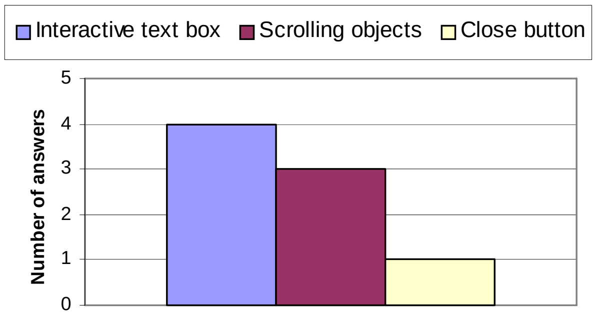

Figure 6-10. Interactive elements identified.

an interactive feature that was not implemented, therefore it is believed that he/she in fact suggested a different interactive functionality to be implemented here.

The most cited element was the interactive text boxes (in yellow in figure 6-8). These boxes appear on the screen when the user moves the mouse over the timeline and disappear when the 'close' button is clicked. Therefore it was no surprise that the second most mentioned element was scrolling objects. These were mentioned by three respondents. The scrolling objects, including the timeline, control which text box can be displayed when requested. The element least cited was the 'close' button, cited by just one respondent (figure 6-10).

6.3.2.3 Topic 'Archaeological Sites' (*Sítios Arqueológicos*)

The topic on 'Archaeological Sites' was used to facilitate Template 2. The interface design of this particular topic was extensively analysed in the previous chapter. There is a clickable map located at the left of the screen and an interactive text box located on the right. The text is controlled by a scroll bar (in gray) located at the right. Below the text box there is a 'help' box, in blue (figure 6-11).

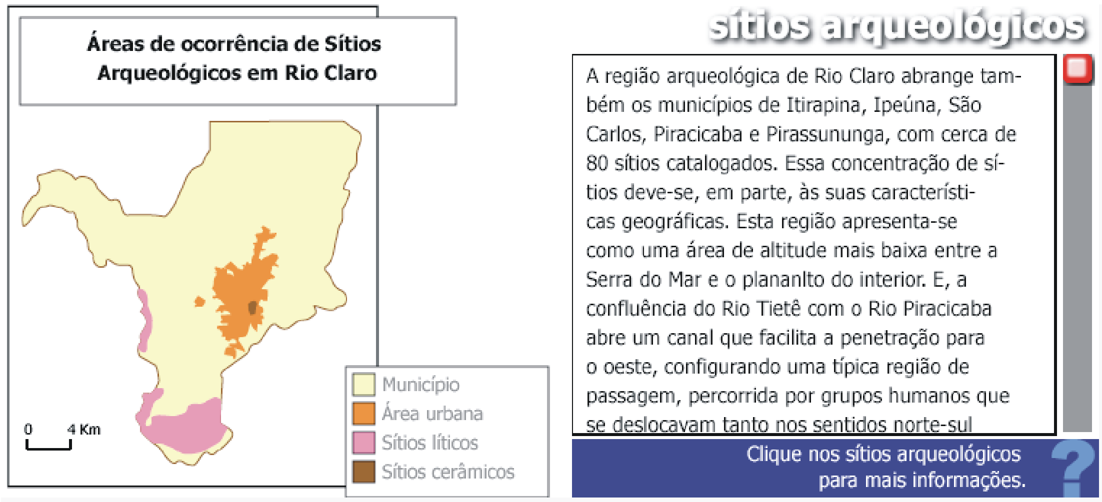

Figure 6-11. Graphic interface of the topic on Archaeological Sites.

The text box changes according to the area clicked on the map. Different archaeological sites will open different text boxes superimposed on the initial text box.

The interface element most cited by the respondents was the map. This was mentioned by all respondents. The second most cited element was the legend/text (cited by 10 teachers). There are two main reasons that can best explain the high attention focused on the map legend: the first (and most obvious) is that it explains the content of the map; the second is that the legend, as well as the map itself, is interactive; in other words, clicking in different parts of the legend will trigger different interactions for this topic.

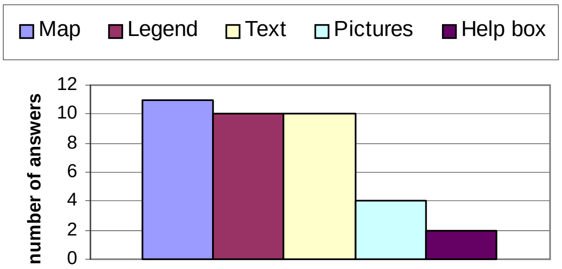

Figure 6-12. Interface features mentioned by respondents.

The third most cited element were pictures, mentioned by four respondents. Here, for this topic the group's attention was clearly focused on the map and the map interaction (opposite from the topic 'Location and Orientation' where the attention was equally divided). Once more, the element of the interface that received less answers was the 'help' box, mentioned by only two respondents.

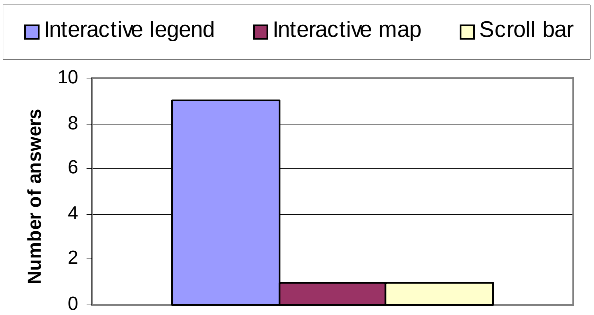

Figure 6-13. Interactive features mentioned by respondents.

Regarding interactive features, the most cited element was the interactive legend, cited by nine respondents. One responded mentioned the interactive map and another mentioned the scroll bar as additional interactive elements.

The teachers' perception of interactive features for the topic 'Archaeological Sites' can provide some clues on digital map use. When asked to point out graphic elements in the interface design their main focus of attention was the map itself, however when asked to indicate interactive features their attention shifted from the map to the legend. The interactive map was mentioned by just one respondent. This information can allow for two distinctive conclusions:

1. The teachers are not used to interact with clickable maps. Clickable maps are considered to be a quite widespread resource for Internet map publishers, however, the sample group appears to be still oblivious about it; and
2. The teachers reproduce, in their dealings with the digital product, the same *modus operandi* used with paper maps. In other words, in a paper map they refer to the legend for further information. In a similar fashion they associate the legend to further information in a digital map and they generally did not turn to the map itself for interaction.

Additionally the scroll bar was cited by just one respondent, this could be due to the fact the scroll bars are a quite a widely used interface metaphor and, therefore, the respondents just took it for granted and did not perceive them as an interactive element worth mentioning.

6.3.2.4 Topic 'The Initial Inhabitants' (*Os Primeiros Habitantes*)

The interface design adopted for the topic 'The Initial Inhabitants' (figure 6-14) was used as a basis to develop Template 3. It was extensively analysed in the previous chapter.

Figure 6-14. Interface design – 'The Initial Inhabitants'

To summarise, the screen was split in two; to the right is a text box, always visible, and on the left are three boxes. The yellow box on the top shows pictures related to the text content, the orange box contains links to additional content (that open as separate pop-up windows – figure 6-15) and shortcuts to specific pictures and the blue box on the bottom of the screen provides help messages.

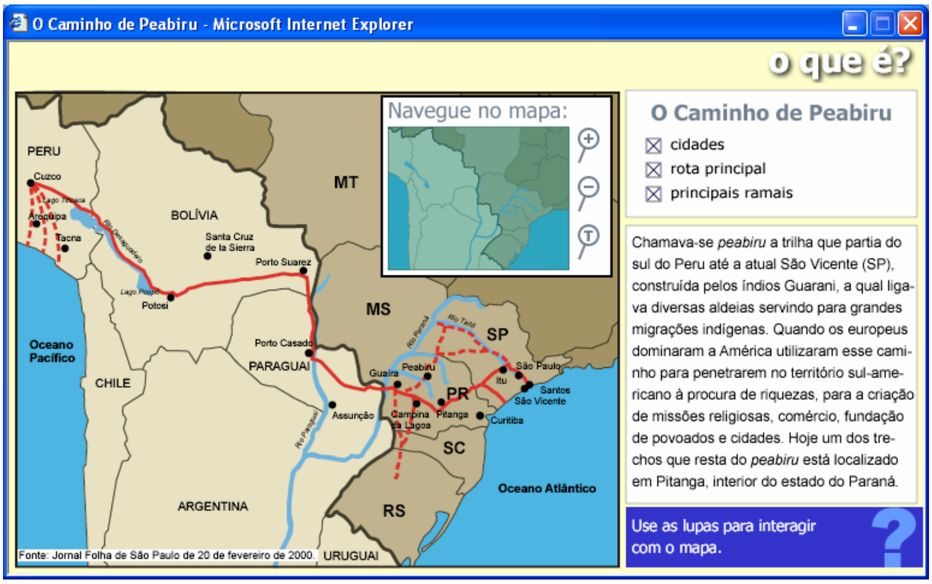

Figure 6-15. One of the pop-up interactive maps linked to the topic on 'The Initial Inhabitants'.

With regards to interactive elements, there is a scroll bar that controls the main text (not new for the users), and hyperlinks within the text, and in the additional contents box (in orange).

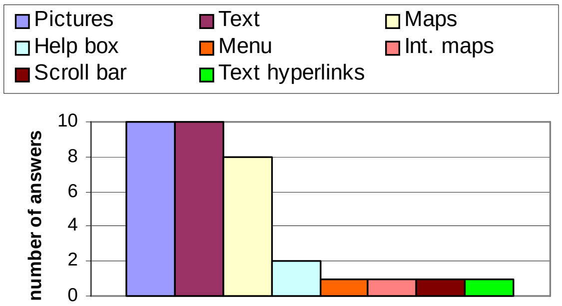

Figure 6-16. Graphic Interface features mentioned by respondents.

Regarding the graphic elements perceived, the most cited elements were the text and the pictures (10 answers each). The second graphic feature most mentioned was the maps, cited by 8 respondents. The help box (seen previously in all other topics) was noted by two respondents. The menu (in the orange box in figure 6-14), the interactive map elements (in the pop-up windows), the scroll bar and text hyperlinks were mentioned once by each respondent (figure 6-16).

The answers given in this topic allow observations to be made. Firstly, the most noted elements were pictures and text. Interestingly, the teachers once again split their attention between pictures and another interface element. A similar pattern of behaviour was noted when analysing the topic 'Location and Orientation'.

Maps were the second most noted element, mentioned by eight respondents. It is important to emphasise here that maps were not given to the users initially, but rather opened on request (clicking hyperlinks) in pop-up windows.

The other elements (menu, interactive elements in maps, scroll bars, help box and hyperlinks) were mentioned by one respondent. Some reasons for the low interest in those interface elements can be presumed and, the ‘taken for granted’ factor is a possible reason. Most of these elements were seen previously by the respondents, either within the prototype or in other applications and, therefore, the teachers might have thought that they were not worth mentioning.

Regarding interactive elements in maps (for example the magnifying lenses in figure 6-15), which were mentioned by one respondent, it is believed that, in this first stage when the teachers were not asked to look for interaction, they were more interested in the map itself. It is believed that the question in their minds was “What do we have here?”, rather than “What can we do here?”.

Considering interactive elements available in the topic ‘The Initial Inhabitants’ the respondents’ attention was almost exclusively focusing on the pop-up interactive maps. The main page with contents was virtually ignored by the teachers. Nine respondents mentioned interactive layers of information as a significant interactive feature, and eight respondents mentioned the interactive magnifying lenses (for zooming in, out and zooming to extent). The answers given by respondents can be verified in figure 6-17.

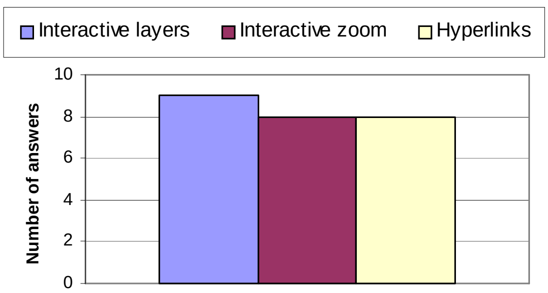

Figure 6-17. Interactive features mentioned by respondents.

In the main content page (figure 6-14) eight teachers mentioned interactive hyperlinks within the main text (demonstrating that they were interested in exploring the text, although they did not mention the scrolling bar as an interactive feature). It is important to emphasise that the hyperlinks mentioned by the respondents open the pop-up maps as well as exchange the pictures on the main page.

One interesting point here is that no teacher mentioned the interactive help box in their answers. Although two mentioned the help box as an element of interface design, none of them realised that the help box was actually interactive and the help messages were changed according to the mouse over on the map or the map interactive tools.

6.3.2.5 Topic 'Occupation of Sao Paulo's Territory during the 16th Century' (*A Ocupação do Território Paulista no Século XVI*)

The interface design followed in the topic 'Occupation of Sao Paulo's Territory during the 16th Century' follows the guidelines established in Template 3, with some changes (figure 6-18).

The main changes were that the help box was removed and the additional contents box (in yellow) was enlarged. When the user passes the mouse over the links an image related to the link is shown.

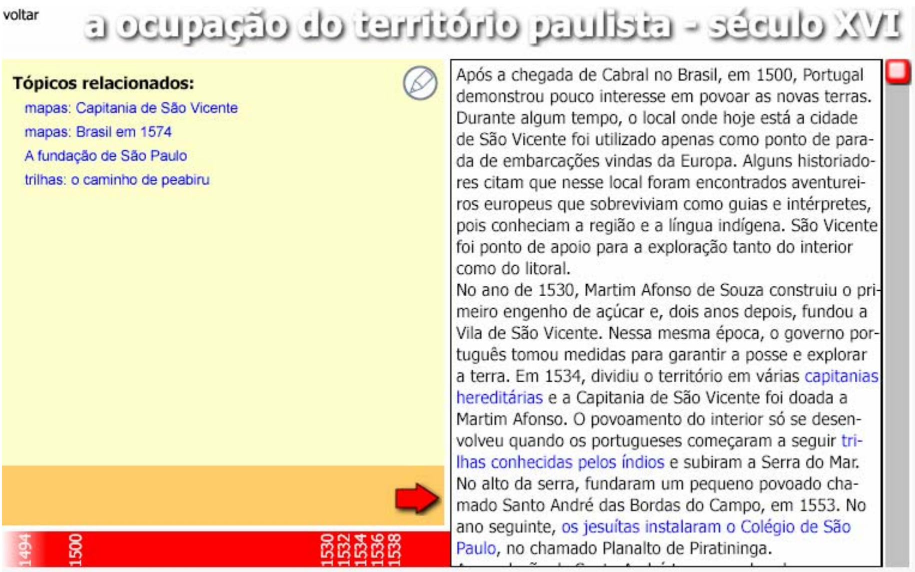

Figure 6-18. Interface design in the topic 'Occupation of Sao Paulo's Territory during the 16th century'.

Another change introduced here was the addition of an icon located on the top right corner of the yellow box. The icon links to a separate PDF file that contains a separate activity for printing for students.

Considering the interface design, the most cited element was the icon mentioned above that links to a file to print. Nine respondents mentioned this element. Eight respondents mentioned historical maps, shown when moving the mouse over different hyperlinks. The text, timeline (in red), scroll bar and hyperlinks were each mentioned by two respondents. Arrows that control the timeline, the response area (in orange) and the interactive zoom tools in pop-up maps were each cited by one respondent (figure 6-19).

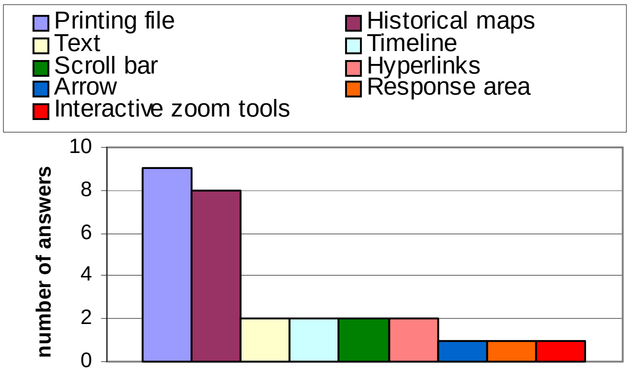

Figure 6-19. Interface elements mentioned by respondents.

The answers given by the teachers in this topic allow some conclusions to be made. Apparently, after being in contact with five different topics in the prototype, the teachers felt more confident with the product because their attention was clearly directed to new elements of the interface, whilst elements seen previously appear to have been a secondary concern in their answers. In this topic nearly all respondents cited the icon for printing a file as an element of interface design. Eight respondents cited historical maps. Both elements were introduced in this topic and therefore, they were new to the respondents.

All other elements were mentioned by just one or two respondents. They were all interface elements seen previously. An interesting piece of information here is that interactive zoom tools, available in pop-up maps linked to the topic, were mentioned by just one respondent. It seems that, because those maps had been seen previously, and had caused great impact, they had now been absorbed by the teachers that diverted their attention to other elements in the prototype.

Regarding interactive elements in the topic on 'Occupation of Sao Paulo's Territory during the 16^{th} Century', the most cited element was interactive maps, mentioned by nine respondents (figure 6-20).

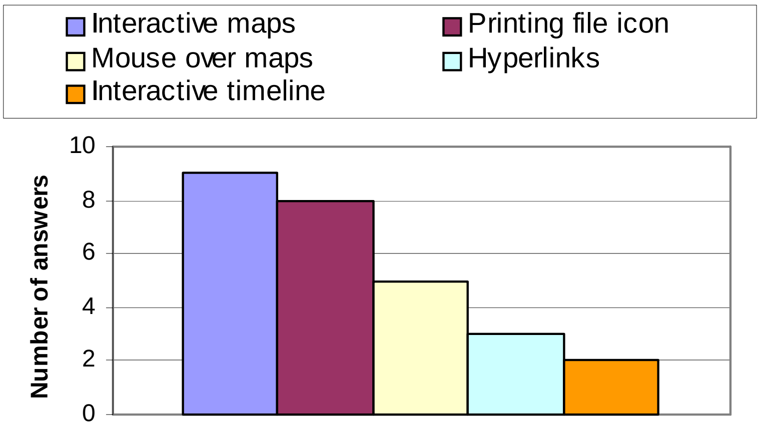

Figure 6-20. Interactive elements mentioned by respondents.

Initially this high level of response seems to contradict the conclusions made previously, however when analysing the answer in details it can be said that this information corroborates the previous analysis. All respondents that indicated interactive maps as being an interactive element in the topic indicated the map they referred to. Seven referred to the map of Sao Paulo's coast line and just two referred to the *Peabiru* track map. The latter had been seen in the previous topic, 'The Initial Inhabitants', and therefore the respondents seem to not haven taken much notice of it, rather diverting their attention towards the new map on Sao Paulo's coast line.

The second most cited interactive element was the icon for printing a PDF file. This was also new for the respondents and also had a high level of response as an element of interface design. The third element mentioned, mouse over maps, cited by five respondents, were also a new element to the candidates. As stated previously, those maps were shown in the yellow area, just below the menu at the left. These were activated when the user passed the mouse pointer over the menu options. Hyperlinks (mentioned by three teachers) and interactive timeline (mention by two) were seen in previous topics and, therefore, were mentioned less.

The pattern of responses in this topic appears to confirm the hypothesis stated previously. After exploring four topics in the prototype the teachers appeared feel confident with the product and they started to make more accurate comments on the questions. Specially, they started to make selective comments on new elements they could find.

6.3.2.6 Topic ‘Occupation of Sao Paulo’s Territory during the 17th Century’ (*A Ocupação do Território Paulista no Século XVII*)

The topic on ‘Occupation of Sao Paulo’s Territory during the 17th Century’ followed almost exactly the same interface design described in the previous section, seen in figure 6-21. The only difference to the interface design here is that the icon located on the top right corner of the yellow box in the previous topic was removed.

Figure 6-21. Interface design adopted on the topic ‘Occupation of Sao Paulo’s Territory during the 17th Century’.

That icon was not included here because it linked to contents that were not presented in the original version of the *School Atlas of Rio Claro* and it was introduced on the topic ‘Occupation of Sao Paulo’s Territory during the 16th Century’ for testing purposes.

Figure 6-22 illustrates the responses considering the interface elements identified. The respondents split their attention between pictures and the timeline (ten mentions each). The second element mentioned were hyperlinks within the text and menu. These were mentioned by eight respondents.

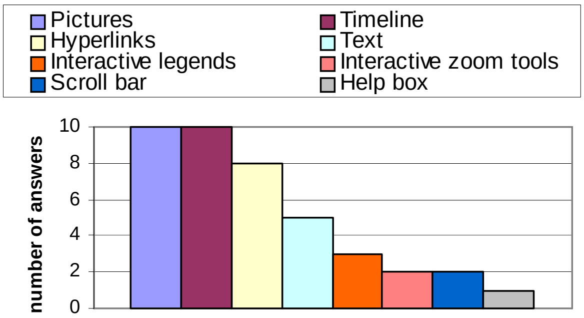

Figure 6-22. Interface elements identified.

The text was the third element mentioned, with five citations. Interactive legends in pop-up maps were mentioned by three respondents. Two respondents mentioned interactive zoom tools and the scroll bar in the main text. Finally, the help box (available in pop-up maps) was noticed by just one respondent.

The analysis of the teacher's answers regarding interface design provides some important clues on the digital atlas' use. The interface presented in this topic is nearly the same as that presented in the previous. This can make its use slightly boring for a user and considering the usage pattern observed in the previous topics, appears to be eager to explore new interfaces.

In addition, when the interface design offered no challenges, the teachers turned their attention to the content and, once more, their attention were split between pictures and other interface elements. This pattern of behaviour seems to corroborate the conclusions made by Oliveira (2003).

In his masters dissertation, Oliveira analysed the use of the *School Atlas of Limeira*. This atlas was produced by the same academic team that produced the *School Atlas of Rio Claro* and, therefore, it follows the same general structure analysed here. Oliveira (2003) studied the use of the paper atlas in the classroom and amongst other conclusions he claimed that the teachers seemed to use images as the main teaching resource and the text was used for support.

During the interface design described here, the main text was always presented a the main screen, sometimes along with pictures, sometimes not. However the text was always in the initial view. Despite this, the pictures were continuously mentioned by a high number of respondents. Most of the time pictures were mentioned in the first place on the list by the teachers (which show to which item their attention was first directed). This seems to indicate that, although dealing with a different medium, the teachers appeared to reproduce the same patterns of atlas use verified on paper.

Considering interactive elements observed in the topic ‘Occupation of Sao Paulo’s Territory during the 17th Century’ (figure 6-23), ten respondents indicated interactive zoom tools in pop-up maps. This item received the highest level of response for this topic. The second most noted element was interactive layers (in pop-up maps) and hyperlinks (in the main screen). These were each mentioned by nine respondents. The third interactive feature mentioned was the interactive pan tool in the navigation map (in pop-up maps such as the map portrait in figure 6-15). This feature was mentioned by two respondents. Mouse over maps, presented in the main screen when the user passes the mouse pointer over different menu options was mentioned by one respondent.

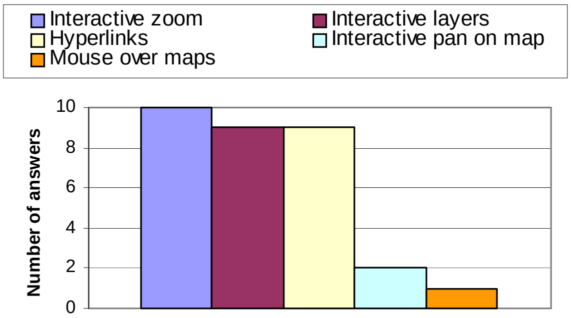

Figure 6-23. Interactive elements identified.

It is important to highlight that, because the interface design and interactive features became repetitive, the teachers took more time to explore the main screen and the pop-up maps. The main element to draw this conclusion is the fact that the interactive pan zoom in the navigation maps was mentioned by two respondents as an Interactive feature that was available.

The respondents had been in contact with this tool in the topic ‘The Initial Inhabitants’, but they were unaware of its existence here. This may have happened because they associated interaction with icons in the pop-up maps. As they did not see an icon to indicate this interactive functionality they did not explore the navigation map. On the other hand, interactive elements in the main screen (which are mostly textual) received few mentions. This information also indicates the hypothesis that the teachers tended to shift their attention to graphic elements (here pop-up maps) rather than focusing on text.

6.3.2.7 Topic 'Occupation of Sao Paulo's Territory during the 18th Century' (*A Ocupação do Território Paulista no Século XVIII*)

Similar to the topic described above, the interface design of the topic on 'Occupation of Sao Paulo's Territory during the 18th Century' repeated the design adopted in the previous two topics, with the exemption of the printing file icon (figure 6-24).

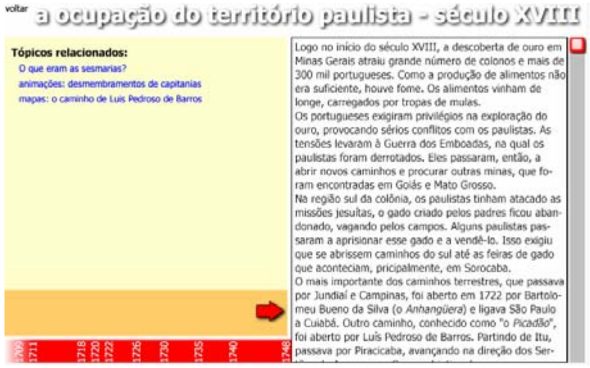

Figure 6-24. Interface design adopted in the topic 'Occupation of Sao Paulo's Territory during the 18th Century'.

However there were some changes in the content conveyed for this topic which led to sight changes on the interface design. The content related to this topic in the paper atlas was presented as a series of temporal maps showing the territorial evolution of Sao Paulo State.

Instead of using navigation arrows to swap maps on the screen (a resource extensively used previously and proposed on the templates) it was decided to use time to control the map display. In this way the first map was shown for a certain amount of time and then a second map replaced the first, and so on. In this way a frame-based animation was implemented with SVG, this resource was not included in the templates because it was verified just once in the entire atlas and it was included here for testing.

Regarding interface elements identified by the respondents in this topic, nine respondents mentioned the timeline. Pictures, text and maps were each cited by eight respondents. Hyperlinks within the text and in the menu were mentioned by five respondents and three mentioned the scroll bar. Interactive zoom tools and interactive text area (in orange in figure 6-24) were each mentioned by one respondent (figure 6-25).

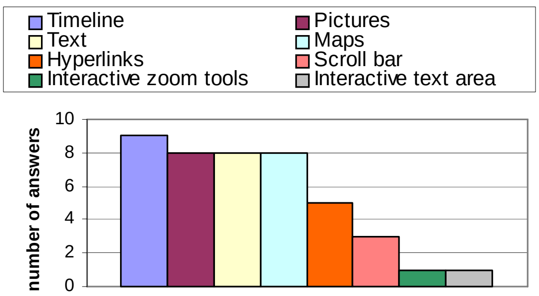

Figure 6-25. Interface elements identified.

In this topic, the timeline turned out to be the interface element most mentioned. However, pictures are one of the three interface elements that scored the second highest number of mentions. It is important to emphasise here that, even though it seems that the pattern of atlas use - where pictures attract greater attention – was not confirmed, in the list of answers pictures were usually the first element noted.

After interacting with several topics in the prototype, it appears that the users were more comfortable with the interface and also the nature of the question asked, providing more accurate answers and mentioning a greater number of interface features.

Considering the interactive features identified, the feature that received more mentions was interactive zoom, mentioned by nine respondents. Hyperlinks were mentioned by six teachers followed by interactive legend, mentioned by three respondents. Two respondents cited animation as an interactive feature in this topic and interactive timeline and mouse over maps were each mentioned by one respondent (figure 6-26).

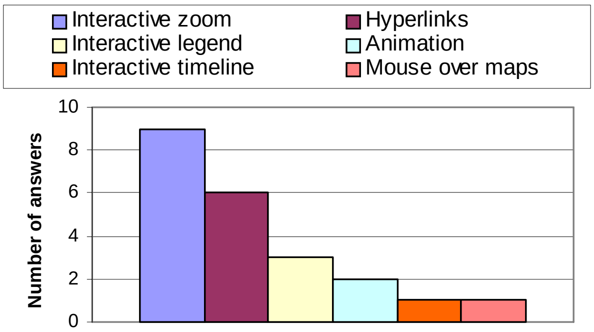

Figure 6-26. Interactive features identified.

An interesting remark in the answers illustrated in figure 6-26 is the low level of responses related to the animation introduced here. It is believed that, because the interface design had become repetitive, the teachers preferred to explore the pop-up maps and the main interface of the topic, rather than exploring the content of every hyperlink. It is believed that, for this reason, most respondents did not realise the existence of a different feature in this topic, even though the link that led to the animation clearly stated this.

6.3.2.8 Topic 'The Beginning of Colonisation' (*O Início do Povoamento*)

The interface design adopted in the topic 'The Beginning of Colonisation' followed the same standards adopted in the previous topics, shown in figure 6-27. In the main interface there is a text box to the right side and at the left there is a menu with just one option provided. A timeline (in red) can be found on the bottom left side. This design was adopted because the pages that covered this topic in the original atlas had information that could fit in two different templates.

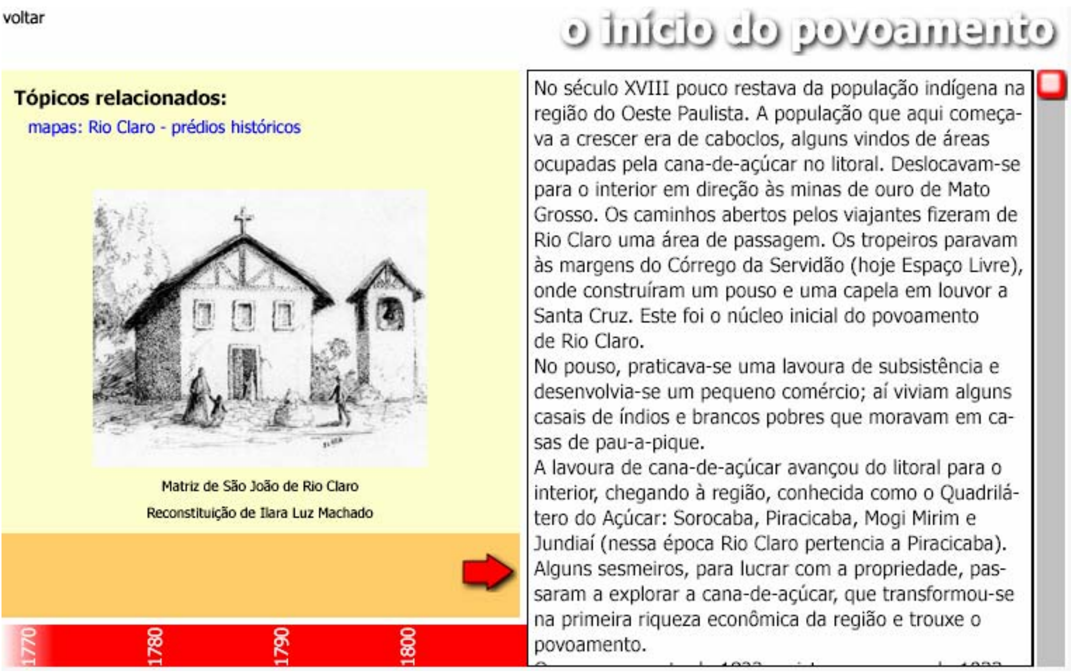

Figure 6-27. Interface design adopted in the topic 'The Beginning of Colonisation'.

Figure 6-28. Interface design adopted for the clickable map in the topic.

There was text and images (therefore Template 3 could be adopted), but also included was a cadastral map of the city centre. In this way it was decided to use the standard image-and-text interface adopted as the main contents page and add a link to a second screen developed according to Template 2 and applied to a clickable map of the city centre (figure 6-28). Using the map illustrated in figure 6-28, every dot clicked on the map led to a different image in the city centre. Considering the teachers' perception about the interface design adopted, once more the element that was mentioned more time was pictures, this time cited by all respondents.

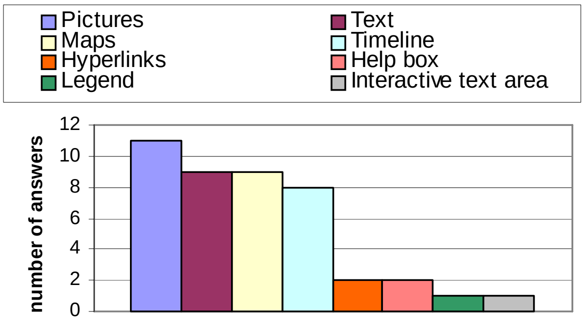

Figure 6-29. Interface elements mentioned.

The second focus of attention, mentioned by nine respondents, was text and map. The timeline presented in the main screen was mentioned by eight respondents and two teachers cited hyperlinks and the help box as interface features. The map legend and the interactive text area above the timeline were mentioned by one respondent each.

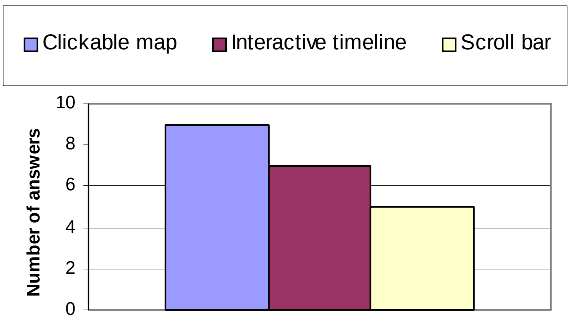

Figure 6-30. Interactive features identified.

Regarding interactive features perceived, the majority of respondents mentioned the clickable map (cited by nine teachers), seven teachers cited the interactive timeline presented in the main page and five mentioned the text scroll bar as an interactive feature in the topic.

In this topic, the element that attracted more attention was the pictures. However the pictures were made available when interacting with the clickable map. Because the pictures were mentioned by all respondents it is believed that all respondents interacted with the map. This can be also verified in figure 6-30 by the high number of teachers that mentioned the clickable map as an interactive feature.

From all topics analysed in the prototype, the topic on 'The Beginning of Colonisation' appeared to have caused a significant impact amongst the respondents because many teachers started to discuss the potential of using the cadastral map with students in exploratory field trips to the city centre. Finding ways of applying the content of the digital atlas to practical student activities was the object of discussion with the teachers in the final part of the tests, discussed in section 6.3.3.2 in this chapter.

6.3.3 The Prototype Assessed by Teachers

The third questionnaire given the group of volunteer teachers aimed to provide them with the opportunity to assess the prototype. Initially they were asked to identify any difficulties they had using the atlas. They were also asked about the importance of using text and images in the digital atlas in comparison to how they would use the paper atlas. Another question focused on the role reserved for the teacher in a digital classroom.

Another part of the questionnaire asked for suggestion for product improvements. The final question dealt with the need for a course to learn how to use the digital atlas effectively. The analysis of the answers is provided in the following sections.

6.3.3.1 Difficulties using the Internet Atlas

Initially the group was asked whether they had any problems to open the prototype from the CD-ROM or from the URL provided. From the twelve teachers that responded this questionnaire, nine said they did not have any problems opening the product. One teacher mentioned that he/she had to install the SVG plug-in, although he/she did not describe it as a problem.

Another teacher mentioned that the only problem verified was not having access to the Internet. This is not considered to be a problem since they were given a hard copy of the prototype and necessary plug-in and no Internet connection was needed. One teacher mentioned that he/she had problems with the pop-windows being blocked by the Web browser. In fact several teachers reported this problem during the tests as many maps were opened as pop-up windows. Once they were informed how to unblock pop-up windows in Web browser the problem was solved.

Additionally they were asked to indicate the difficulties they had in using the atlas and in which topic they had encountered problems. Two respondents indicated problems. The first said he/she had problems using the scroll bar and another repeated that the Web browser was blocking pop-up windows. In fact the scroll bar implemented is slightly different from the scroll bars found in *Windows*-based applications. The reason that the others did not mention it as a problem, and because this matter was never raised by any of the participants, it is believed that this remark is more a comment than a real problem in using the prototype.

The following questions dealt with a more sensitive subject, although not related to the atlas use can affect it. It is believed that teachers could generally perceive digital products for education as being a menace to their teaching practice. Even though the test group was considered to be fairly experienced in using computers, the use of computers for education is a different matter. Some questions were introduced in the questionnaire so as to verify whether candidates would accept a digital atlas for classroom use.

Initially, they were informed that previous research that analysed the use of paper atlases revealed that the main focus of attention was images and text. Then they were asked if they believed that digital atlas use would follow a similar fashion to paper atlas use. It was noted that the teachers were quite surprised by the question and they provided very interesting responses. Most of teachers said that digital atlas use would certainly follow the same pattern as paper atlas use, highlighting that the use of printed maps and other supporting materials should not be neglected. One teacher stressed that the digital atlas would be complement to paper atlases and not be the main teaching material used. Therefore this teacher subtly stated that he/she would decide whatever content would be taught to the students and the digital atlas could be part of it. Other teachers emphasised that, being in a different media and learning environment students would be more motivated to learn. One teacher made an interesting remark. Already planning the use of the atlas in the classroom, he/she said that the students should first be given digital maps in the prototype. He/she believed that this would trigger the student's curiosity and therefore they would be more eager to work with complementary paper maps.

The next question dealt with the role of the teacher in a digital classroom. The answers for this question were quite diverse. All teachers said that the teacher would be an advisor and would facilitate learning in a digital classroom. However, the definition of their role in the teaching-learning process seemed to be still slightly unclear in their understanding of the matter. Some teachers, when answering the question, implied that the teacher would be passive in the classroom and their role would be more to conduct the student through the content of the atlas. Others stressed just the opposite. Interestingly, they seemed to be aware that in the beginning the teacher would be certainly passive, because the students would be likely to interact randomly with the product. Regarding this one of the teachers stated that "The teacher is a mediator. He/she will interact with the product together with the students, after the students had interacted with the product by themselves" (translated from Portuguese). Many respondents, however, stressed that the main role of the teacher, when using the digital atlas, would be to give a meaning to the product content related to the subjects they taught.

Finally, the teachers were asked to suggest changes to improve the product considering the problems they had in its use. The overwhelm majority of respondents (10 teachers) did not answer this question. It would be naïve to believe that they had no suggestions, and it is believed that the way the test was conducted might have hampered these particular responses. Because the teachers had been in contact with the researcher for a long time using the product, they had presented many suggestions during the course and therefore they did not report the suggestions at this stage, probably believing it was not relevant since they had already made suggestions previously.

The main suggestions they presented informally related to the use of standardised colours and the mouse over effects associated with different maps. The two teachers that responded to the question stressed that colours, symbols, interactive effects and screen should be standard throughout the application.

6.3.3.2 More Advanced Interaction: teachers contributing to the atlas

The last activity undertaken with the teachers was not a questionnaire. This time they were asked to prepare a paper activity based on the atlas content that could be included in the prototype. The idea behind this activity was to foster the teachers not be passive and to interact with the product in a more active fashion. In order to enable them to take full advantage of the use of simple digital tools they were briefly trained to screen capture, use image editing software (they were instructed on the use of *Paint*, an image editing application available in *Windows*) and to copy text from the atlas.

Some teachers reproduced traditional teaching-learning methodologies. One teacher prepared two questionnaires, one related to the historical content of the atlas. Therefore the students would be forced to read the atlas content to answer the questions. The same teacher proposed a second activity. He/she used the political map of Brazil and asked students paint the State were the city of Rio Claro was located in red and all other States that share borders with it in yellow. The fact is that there were no labels in the map to identify the states and the teacher referred to the name of the city instead of the name of the State would foster students to interact with the maps in the prototype to answer the questions.

Other teachers presented similar activities. On teacher captured all maps in the topic 'Location and Orientation'. The polygons within the maps were cleaned and the teacher asked the students to colour the maps to answer questions proposed.

Using the map of routes depicted in figure 6-15 (section 6.3.2.4 in this chapter) three teachers proposed a series of activities. One teacher erased the names of Brazilian cities along the route and asked the students to identify their locations. Another teacher erased the name of the Brazilian States along the route and asked the students to identify them. The third teacher went further and provided a complete map and a table with the names of the Brazilian cities along the route, asking students to research their date of foundation. It is believed that such specific information would be more likely to be found on the Internet itself and therefore this particular teacher was able to link the contents of the atlas with the Web, this kind of activity would certainly empower students' Web searching skills.

Two teachers worked with the map of cities in Rio Claro's region, available in the topic 'Location and Orientation'. The first teacher asked the students to colour the map and prepare corresponding legend. The second teacher numbered all the 86 cities in the region and provided a map with a legend. He/she coloured Rio Claro in red and kept all other cities in yellow; an attached questionnaire asked the students to identify the number that corresponded to Rio Claro and cite the numbers and names of its neighbouring cities. He/she also asked which cities of the map were located on the coast (none of them is located on the coast, to answer this question the student should refer to other maps within the atlas). Other question asked the students to identify the cities that shared borders with the State of Minas Gerais and the final question asked the students to identify the biggest city (in area) in the region.

The activity proposed by this second teacher was particularly interesting considering that he/she declared at the beginning of the course that she had little experience using computers and still felt insecure using the Internet. It is believed that, amongst all respondents, this teacher was one of the teachers that edited the map with accuracy (not distorting the original map when enlarging it).

Two teachers proposed activities with the cadastral plan of the city centre. Both proposed a field trip with students to the city when the students could fill the map with reference point such as banks, pharmacies, the Town Hall and so forth and to prepare a proper map legend. This activity is considered to be very beneficial because it connects the abstract map on the computer screen to the geographical space that can be explored and mapped by the students. Additionally it improves student's navigation skills.

All activities proposed by the teachers could be included in the atlas. Once converted into PDF files they could be easily inserted into the topics of the atlas to which they are related. This kind of advanced interaction, where the teacher is no longer a mere user, but a critical user enriches the atlas content, follows the same underlying idea used on the development of the original *School Atlas of Rio Claro*. The inclusion of such activities would foster further involvement of teachers with the product and enhance the teaching-learning process.

6.4 Test 2: Test Execution

The second test was conducted with a group of six graduate students (Masters and PhD) undertaking their studies at the University of Sao Paulo State, Rio Claro Campus. The purpose of this test was to ascertain the effectiveness of the templates proposed as a tool for publishing Web atlases. It was decided to undertake this test within the academic community because, similar to paper atlases analysed previously, it was believed that future atlas developer's teams would be comprised by teachers and academics. The first would be responsible for developing content and testing it with students and the later would also be responsible for providing content as well as publishing the final product.

The test was again set up as a course. When undertaking their Masters and PhDs in Brazilian universities the candidates have to attend a compulsory number of subjects. Therefore a subject on Cartography on the Internet was proposed. The course was divided into two parts. In the theoretical part the candidates were introduced to concepts such as geographical visualisation, multimedia and cartography, animations and interactive mapping. They were also instructed in basic technologies for Web publishing.

In the practical part of the course the candidates used the templates to publish an Interactive atlas of the University's campus. They used the same computer laboratory used in the first test. The initial motivation for the candidates to undertake the test was to obtain credit points they needed to finish their degrees. However, as several lecturers offer a myriad of different subjects it is believed that the candidates were interested in the field. Moreover, the candidates were informed that there would be no formal assessment during the course such as an exam or seminar. Instead, the candidates were required to finish only the practical part of the course.

At the end of the course, after their prototype atlas was complete, they were asked to answer a questionnaire to assess the experience. An analysis of their responses is provided in the following sections.

6.4.1 Candidate Profile

The volunteer group for this second test comprised six people. One candidate was undertaking the course as part of the requirements for his/her degree in Environmental Science, three were undertaking graduate studies in Geography, one was undertaking a graduate degree in Physics applied to Information Technology and one was not yet enrolled at graduate level although he/she intended to do so.

Regarding their background five had an undergraduate degree in Geography and one had finished an undergraduate degree in Information Technology. Half of the group declared they had had worked regularly one was a teacher in primary and secondary schools (thus the feedback provided by this particular candidate was extremely valuable), one was self-employed and one worked as an IT analyst.

Considering their experience with computers four respondents had between 5 and 10 years of experience using computers, one respondent had more than 10 years of experience and one respondent had 1 to 5 years of experience using computers. Therefore the group was considered to be comprised of experienced computer users.

Considering their computer usage habits and needs (figure 6-31), all respondents said they used computers for spatial analysis with Geographical Information Systems (GIS) and for Internet navigation. Five respondents also used computers for text editing and four declared they used computers for Computer Aided Design (CAD). One respondent used spreadsheet software and one declared he/she had programmed computers.

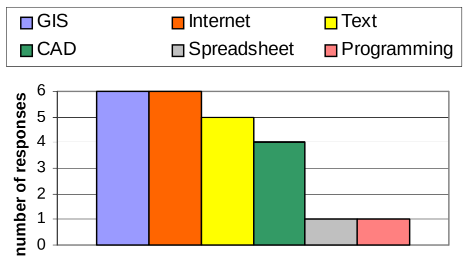

Figure 6-31. Computer usage habits amongst respondents.

The pattern of computer use suggested that as well as being a group of experienced computer users, the group was also experienced in geospatial-related technologies, all were regular users of GIS and CAD applications in their work or studies.

Considering Internet use, two respondents said they started using the Internet 3 to 5 years ago. The majority of respondents, four, said they had used the Internet for more than 5 years. Once again, the group can be considered as experienced Internet users. All respondents said they used the Internet to access maps.

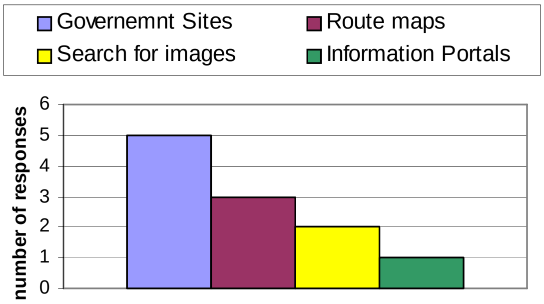

Figure 6-32. Patterns in Web map usage.

Regarding Web map use (figure 6-32), five respondents said they used Web maps via Government sites and/or other official sources. The main source of Web maps in this category was the Brazilian Institute for Geography and Statistics (http://www.ibge.gov.br). This pattern of Internet map use is not surprising, since the sample group was comprised mainly of researchers in geospatial sciences and they used information from official sources in their research. Three respondents said they also used route maps from Brazilian Web sites such as *Apontador* (http://www.apontador.com.br); two respondents said they simply searched for images on the Web using a search engine and typing key words for the search. One respondent mentioned that he/she also searched for maps via information portals.

When asked wether they had had any problems using Web maps most respondents said they did not have any problems. Two respondents however mentioned problems in Web map use. One said that sometimes the Web map server did not respond and another said that the client computer did not have the necessary plug-in to open the maps, and, as well, the site did not provide a link to download the necessary application. The first remark cannot be addressed, since Web servers can go offline at any time. The second, however, can be easily solved since it just requires simple changes in the Web map page to link it to the necessary plug-in.

All respondents said they had interest in publishing maps on the Web. The teacher said that his/her interest was to publish interactive maps that would help in the learning process. Another respondent said that he/she wanted to publish maps on the Web because it would be possible to publish interactive and dynamic maps. One respondent said that his/her main interest was to publish maps on the Web for envisaged future professional projects including distance learning. Another respondent said that he/she needed to publish maps on the Web as part of his/her professional duties. Two respondents highlighted that the wider audience for Web maps and the interactive possibilities provided by them were seem as a major benefit for Web map publishing.

When asked the purpose of their future ventures dealing with Web map publishing (if they engaged in such projects) the group provided various responses. One respondent said he/she would engage in Web map publishing to improve his/her knowledge in the field. Four said they would publish maps on the Web so the product of their work would be available to a wider audience. The teacher said he/she would publish Web maps for educational purposes.

The responses given to both questions implied that, notwithstanding the candidate that dealt with Web map publishing as part of his/her professional duties and the teacher, respondents did not have a clear idea of how they could use Web map publishing, apart from broadcasting the findings of their personal research projects.

6.4.2 Assessing the SVG Templates

Once the respondents' profile and their Web map usage habits and constraints was identified, the focus moved to the difficulties they had during the development of the prototype atlas of the University campus. They were asked to grade this activity. The grades ranged from 1 (very easy), 2 (easy), 3 (requires skill), 4 (hard), to 5 (very hard).

Considering interface design, half of the respondents said that this task required skill (figure 6-33). Two respondents said that it was very easy and one said it was easy. Amongst those that said the task required skill, they said that the main difficulty was to work with the drawing software for the first time. As stated in Chapter five, when using the templates the users had to export their maps to SVG using a 'bridging' application, *Corel Draw 11*. The use of this software was required as the original cadastral map of the Campus, provided by the university,

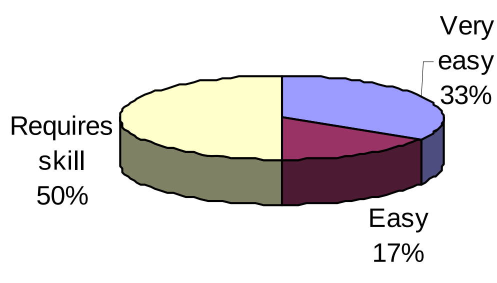

Figure 6-33. Respondents' assessment of atlas interface design.

was in *Corel Draw* format. All candidates argued that after they overcame the original difficulties in using the software the work went smoothly.

Regarding difficulties in developing HTML pages the group was equally divided (figure 6-34). Two respondents said that the task required skill, two said it was easy and other two said it was very easy. The main difficulty described by the respondents is related to their inexperience in developing HTML pages and most of the group developed their first Web page. Just one respondent had previous experience with Web publishing. All respondents that considered that the task required some skill or was easy affirmed that it was just a matter of time to gain experience with the tags and the structure of the file to develop the pages with more confidence.

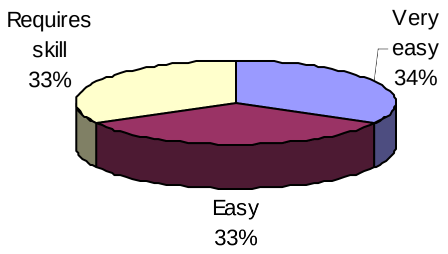

Figure 6-34. Respondents' assessment of their difficulties in creating HTML pages.

The next question asked the respondents to access the level of difficulty they had had to export the maps from *Corel Draw* to SVG. This task involved closing all the polygons within the map, naming features and organizing the information within the file in different layers. Since these tasks are commonplace for CAD users, it is not surprising that half of the group considered the task to be very easy (figure 6-35).

One respondent said that the task was easy; another said that it required some skill and one said the task was hard to execute. All respondents but one commented that the task of simply exporting the file itself was quite easy, the main 'difficulty' was organising the file in layers and naming all the features appropriately, because as highlighted by some respondents it required concentration. Generally the respondents that said the task required some skill and that it was hard (one response each) referred to their inexperience using the program *Corel Draw* as the only problem they had.

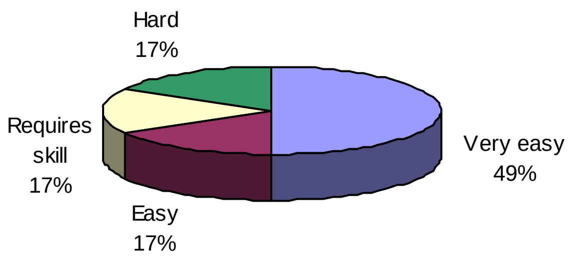

Figure 6-35. Respondents' assessment of their difficulties exporting CDR files to SVG.

After designing the atlas layout, developing the HTML pages, organizing and exporting their maps to SVG the candidates had to use the templates, adapting the proposed interfaces to the design they had chosen. In this section they had to use their basic knowledge in SVG, provided in one lecture, in order to adapt the interface design to suit their needs. They were advised to use Web Safe Colours and Cascading Style Sheets (CSS) when referring to styles within the SVG file. They were not required, at this point, to use JavaScript. Regarding the difficulties they had in adapting the interface design in the templates to their own atlas half of the group said that the task required skill. One respondent said the task was easy and two said it was hard to execute (figure 6-36).

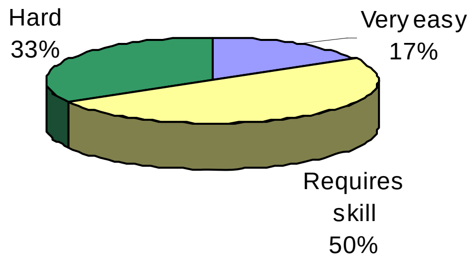

Figure 6-36. Respondents' assessment of their difficulties in creating their interface design in SVG.

Respondents that said the task required skill commented that the main difficulty was their inexperience in programming, therefore it took them some time to understand the structure and the logic behind SVG. For most of the group this was their first experience with coding. One respondent said that his/her main difficulty was to understand the code for something that he/she always worked graphically. This particular candidate had a long experience in using CAD applications and, therefore, it took him/her sometime to get used to creating polygons, lines and points, for example, textually instead of graphically. One of the candidates that said the task was hard and justified his/her opinion by saying that programming in SVG requires a high level of attention. The other respondent that considered the task hard, the teacher, said that due to his/her inexperience with programming he/she decided to simply copy and paste the necessary parts of the code to adapt it to his/her interface design and therefore he/she did not try to understand it.

The following question dealt with the degree of difficulty in understanding the structure of SVG files. Although they did not require extensive knowledge of SVG or any previous programming experience, some understanding of the structure and the logic behind SVG was necessary to facilitate the use of the templates. The patterns of responses for this question repeated the previous responses; three respondents said that understanding the structure of a SVG file required some skill, two said that it was hard to understand and one said it was very easy (figure 6-37).

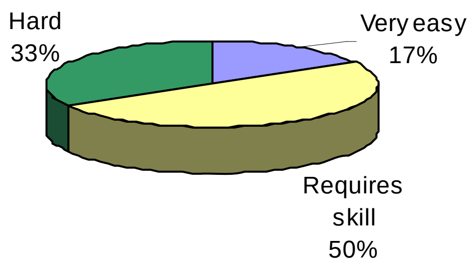

Figure 6-37. Respondents' assessment of their difficulties in understanding SVG files.

Both candidates that said SVG files were hard to understand stated that even though they found it difficult to understand SVG they believed that it was just a matter of getting used to the technology and they would be able to overcome their problems. One of them highlighted that the instructions provided in the templates facilitated his/her understanding of SVG. Amongst the candidates who said that understanding SVG required some skill, one stated that once he/she overcame the initial fear due to the inexperience with code, he/she was more confident and could understand the code better. Another said that once he/she could understand the meaning of different sections of the SVG file he/she did not have any problems with the code. Another highlighted that some commands were quite intuitive whilst others were not so easy-to-understand. It is important to emphasise that they were not required to understand commands or the syntax of SVG files, but rather the structure. For example, there should be a section of the code describing styles, another section for the map legend, another section to insert their map, another for text boxes, etc.

Considering their difficulties in adapting the JavaScript code in the templates to meet their development requirements, the responses given were varied. Two candidates considered that the task was very easy, one considered it was easy, another said it required some skill, one said that it was hard to implement and one considered that this task was very hard (figure 6-38).

One of the respondents that said the task was very easy stated that he/she just had to follow the comments to achieve the necessary result. The candidate that said it was easy to adapt the JavaScript code from the templates said that after he/she understood the way the JavaScript functions work he/she enjoyed testing different parameters to see the changes that would happen in his/her interactive maps. The respondent that said the task required some skill and also affirmed that it was necessary to have some previous experience with JavaScript in order to fully understand the code. The candidates that said the task was hard or very hard claimed that if they had had more time to interact with the template they would have achieved a better understanding.

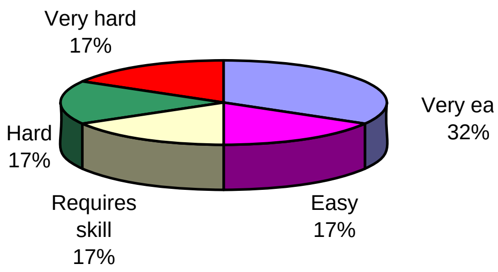

Figure 6-38. Respondents' assessment of their difficulties to adapt JavaScript code to attend their needs.

When asked if they had intention of using SVG to publish Web maps in the future, all respondents said they would be keen to repeat the experience with other projects. Some highlighted the quality of final maps produced as an advantage for using SVG in the future. Another respondent highlighted that the combination SVG + JavaScript made it feasible to publish interactive Web maps, with quality and as compact files that could, therefore, be quickly loaded over the Internet.

The respondents were then asked to identify the advantages and disadvantages of using SVG and JavaScript to publish Web maps. Generally the advantages identified were:

- Using these technologies would empower them with tools to reach an audience that they would not otherwise reach;
- Being an open standard means that developing SVG Web maps would have no actual cost; and
- Using the templates made the task of producing the final interactive map much easier than if they had tried without them.

The disadvantages of using SVG and JavaScript to publish Web maps were highlighted by four respondents as follows:

- People with no Internet access would not have access to the maps being published;
- Because the technology allows virtually anyone to publish Web maps it would create a favourable environment for spreading the number of geospatial applications on the Web. However, the contents and quality of those applications would not be necessarily reliable since there is no official body that monitors the quality of geospatial applications published on the Internet; and
- SVG and JavaScript are not easy to understand for inexperienced developers. However they emphasised that the use of the templates made the task much easier.

Because their experience with SVG producing an atlas happened in a course, the respondents were asked if they considered that an average computer user would be able to achieve the same results with no need of attending a course. One respondent said that ‘yes’, although he/she stated that the person would have more difficulties. Five respondents said that the person would not be able to publish a complete application, explaining that even with a good tutorial it would be very unlikely that a person with no previous programming experience would be able to achieve the same results. Even though none of the respondents mentioned this, it was noted that they took great advantage of group interaction. The respondents worked in pairs, and they usually referred to each other’s work for help or even to learn by their colleagues’ mistakes. Therefore, it is believed that not only the course ‘environment’ but also exchanging experiences with other developers were highly beneficial in achieving the final results.

The respondents also indicated that it would be desirable for the prospective users of the templates to have some knowledge of *Corel Draw*, SVG and JavaScript or some other programming language.

Four respondents said that there would be no need for any extra documentation to accompany the templates. One respondent, however, said that it would be helpful that the user of the templates had access to documentation on SVG, JavaScript and

XML (which can be obtained on the Web for instance). The same respondent said that a document with guidelines for using the templates would be desirable.

6.5 Chapter Summary

In this chapter two tests were described. The first test was conducted with a group of Brazilian primary school teachers aimed to assess the effectiveness of the interface design and information architecture adopted on the proposed set of templates. In order to proceed with this test, part of the *School Atlas of Rio Claro* was published on the Web using proposed templates.

The analysis of the responses provided by the teachers in three questionnaires and one practical activity led to some conclusions. Firstly, the teachers generally reproduced the same pattern of atlas used verified on paper by Oliveira (2003) when using the digital product. The answers revealed that most of the time the teachers did not refer to the maps when looking for interactivity or additional information, they initially referred to the map legend. This finding confirms that the group generally mimicked the way they used paper maps. This information also reveals that they were not used to dealing with interactive digital maps.

It is important to place these findings in the broad context of the Brazilian education system. As described in the previous chapter, the Brazilian Government has invested in computer facilities for didactic purposes for public schools. However in a country with a population of around 180 million (IBGE 2005) this is a huge task and providing computers to public schools alone does not guarantee that equipment will be effectively used for education.

To achieve this goal four approaches need to be adopted. The first is to train teachers on the use of computers and increase their technological skills. This has been done in Sao Paulo State for the late 1990s and, as can be noted in the sample group that participated in this research, it has already produced results. The second is to foster the teachers to effectively use available computers with their students and not only use the computers to produce activities that would be later printed and given to the students on paper. The third approach is to provide teachers with Brazilian applications for education. It is believed that teachers should not be expected to adopt teaching materials that are not in accordance with the Brazilian educational system and context. A forth issue is the language in which the educational products are developed; the teachers should not be expected to deal with education applications with interfaces based in a language other than Portuguese (that is the case with most educational applications available on the market, developed in English), except when the subject taught is foreign language.

The second test was conducted with a group of graduate students from the University of Sao Paulo State, Rio Claro Campus. The group was given the task to produce an interactive atlas of the University's campus using the templates proposed in this research. Working during three weeks the group was able to develop an interactive prototype atlas of the campus based on SVG and JavaScript.

Generally speaking, the feedback provided by the graduate candidates was positive. When answering questions about difficulties they had when developing the product and using the templates they said, most of the time, the task was either very easy, easy or the task required some skill.

Additionally they were nearly unanimous in saying that an average computer user would need a training course to develop a Web atlas, and the templates would be a valuable help in this context. Therefore it is believed that the experience described here should be incorporated in the contents taught in undergraduate courses in Geography, Geology, Environmental Sciences, Ecology and Cartographic Engineering (the courses in which the subject Cartography is taught).

The findings described in this chapter have implications that led to a number of conclusions and final recommendations, which are highlighted in the following chapter.

7 Conclusions and Recommendations

7.1 Conclusions

Computers were first used as a tool for just producing paper maps, however since the mid-1980s they have increasingly been used also as a medium for delivering increasingly interactive cartographic products. Initially, digital cartographical applications – and more specifically atlases – were distributed using discrete media (e.g. magnetic tapes, floppy discs, CD-ROM and DVD), with the growth of the Internet during the 1990s digital atlases migrated to this networked environment. With the advent of mobile computing, and the use of portable computers and hand-held devices, Internet cartography – and atlases – also went mobile.

Acknowledging the potential of these recent technological innovations for atlas delivery this research focused on proposing a methodology for developing Internet atlases for use in primary education in Brazil based on Open Standard methodologies. As well, research indicated that there is a growing interest amongst academics in producing atlases for Web delivery.

Different definitions of digital atlases were provided and the vague boundary between digital atlases and GIS was also analysed in this research. It was found that, digital atlases provide a myriad of interactive features that are not possible with their paper counterparts. Digital atlases can be linked to multimedia content as well: animations, video, photos, text, graphics can be combined in an interactive fashion, making this medium ideal for educational applications. However, the importance of paper atlases and interactive educational activities using paper was not rejected, and the methodology proposed in this document included hard-copy activities that should be included in atlas packages designed for education. Therefore, it is recommended that atlas products should be hybrid, and comprise digital as well as paper-based content.

Research on Cartography for School Children in Brazil established as a significant research focus since the late 1970s; however during the 1990s a new research trend emerged: the development of local school atlases for use in early geographical education classes. Brazilian local school atlases are usually result of partnerships between public university and local governments and are produced with limited funds. Reprinting those atlases is not always viable. Here, the Web is seen as a solution for replacing printed atlases in a long-term solution.

In order to empower Brazilian developers of local school atlas with a low cost and easy-to-use solution to publish their products on the Web a methodology for publishing Web atlases, based on Open Standard technologies was developed. The methodology was based on the guiding principles of:

- Brazilian developers working with restricted budgets and therefore the solution proposed should be as inexpensive as possible;
- Brazilian developers of local school atlases are usually primary school teachers, academics, undergraduate and graduate students with background in education and geography. The group probably would not include Web developers and/or computer programmers. The solution proposed needs to be self-explanatory and easy-to-use; and
- The atlas needs to be built in such a way that it can be accessed using different of computers. Therefore the solution proposed should lead to the publication of atlases delivered over the Internet (using dial-up and broadband connections) as well as stand-alone, from a CD-ROM version;

In order to address the principles listed above, the methodology developed in the research proposed using a set of SVG-based templates to publish Brazilian local atlases on the Web. SVG is an open standard vector-based technology validated by the World Wide Web Consortium, therefore there is no cost to use this technology.

The contents of the *School Atlas of Rio Claro* were used to develop the set of four templates, which aimed to cover different types of information architecture that could be implemented in a Local School Atlas. The templates developed were:

- **Template 1:** to be applied to linear presentations;
- **Template 2:** to help developing clickable maps;
- **Template 3:** to be applied when the text is the main focus of attention;
- **Template 4:** to help developing maps with interactive zoom and pan.

Additionally, part of the *School Atlas of Rio Claro* was published on the Web, using these templates. This small prototype was developed for testing with a group of primary school teachers in Brazil. The templates were also tested with a group of Brazilian graduate candidates from the University of Sao Paulo State.

From the evaluations and subsequent analysis of results, conclusions have been made:

- The methodology proposed and evaluated here can be used by Brazilian developers of local school atlases. A group of Brazilian graduate candidates, whose profile did not differ significantly from local school atlas developers in general, was able to publish a small Web atlas using the templates provided;
- Primary school teachers are eager to use Brazilian Web atlas applications for educational purposes. Therefore if Brazilian developers of local school atlases start exploring the Web as a publishing medium, the atlases they produce will have a higher visibility and will thus be more likely used by teachers in their educational practice;
- The development of a hybrid atlas empowers teachers, encouraging them to improve the content of their 'own' digital atlas, proposing practical activities on paper to be incorporated within the product. In this way the teachers are able to go a step further, they are not passive users, but rather active and critical users; and
- The teachers still however lack experience with interactive cartography and may only reproduce, paper facsimiles in their dealing with interactive maps.

The experience described here has illustrated that it is possible to develop a digital local atlas for education at greatly reduced costs. It is also possible that, in the future, Brazilian public universities can use their practical knowledge, developed through many years of work with paper atlases, to publish their products directly via the Internet, using the SVG Atlas Templates developed as part of this research. Nevertheless, it is believed that the main outcome of this project will be the 'digital inclusion', not only of public school children, but also of Brazilian children's atlas developers.

7.2 Recommendations

The outcomes described in this document logically lead to a series of recommendations. Firstly, additional research could clarify some topics as follows:

- The group of teachers who tested the atlas had used the original paper atlases, perhaps if they had not had contact with the paper product their responses would have been different.
- Further research could identify what kind of map use should be recommended when teachers are in extensive and continuous contact with the digital product. Would it still follow the same patterns identified in this research? Would the teachers develop a new way of using maps?
- What kind of educational games could be introduced in SVG-based atlases? Would they be effective to enhance learning? The teachers involved in this research enquired about the inclusion of games into the prototype, however as it was not part of the scope of the research programme, it is believed that further research could focus specifically on the implementation and testing of SVG-based games for Web local school atlases.

Secondly, it is recommended that teachers be trained in the use of local Web Atlases. The need was identified by the group of primary school teachers during the testings conducted in Brazil. Although they had few problems with the product itself it is believed that a formal short course would provide them with more confidence when using the product, and therefore they would be likely to more effectively use the atlas with students.

Thirdly, considering the architecture of the product it is recommended that local school atlases be published as a client-side application. This architecture would allow students with no Internet connection to access the product using discrete media (CD-ROM or DVD for example).

Fourthly, related to the use of the templates by developers it is important to emphasise that, at the moment, digital technologies are used as a tool in education and geography departments in Brazil, the primary local atlas ‘think tanks’. Academics use computers to produce text, drawing, CAD, spatial analysis with GIS. However they are not trained to develop digital multimedia products or to program. Therefore, it is recommended that the topic of digital publishing needs to be introduced into the syllabus for undergraduate students in geospatial sciences in Brazil (Geography, Cartography, Geology, Environmental Science and Engineering, and Ecology). If undergraduate students in these areas were trained in digital and Web publishing, over time the need for specific training would be eliminated.

In addition, this would create a favourable environment to change the way that future Brazilian local atlases are produced. In this research, the methodology proposed could be considered as an attachment to the well-established and successful methodology already in use to produce paper atlases. In other words, the methodology proposed aimed at providing developers with the means to transpose from paper to digital media, but the concept does not change. Brazilian school atlas developers are therefore invited to conceive their products to computer screens instead of A4 paper. The introduction of digital publishing element into Brazilian geospatial undergraduate courses would allow for the future content of local school atlases to be conceived primarily for digital publishing.

Finally, the Open Standard technologies employed in this research programme could be freely used in computer laboratories in Brazilian public universities, where funds for buying educational software are generally very limited. In this way, it is believed that the use of the methodology proposed would foster the use of other Open Standard technologies in Brazilian universities.

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Appendix A

Survey Questionnaires

Questionário

1. Identificação
Nome completo:
Data de nascimento:

2. Formação Escolar
2.1 Ensino Médio
Nome do curso:
Escola:
Ano de conclusão:

2.2 Ensino Superior
Nome do curso:
Universidade:
Faculdade ou Instituto:
Ano de conclusão:
Título obtido:

2.3 Outros cursos superiores ou especialização
Nome do curso:
Universidade:
Faculdade ou Instituto:
Ano de conclusão:
Título obtido:

2.4 Pós-graduação
Nome do curso:
Universidade:
Faculdade ou Instituto:
Ano de conclusão:
Título obtido:

3. Experiência profissional
Local onde trabalha:
Função:
Há quanto tempo:
Outras atividades remuneradas:

4. Experiência com computadores
Desde quando você usa computadores?
Para que usa?
Quais os principais softwares utilizados?

5 Uso da Internet
Você usa sites de busca?
Você usa:
( ) E-mail
( ) Messenger

( ) FTP

Se não usa, por quê?

Você consulta mapas via Web? ( ) Sim ( ) Não

Site de rotas? ( ) Sim ( ) Não

Atlas? ( ) Sim ( ) Não

Quais problemas você identifica nos mapas que utiliza na Internet?

CURSO: ATLAS MUNICIPAL ESCOLAR DE RIO CLARO NA INTERNET
Unesp – IGCE – Deplan – Maio de 2005

No desenvolvimento do protótipo de atlas digital uma série de adaptaçòes foram necessárias na transposição do conteúdo em papel para a tela do computador. Outras adaptações foram introduzidas com o intuito de prover maior interatividade ao atlas e, desta forma, facilitar o processo de ensino-aprendizagem.
Nesta planilha você deve especificar os elementos de interface, ouse seja: mapas, barras animadas de tempo, imagens, etc. Pedimos também que você identifique o tipo de interatividade presente no tema, por exemplo: o aluno pode, em alguns momentos mover o mapa na tela (*pan*), ampliar o mapa (*zoom*), alterar a exibição de diferentes *layers* do mapa, acessar fotos panorâmicas em janelas separadas, etc. Uma vez que nós sejamos capoazes de identificar o tipo de interface e interatividade disponíveis nós poderemos planejar adequadamente seu uso em sala de aula.

TEMA	TIPO DE INTERFACE	TIPO DE INTERATIVIDADE
Onde estamos na Terra		
Sinais dos primeiros homens		
Sítios arqueológicos		
Os primeiros habitantes		
A ocupação do território paulista no século XVI		
A ocupação do território paulista no século XVI		
A ocupação do território paulista no século XVI		
O início do povoamento		

Atlas Escolar de Rio Claro na Internet: utilização em sala de aula

Questionário – Avaliação Final

Informações Pessoais
Nome:
Nome da Escola:
Uso do Atlas:
Você teve dificuldades para abrir o atlas eletrônico? Quais? ____________________
Quais dificuldades você teve no uso do atlas? ( ) no entendimento da página inicial (ícones de opções) cite:____________________ ____________________ ____________________ ( ) no tema "onde estamos na terra" cite:____________________ ____________________ ____________________ ( ) no menu de história cite:____________________ ____________________ ____________________ ( ) no tema "sinais dos primeiros homens" cite:____________________ ____________________ ____________________ ( ) nos temas sobre a ocupação do território paulista cite:____________________ ____________________ ____________________ ( ) no uso dos mapas históricos cite:____________________ ____________________ ____________________ ( ) nas linhas do tempo cite:____________________ ____________________ ____________________
Em pesquisa anterior onde foi estudado o uso do atlas em meio gráfico, verificou-se que as imagens e o texto constituíram o maior foco de atenção para os usuários. Você considera que o uso dos textos e dos demais conteúdos terão a mesma importância nas atividades de ensino com o atlas eletrônico? ____________________ ____________________ ____________________

____
Qual seria a função do professor ao ensinar com um atlas interativo? ____ ____ ____ ____
Quais seriam suas sugestões para a melhoria da versão digital do atlas? ( ) padronização no uso de cores e símbolos ( ) padronização de telas ( ) padronização de efeitos interativos (cores de elementos do mapa mudando conforme o usuário passa o mouse, mensagens ao usuário repetidas) ( ) outras, favor explicar: ________________________________ ____ ____
Você teria o mesmo entendimento do atlas eletrônico se não tivesse participado deste curso? Explique.____ ____ ____
Avaliação do curso:
Avalie de 1 (fraco) a 5 (adequado): O conteúdo teórico: ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 Explique:____ ____ A organização didática do curso: ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 Explique:____ ____ A importância do curso para a formação dos professores: ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 Explique:____ ____

Questionário – Avaliação das Templates

Informações Pessoais
Nome:
Trabalho:
Formação:
Experiência com computadores:
Duração: ( ) menos de 1 ano ( ) entre 1 e 5 anos ( ) entre 5 e 10 anos ( ) dez anos ou mais
Para que você normalmente usa computadores? (escolha mais que uma opção se necessário) ( ) Editoração gráfica (incluindo produção para a *web*) ( ) Digitalização (CAD) ( ) Análise Espacial (SIG) ( ) Cálculo ( ) Programação ( ) Digitação de texto ( ) Navegação na Internet
Quais programas você normalmente utiliza?
Uso da Internet:
Duração: ( ) menos de 1 ano ( ) entre 1 e 3 anos ( ) entre 3 e 5 anos ( ) entre 5 e 8 anos ( ) 8 anos ou mais
Você costuma consultar mapas via *web*? ( ) sim ( ) não Em caso negativo, por quê?
Pule esta pergunta caso a resposta anterior seja negativa Quais tipos de mapas você normalmente consulta? ( ) sites de rotas – quais? ( ) atlas *online* – quais? ( ) sites governamentais (como o IBGE por exemplo) – quais? ( ) mapas disponíveis em portais – quais portais? ( ) simplesmente faço buscas por imagens na *web* ( ) outros – quais?
Já teve problemas com mapas consultados na web? ( ) sim ( ) não Em caso positivo, quais?
Experiência com cartografia:
Você tem interesse em publicar mapas na web? ( ) sim ( ) não Em caso positivo, por quê?
Com que objetivo você publicaria mapas na *web*?

Experiência de desenvolvimento:
Identifique de 1 (fácil) a 5 (muito difícil) o nível de dificuldade: No desenho da interface do atlas: Explique: No desenvolvimento das páginas HTML: Explique: Na organização dos mapas em Corel Draw para a exportação em SVG: Explique: No desenvolvimento da interface do mapa em SVG: Explique: No entendimento da estrutura do arquivo SVG: Explique: No da adaptação do código JavaScript para atender às suas necessidades: Explique:
Você repetiria a experiência deste curso no seu trabalho cotidiano com mapas? Por quê?
Quais vantagens que você identifica no uso de SVG + JavaScript para a publicação de mapas na Internet?
Quais desvantagens que você identifica no uso de SVG + JavaScript para a publicação de mapas na Internet?
Você acha que um desenvolvedor sem profundos conhecimentos de informática poderia reproduzir a sua experiência sem treinamento específico? Explique
Pule esta pergunta se a resposta anterior for positiva. Qual tipo de conhecimento e/ou treinamento você acredita que seja imprescindível para quem queira publicar mapas interativos em SVG na Internet?
Você acha que alguma documentação adicional deveria acompanhar as templates? Que tipo de documentação?

Appendix B

Letter to the teachers

Atlas Municipal e Escolar de Rio Claro
versão digital

Prezado (a) Professor (a),

Venho por meio desta convidá-lo(a) a participar da minha pesquisa de doutorado que visa o desenvolvimento de um modelo para a produção de atlas escolares na internet. Meu modelo será baseado em tecnologias abertas, a intenção é minimizar os custos de produção, tornando, desta forma, o desenvolvimento muito mais barato.

No presente momento estou trabalhando no desenvolvimento da interface do Atlas. Interface é a "cara" do atlas. Uma interface adequada deve ser clara para sua compreensão seja natural e o usuário (no meu caso o aluno) não perca tempo tentando entendê-la.

Um artifício bastante comum no desenvolvimento de interfaces é o uso de metáforas. O próprio Windows é todo baseado em metáforas, são exemplos a ampulheta, as pastas, o ponteiro do mouse, etc.

Para a interface do Atlas optamos por trabalhar com a metáfora do mapa. A barra de menu será posicionada no topo da página e ficará visível o tempo todo, desta forma o aluno poderá alternar a qualquer momento entre diferentes partes do atlas.

O menu será composto por quarto opções:

- **Onde Estamos?** Esta parte abrange o item Onde estamos na Terra.
- **História.** Nesta opção serão agrupados os temas de Arqueologia e História.
- **Patrimônio e Recursos Hídricos.** As duas partes do atlas serão agrupadas na mesma opção do menu.
- **A Cidade.** Esta parte abrange os ítens Geografia, Infra-estrutura urbana e ambiente urbano e Bairros.

Desta forma terei mais espaço para trabalhar na criação de uma interface interessante, e é aqui que sua colaboração será muito importante. Acho que a interface seria ainda mais interessante se ela fosse criada pelos próprios alunos. Eles poderiam criar um mapinha simples que seria a base da interface do atlas. O mapa não pode ser muito elaborado pois isso dificultaria a compreensão do usuário. Um exemplo que eu desenvolvi pode ser visto abaixo.

As medidas para o barra de menu são
Área total: 20,1 cm por 2,64 cm
Área do logo: 3,6 cm por 2,64 cm
Opções do menu:
Onde estamos?, História e A Cidade – 3 cm por 0,7 cm
Patrimônio e Recursos Hídricos – 3,5 cm por 1,2 cm

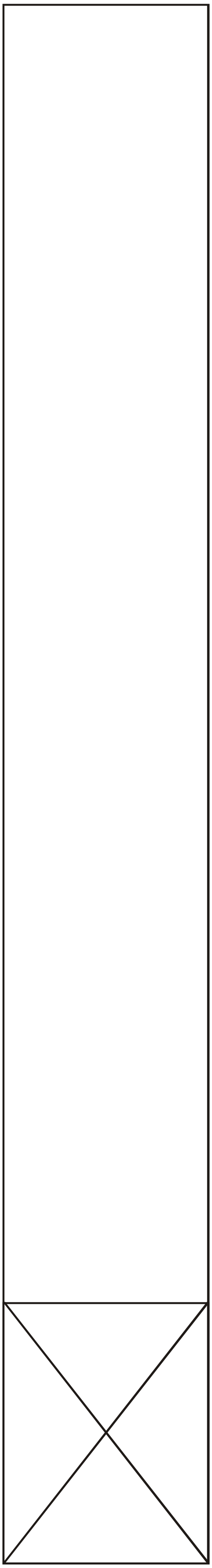
Estou mandando em anexo um modelo, ampliado em 35% da barra de menu. Os alunos não devem trabalhar na área do logo (marcada com um x) e devem deixar áreas em branco onde as etiquetas com as opções do menu (retângulos menores) possam ser colocadas.

Estas instruções podem ser consultadas *online*, no endereço: http://131.170.80.242/interface.htm

Qualquer dúvida, meu email é: cristhiane.ramos@rmit.edu.au

Agradeço antecipadamente sua colaboração.
Atenciosamente,

Cristhiane da Silva Ramos
Doutoranda – RMIT University



Onde Estamos?

História

A Cidade

Patrimônio e
Recursos Hídricos

Appendix C

Results of the surveys

Test 1 - Summary of Responses

User Profile

	<= 5	5 |- 10	15 |- 20	> 20
Years of work experience	2	3	7	2

	<= 1 year	2 years	3 years	4 years	5 years	> 5 years
Experience with computers	1	3	3	1	1	5

	Text editing	Games/leisure	Spreadsheet	Internet Access	Presentation	Image editing
Purpose of computer use	11	7	6	13	4	1

	Web	email	Messenger	FTP
Habits in Internet use	12	12	4	1

Issues in Atlas Use

Location and Orientation

	Int. maps	Pictures	Navigation arrows	Int. question marks	Int. response area	Help Area
Interface elements mentioned	11	10	5	5	3	1

	Clickable map	Mouse move effects	Clickable arrows	Interactive text
Interactive features mentioned	10	9	5	3

Evidences of First Settles

	Navigation arrows	Timeline	Back option	Landscape	Text boxes	Close button
Interface elements mentioned	11	11	6	5	2	1

	Int. text box	Scrolling objects	Close button
Interactive features mentioned	4	3	1

Archaelogical Sites

	Map	Legend	Text	Pictures	Help box
Interface elements mentioned	11	10	10	4	2

	Interactive legend	Interactive map	Scroll bar
Interactive features mentioned	9	1	1

The Initial Inhabitants

	Pictures	Text	Maps	Help box	Menu	Int. maps	Scroll bar	Text hyperlinks
Interface elements mentioned	10	10	8	2	1	1	1	1

	Interactive layers	Interactive zoom	Hyperlinks
Interactive features mentioned	9	8	8

Occupation of Sao Paulo's Territory during the 16th Century

	Printing file	Historical maps	Text	Timeline	Scroll bar	Hyperlinks	Arrow	Response area	Interactive zoom tools
Interface elements mentioned	9	8	2	2	2	2	1	1	1

	Interactive maps	Printing file icon	Mouse over maps	Hyperlinks	Interactive timeline
Interactive features mentioned	9	8	5	3	2

Occupation of Sao Paulo's Territory during the 17th Century

	Pictures	Timeline	Hyperlinks	Text	Interactive legends	Int.zoom tools	Scroll bar	Help box
Interface elements mentioned	10	10	8	5	3	2	2	1

	Interactive zoom	Interactive layers	Hyperlinks	Interactive pan on map	Mouse over maps
Interactive features mentioned	10	9	9	2	1

Occupation of Sao Paulo's Territory during the 18th Century

	Timeline	Pictures	Text	Maps	Hyperlinks	Scroll bar	Int. Legend	Int. zoom tools	Interactive text area
Interface elements mentioned	9	8	8	8	5	3	2	1	1

	Interactive zoom	Hyperlinks	Interactive legend	Animation	Interactive timeline	Mouse over maps
Interactive features mentioned	9	6	3	2	1	1

Beginning of Colonisation

	Pictures	Text	Maps	Timeline	Hyperlinks	Help box	Legend	Int. text area
Interface elements mentioned	11	9	9	8	2	2	1	1

	Clickable map	Interactive timeline	Scroll bar
Interactive features mentioned	9	7	5

Test 2 - Summary of Responses

User Profile

	GIS	Internet	Text	CAD	Spreadsheet	Programming
Experience with computers - purpose c	6	6	5	4	1	1

	<1	1-3	3-5	5-8	8>
Years of Internet use	0	0	2	4	0

	Yes	No
Access maps on the Web	6	

	Governemnt Sites	Route maps	Search for images	Information Portals	Atlas
Source of Web map used	5	3	2	1	0

Templates Use

	Very easy	Easy	Requires skill	Hard	Very hard
Interface Design	2	1	3	0	0
Developing HTML pages	2	2	2	0	0
Exporting the maps to SVG	3	1	1	1	0
Developing the SVG interface	1	0	3	2	0
Understanding the SVG file	1	0	3	2	0
Using JavaScript	2	1	1	1	1