Applying Information Visualisation to externalising student data in web-based Distance Learning System

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BSc Information Systems and Management Studies
Session (2002/20013)

The candidate confirms that the work submitted is their own and the appropriate credit has been given where reference has been made to the work of others.

I understand that failure to attribute material which is obtained from another source may be considered as plagiarism.

(Signature of student) ______________________________
Summary:

This report describes a project that investigates the application of Information Visualisation to web-based learning, focusing on helping teachers to obtain a better understanding of the data provided by these on-line web-based learning systems.

This project will provide the reader with a good foundation for learning about Distance Learning and Information Visualisation and it will link these two areas together to show the best use of visualising techniques that can be applied on data from web based learning systems. It will also identify the available visualising tools that can be used for such data and it will explain the advantages and disadvantages of each of these tools. Finally, this project will use the Nathan Bodington as a case study to examine the possibility of employing Information Visualisation to help teachers there to overcome the problems they face.
Acknowledgement:

"In the Name of Allah, the Most Gracious, the Most Merciful. All praise and thanks are to Allah, the Lord of mankind, the jinns and all that exists. The Most Gracious, the Most Merciful. The only Owner and the Only Ruling Judge of the Day of Recompense. You Alone we worship, and You Alone we ask for help for each and everything. Guide us to the Straight Way. The Way of those on whom You have bestowed Your Grace, not the way of those who earned Your Anger …, nor of those who went astray …" (The Noble Qur'an 1996). Also I restate that all the praises and thanks are to Allah and peace be upon the Master of the Messengers, Muhammad (Peace be upon him).

I should like to thank my supervisor, Dr Vania Dimitrova, who provided me with all the advice and I needed, which had the effect of directing this project to a successful conclusion. I appreciate the help she proffered, without which this project would not have been realised.

Also I would like to thank Riccardo Mazza, who sacrificed time and effort in guiding and helping me throughout this project.

I would also like to thank my dear friends, who stood by me in difficult times and acted generously in these easier-said-than-done situations.

Finally I would like to offer my sincere thanks to my family, who kept encouraging me with love and affection, especially my parents, who I would be dutiful to them and even "If one of them or both of them attain old age in [my] life, [I would] say not to them a word of disrespect, nor shout at them but address them in terms of honour. And [I would] lower unto them the wing of submission and humility through mercy, and say: (My Lord! Bestow on them Your Mercy as they did bring me up when I was young)" (The Noble Qur'an 1996).
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Chapter 1: Introduction

1.1 Motivation:
Distance Learning is one of the important methods of learning in human history. People always used to travel to gain the knowledge they needed to succeed in their lives and improve their living standards. People tend to follow a number of steps in order to simplify the way of making Distance Learning easier than it normally would be and more attractive. When technology began to be involved in daily life, people started to think about using the new technology in such a way as to deliver the material from teachers to students within a short space of time and with a high degree of accuracy. Therefore, Distance Learning and web-based learning systems appeared, in which people are able to join in courses provided by these web-based systems in order to save time and cut costs. Assessments in such systems are quite different from the normal life course assessments, because teachers are not communicating with their students face to face as they do in normal life. Moreover, teachers needed new methods to monitor their students, such as, checking their access to the course materials, which became available with the use of technology. For example, teachers can be provided with reports of the accessing details of each student to the course material and the time taken on each page. Also they can oversee the discussions between students and set criteria to assess them on these discussions. Therefore, it was an attractive point to investigate what sort of data teachers might be keen to know about their students that might help in their assessment and what type of problems they might face in obtaining this data and presenting them in an easy and acceptable way.

The data about the system users are normally stored in what are called "log files". These files normally store such data in a numeric format, which might cause some difficulties in reading them and might take some time to understand. Therefore, ways of visualising these types of data are needed to improve the teachers’ understanding and ability to improve the weaknesses whenever they are found. That is why Information Visualisation is a growing area and an attractive field for in-depth research. Therefore, investigating the best techniques that could be used to help
distance teachers in visualising these data was another motivating factor for conducting this project.

1.2 Project Overview:

This study will investigate Information Visualisation applications to Distance Learning and will examine ways in which it can help teachers to have a better understanding of the data provided by web-based learning systems. To address this aim, both theoretical and empirical studies have been conducted. The theoretical study investigates the applications of web-based learning systems and, the applications and techniques of Information Visualisation based on previous studies, whereas the empirical study investigates the main problems that teachers might face in obtaining the data they need in assessing their students and what type of the Information Visualisation techniques can be used for what type of data. In addition two free visualisation tools are examined for a possible use by distance teachers. In order to give the reader a clear overview of the project’s work, the outline of each chapter is explained below:

In Chapter 2, the reader will be given a general idea about Distance Learning and Information Visualisation. In this review of literature, the definition of Distance Learning and Information Visualisation will be given. It also will examine the requirements of Distance Learning. Moreover, it will provide the reader with the important techniques of Information Visualisation that can be used in Distance Learning.

Chapter 3’s work will concentrate on linking Distance Learning and Information Visualisation together by providing the reader with the type of visualisation techniques that can be used in Distance Learning. It also will explain why the specified techniques are the most suitable ones to be used. Moreover, this chapter will give the reader a better view about the examined visualisation tools by providing a short summary about each one of them and highlighting the technical problems distance teachers might face in using these tools.
Chapter 4 will highlight the technical problems that have been faced within the completion of this project. It also will present some problem that teachers might face in understanding the figures and graphs.

Chapter 5 will investigate the Nathan Bodington Building as a case study for this project to examine the possibility of applying visualisation techniques in its applications and in teacher practice.

Chapter 6 will give an evaluation on this study going through each of the objectives.

1.3 Aims and Objectives:
The main aim of this project is to investigate the application of Information Visualisation to web-based learning, focusing on helping teachers to gain a better understanding of the data provided by these on-line web-based learning systems.

The following objectives needed to be met, in order to fulfil the project’s aims:

♦ Gain sufficient understanding of Distance Learning in order to identify the types of data the teachers are provided with in web-based learning systems.
♦ Gain a proper understanding of Information Visualisation and its techniques.
♦ Identify possible free tools to be used for visualizing data in distance learning.
♦ Investigate possible ways of using the Visualisation tools to visualise data from the distance learning systems.
♦ Examine an exciting web-based learning system, as a case study for this project.
1.4 Minimum requirements:

The minimum requirements are:

1. Review Information Visualisation techniques with regard to visualising data in distance learning.
2. Review of possible free available tools that can be used for visualising data in distance learning, e.g. OpenDX and GraphViz.
3. Identify possible visualisation techniques and tools that can be used for helping teachers understand group activities in web-based learning systems.
4. Investigate what might be the problems of using Distance Learning in Nathan Bodington and how Information Visualisation can help to address these problems.
1.5 Schedule and Milestones:

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This project consisted of three phases. The first was concerned with background readings in Distance Learning and Information Visualisation and this was completed in Chapter 2. The second stage followed two directions: one, investigating free available tools and the other conducting the interviews. The final phase was to analyse the results from the interviews and to complete the project.

For a variety of reasons a number of things changed in the schedule throughout its working period. First of all, the questionnaire was cancelled because a similar one was conducted by a PhD student in University of Leeds (Riccardo Mazza) as will be explained later. It was therefore, replaced by interviews to investigate several matters in greater depth.

It appears that most of the time was spent on installing the OpenDX tool. This installing proved difficult, which was something that was not expected. Thus time spent on this caused some delay in the general progress of the project. These difficulties will be explained in detail later on. The delay affected the work that needed to be done to create some visualisation images of data taken from a web-based learning system, the reason being that this tool needs high programming skills and the time left was not enough for a sufficiently in-depth investigation to allow such images to be produced.

In this new schedule, more detailed information were given about the completion of each chapter of work done related to this project, as can be seen. It also displays any work submitted by using a red O and shows the working period with an X, to make it easy for the reader to follow the work flow.

The first objective was covered in Chapter 2, which gives the reader a clear idea of what Distance Learning and Information Visualisation are. It also clarifies some technical terms as well. These two areas will be linked together in Chapter 3 to meet the first objective in full. Chapter 3 will describe the free investigated tools with a clear explanation of the difficulties faced in covering the second objective. The third objective will be covered in Chapters 3, 4 and 5. Chapter 5 will mainly deal with the fourth objective which used the Nathan Bodington Building as a case study.
Chapter 2: Literature Review

2.1 Distance Learning:

2.1.1 Distance Learning definition:

"Distance education" is a term that is increasingly used nowadays among educational communities. Liu (2001) argued that most education communities prefer to substitute "distance education" for "distance learning", because they claim that the word "education" does not reflect the importance of the student’s responsibility for their own learning. The United States Distance Learning Association (USDLA) distinguishes between these two terms in that distance "education includes distance teaching – the instructor’s role in the process; and distance learning – the student’s role in the process" (Distance Learning Information).

Distance learning has been defined by a number of educational communities and authors. Hess (2000) has defined distance education as "a system in which educator and learner are separated by physical distance." The California Distance Learning Project (CDLP) has defined distance learning as "an instructional delivery system which connects learners with educational resources. DL [Distance Learning] provides educational access to learners not enrolled in educational institutions and can augment the learning opportunities of current students" (Distance Learning Information). AT&T simplifies this definition into, "a directed system or a process connecting learners with remote resources. DL can be the primary or supplemental means of learning" (Distance Learning Information). These definitions indicate that the learners do not experience the educational institutions’ environment because they are separated by distance. Also they show that there is no interaction between participants, that means it is only one-way traffic (Liu 2001).

The United States Distance Learning Association (USDLA) defines distance learning as "the delivery of education or training through electronically mediated instruction including satellite, video, audio graphic, computer, multimedia technology and other forms of learning at a distance" (Distance Learning Information). It has also been defined by (Distance Learning Information) as that
"distance education takes place when a teacher and student(s) are separated by physical distance, and technology (i.e., voice, video, data, and print), often in concert with face-to-face communication, is used to bridge the instructional gap."

These designations concentrate on the involvement of technology to deliver material to learners and represent a sense of interaction between teacher(s) and learner(s).

2.1.2 Development of Distance Learning:

Liu (2001) has identified three main generations in the history of distance learning. He argued that, the first generation appeared in the late 1800’s. This generation was privileged with the use of text-based materials, which are normally sent by teacher(s) to student(s) who are not on the University’s campus.

The second generation of distance learning appeared in the 1960’s when television and radio became more available to the public (Liu 2001). But this generation suffered from the same problem the first generation suffered from. There was no interaction between teacher(s) and student(s) which means, it was a one-way traffic, as has been shown above.

The third generation was meant to be a solution to the interactivity problem. This generation was addressed with the support of new technologies "when computers became more accessible and so more educational establishments used them for the delivery of their distance learning courses" in the 1970’s and 80’s (Liu 2001). This generation tried to solve the weaknesses that appeared in the first two generations of distance learning.

Since technology was used at the education level, "many software techniques [were] used to build computer-based educational systems" (Kosba 2002), such as, Computer-Aided Instruction (CAI) and Intelligent Tutoring Systems (ITS). Kosba (2002) defined CAI as "an educational technology oriented toward developing instructional systems that facilitate tutoring of well-prepared course material." Also he argued that, this system deals with all students as one student and it does not adjust its action according to the status of the student. By contrast, he defined the (ITS) as "a computer program that aims at providing knowledgeable, individualized instruction in a one-
Kosba (2002) pointed out that the main difference between CAI and ITS, is in the focusing on individualised learning.

A question might be asked. Which one of these two programmes will be better to use in Distance Learning? Is it better for a teacher to deal with students individually or in a group? If it is better in a group, how will the teacher be able to know the performance for each student? Many questions will be discussed later on in the project.

2.1.3 How is the material delivered:

There are a wide range of technologies that educators can use in order to deliver teaching materials in distance learning to their learners. They are mainly gathered in four main groups, which are voice, video, data and print (Distance Education: An Overview, 2002).

Distance Education: An Overview (2002) argues that interactive technologies, such as telephone and short-wave radio, can be used to deliver the educational audio tools. Also images such as slides, pre-produced moving images, for example film and videotape and real-time moving images, can be used as well to deliver the instructional video tools.

The main technique that this project is going to concentrate on is the use of Web-Based technology. This type of technology has a distinctive feature in that, it can incorporate all categories which are used to deliver the materials – in the old form of distance education – in a way that has a degree of an interaction between teacher(s) and learner(s). For example, computers can be used to send and receive information electronically. Also a number of computer applications for distance education can be used, such as, Computer-Aided Instruction (CAI), Computer-Managed Instruction (CMI) and Computer-Mediated Education (CME). This technology can also be used for sending and receiving printable documents with different formats, for instance, textbooks, study guides, workbooks, course syllabus, and case studies. This can save time and effort. It can also reduce cost of sending and receiving such documents using the normal mail delivery (Distance Education: An Overview, 2002).
A question earnestly asked is, Is this technology affordable? Because the main purpose of Distance Learning is to provide education at a long distance for those who cannot be on the university campus. So with this technology, will people be able to use it? Because for those who cannot afford campus study expenses, will they be able to afford the requirements of distance learning. Therefore, the availability of the distance learning requirements should be taken into account and this will be discussed in the following section.

2.1.4 Requirements of distance learning:

There are number of considerations should be taken into account when a distance learning program is about to be created. Some of these requirements have been discussed in AACE, (1996):

- Consider characteristics of teachers and students.
- Consider content requirements and technical constraints.
- Ask for a regular feedback from teachers, content facilitators, and learners.
- Involve some level of interactivity:
  - Between teacher and students e.g. By voice or e-mail.
  - Between students and the learning environment e.g. visual aids, lecture slides.
  - Among students themselves e.g. News Group.
- Use of interactive communications technologies e.g. PalTalk, NetMeeting, etc.
- Learners must have a responsibility of their own learning goals.
- Giving students some expectations about the purpose of their viewing e.g. if they about to play a video, some instruction should be given to them and the main aim of the video should be clearly stated.
- Students must learn to distinguish between useless information and quality information.
- Using appropriate objects with relevant attributes e.g. pictures, images, etc.
2.1.5 Who is involved in Distance Learning:

The key players in distance learning in web-based programmes are students, teachers, facilitators, support stuff and administrators. Each of these five distinct groups has some features which distinguish them from the others.

The main mission for any effective distance learning programme is to meet the educational needs of its students. Also the main aim of those students is to learn what has been provided by such programmes. Normally more challenges are present when instruction is delivered at a distance. That is for a number of reasons which will be discussed in more detail in a later section (Distance Education: An Overview 2002).

The Teacher is a main actor in the success story of any distance learning. They have to develop the characteristics and needs of their students with limited face-to-face contact. They also have to consider the needs and expectations of multiple audiences when taught materials are delivered (Distance Learning Information).

The Facilitators normally play the role as a middle ring between the students and the teacher. They usually act like the teachers by setting up equipment, collecting assignments and proctoring tests. They also have to be willing to follow the directives established by the teachers (Distance Learning Information).

The Support Staff have to ensure that all the details required for the programme's success are dealt with effectively. Also most successful distance learning programmes strengthen support service functions (Distance Education: An Overview).

The "Administrators are typically influential in planning an institution's distance education program" (Distance Learning Information). They are normally involved in building and decision-making. They also work closely in parallel with technical and support service staff to ensure that the technological resources are effectively deployed.
2.1.6 Web-based distance learning:

Many systems have been built to provide distance learning for students around the world. Such systems are mainly concentrating in web-based technology, such as WebCT, BlackBoard, topClass and Nathan Bodington.

For example, in Nathan Bodington, the student is allowed to access the relevant material for his/her course models. That is normally done by protecting other model files with an access protection, which checks the authorisation of the user. If the student is not taking this model, then access will be denied.

The student is able to download the teaching material to his/her personal PC or s/he can access whenever s/he wants to. Also s/he can print them out for a classic revision.

The student can contact the teacher by e-mail only, and this could be counted as a weakness that should be solved, because it might make the student feel isolated from the learning environment and affect his/her level of learning. This problem can be solved by adding a voice feature, which will allow the student to communicate with teacher more easily.

The student can communicate with other students as well by using the news group or bulletin board. But this technology does not give the students a live connection with each other. Therefore, more interactivity between students is required for more effective learning.

Such a system records every visit made by student to the site and it records the time spent each time. Such a feature might be useful for teachers to know more about the students’ effort in learning the material provided. But the type of data provided in such a system might not be very clear to teachers to evaluate students’ work according to such information. Therefore, a new technique is needed in order to enable teachers to evaluate course and students very accurately and make a right decision in regard to the information provided to them. Moreover, visualising data in a form that allows teachers to be able to see the trends and anomalies in their courses would be a very good solution for this problem.
Thus, the following section will to discuss the information visualisation issue in more detail.

2.2 Information Visualisation:

2.2.1 Introduction:

Over a long period of time, data expands and grows very much and becomes very large in size. Therefore, a way of simplifying this enlargement in the amount of data is needed for better decisions and judgements.

There is a need to have a way of making this data understandable and easy to follow. The need to visualise data became essential, and a new technique proved to be the solution for such a problem. This type of technique is called **Information Visualisation**.

2.2.2 Definition of Information Visualisation:

Information visualisation is an area of research. Much research has been conducted in many fields, such as science, education, cartography, games, statistics, etc. Therefore, it has been given many definitions, but they proceed in the same direction and share more or the less the same meaning.

Bertin (1981) has defined Information Visualisation as "... **augmenting ... natural intelligence in the best possible way, ... finding the artificial memory that best supports our natural means of perception.**" In fact the word "visualise" has been defined in the Oxford dictionary as "**to imagine or remember as if actually seeing.**"

But these definitions do not show the main purpose of using the information visualisation method. Therefore, Prof. Hearst M. (2002) defines it as "**the depiction of information using spatial or graphical representations, to facilitate comparison, pattern recognition, change detection, and other cognitive skills that make use of the visual system.**" This definition gives a clear idea of the main use of the information visualisation method. It also somehow indicates various types of
techniques that can be used with the information visualisation’s tools, which will be discussed later on in this report.

So information visualisation can be defined as a way to represent a collection of data into a set of images or graphs that can give the reader an understandable idea, by using special techniques in order to enable people to gain a proper understanding about these data.

2.2.3 Aim of Information Visualisation:

The main purpose of information visualisation is to help people explore, calculate, communicate and decorate data in ways that are easy to attempt. For example, it can be used to calculate and explore data, which can give people a clear analysis and reasons about presented information. It can also be used with communicated data to explain these data for its users to enable them to make their decision based on the reasons given about presented information (Hearst 2002).

Information visualisation techniques are meant to be different from any other interface. That because they should provide things that other interfaces can not provide. For instance, they should be used for easily seeing trends in the data presented, easily seeing outliers, identify boundaries, seeing an enormous amount of data on one screen, easily identifying maxima and minima, largest and smallest, most recent and oldest etc (Brautigam (a) 1997).

2.2.4 Advantages of Information Visualisation:

There are number of advantages that have been counted for information Visualisation technology. It can reduce the chance of missing information (Bederson 2001), because it is easy for someone to become lost in a large quantity of data. For example, it can give a teacher a clear idea about a student's interaction throughout the course and thereby can let him/her make a better decision in evaluating the student’s performance throughout the course.
Information Visualisation can also facilitate the spotting of trends and anomalies (Bederson 2001), for example, it is sometimes feasible to see what is going wrong in the course. However, with such a technology these types of problems will be easy for the teacher to see whether the anomalies result from the student himself/herself or from the course structure.

Information Visualisation can reorganize the access to details (Bederson 2001) to make such data easy for the user to complete his/her job and it saves time for him/her. Because users are normally forced to search through the whole data to find what they want to know and then organize it in the way that they want. Therefore, this technology allows the user to specify what s/he is looking for and then it gives him/her the details in a reorganized way depending on what s/he wants to visualise.

Also Information Visualisation should remain simple and tailorable to various applications (Bederson 2001), because normally when a user wants to visualise a set of data, s/he wants to link different outcomes from different applications, which are normally somehow linked with each other. Therefore, this technology has come to be compatible with such needs.

2.2.5 Disadvantages of Information Visualisation:

On the other hand, there are some drawbacks to this technology. For instance, Information Visualisation has some limitations in record keeping which can hamper effectiveness (Bederson 2001), and the question may be asked, will this be the case in the education area? This depends on the course strategy and structure. If it consists of lots of record-keeping then this problem might occur.

Moreover, there might be some difficulties in reaching an agreement on a data encoding scheme (Bederson 2001). This is because this type of technology should be carefully set and the roles of Human Computer Interaction should be taken into account to make visualised data easy for navigation. Colours should also be carefully selected, because this might not suit colour-blind people. It should also be using a common-sense language in following the instructions to be user-friendly.
Information visualisation is for sighted people and there are "many users [who] may not be visually oriented. They may prefer textual or numerical data formats in scrolling rather than visual presentations" (Card, Mackinlay and Shneiderman 1999) and that might make this technology useless. Therefore, it should also meet this type of people’s needs and avoid ignoring them.

Information Visualisation might lead to incorrect conclusions and wrong decisions if people misused it. Therefore, more training courses are needed for its users to avoid errors of inconsistency.

2.2.6 Techniques of Information Visualisation:

There are number of techniques that should be followed or taken into account when information visualisation technology is being used. Also within each type of technique there are number of tools that can be used to implement the data, which the user needs to visualise. There are four main techniques that are used to categorise data, for example, focus and context, zooming and filtering, widget for information visualisation and perceptual impedance matching (Brautigam 1997).

As mentioned before, there are a number of tools specified for each of these types of technique. Moreover, it is not necessary for these tools to be taken in account for visualising data in distance learning in this project.

In the Focus and context technique "detailed views of particular parts of an information set are blended in some way with a view of the overall structure of the set (Brautigam, M. 1997)." It has a number of tools that are used to implement data such as, fisheye views, cone tree, multiple views, SeeSoft, perspective wall, butterfly citation browser, hyperbolic tree browser, fractal views, variable zoom and data sphere.

The Zooming and filtering technique has been defined by Brautigam (1997) as if the information wanted to be filtered in some way and "this filtering takes the form of selecting a subset of the data along a range of numerical values of one or more dimensions". This technique works to reduce the amount of context in one display, which is different from the focus and context technique. There are number of tools
that use this type of technique, such as, Starfield Display, TreeMaps, Focus Interactive Table, TileBars and Pad++.

**Widgets for information Visualisation** technique allow users to deal with large amounts of information. "These techniques allow the user to select a focus, filter out extraneous information, zoom in on certain ranges of information, and create complex query criteria for finding particular information" (Brautigam 1997). It appears from this definition that there is more interaction between the user and the tools, which apply this technique. The main tools used for this technique are *Alphaslider, Range Slider, Query Spreadsheet, Movable Filters, Magic Lens and Zoom Bar*.

The **Perceptual impedance matching** technique means keeping "the user working and [keeping] the user from becoming disoriented … because [such a technique tries] to keep the flow of information constant and flowing" (Brautigam 1997). And this definition clearly shows that the user contributes to the visualisation performance. The main tools, which are used in such a technique, are *Dynamic Queries, Scatter/Gather* and *Animation*. 
Chapter 3: Information Visualisation uses in Distance Learning

3.1 Usefulness of Information Visualisation tools for Distance Learning's teachers:

As shown in previous chapter there are many applications where visualisation tools can be used and they create a satisfactory use by offering a good understanding and better view for any problem. Such overwhelming understanding will be good for tackling problems perfectly and might provide a better approach for different strategies to be followed. Therefore, this chapter will concentrate on the more efficient uses of the visualisation techniques in web-based learning systems by showing their use to teachers in web-based learning. It will also introduce the type of data needed to be visualised in rational Distance Learning Systems. Moreover, it will present free investigated tools, such as OpenDX and GraphViz, by providing short descriptions of them and how they can be used to visualise the data from Distance Learning Systems.

Information Visualisation can be used to help teachers in Distance Learning and web-based learning systems to generate a better mental model for the information they have about their courses and students. Because normally these teachers try to find the relevant data about their students that might help them to know the performance of students and their status in the course, which they involved in. They can also conceptualise a clear picture of the courses that they are running. So they will be able to find their strengths and weakness, which will help teachers to create an acceptable strategy to overcome problems that face their courses and students.

Teachers can use a number of data to build up the model that helps them to see the big picture about their students and course. For example, in normal life, teachers use an attendance sheet to monitor their students and spot who is active and who is not. This technique can be applied in Distance Learning and web-based learning systems, by checking the accessing file of the students (system users) to the course materials. Using these data to plot them on a graph can be termed one use of Information
Visualisation. Actually most teachers use such a technique in their courses – sometimes- without being aware that they are using Information Visualisation.

In the main, the difficult part about these data in Distance Learning and web-based learning Systems is that they normally come in a numeric format which might be difficult for teachers to read as they usually read the attendance sheet report. Therefore, a growing desire to find a way of presenting these data in an acceptable format, which makes its reader able to follow it and makes it easier to understand. That is why we find that Information Visualisation is an attractive field for researchers to investigate.

Teachers can use any technique that suites them in finding what they want to know from the data they have by using any of the various techniques of Information Visualisation, such as focusing and filtering. These techniques help the teachers in a better handling of the data they have.

3.2 The type of data needed to be visualised:

There is a great deal of data most teachers in Distance Learning and web-based learning systems are keen to know about their students. Teachers use some of this data in assessing their students. These kinds of data, which will be presented in the following paragraphs and which are requested by teachers who are involved in Distance Learning Systems, are based on a questionnaire conducted by a PhD student (Riccardo Mazza) of University of Leeds. A copy of this questionnaire can be retrieved on this link http://telos.usilu.net/survey/questionnaire.html.

The researcher has gathered the most common information about students that distance teachers might find interesting. The following table (Mazza (a) 2003) shows the results that the researcher has found.
This data can provide distance teachers with a large amount of information about their students that might help them in their assessment and give teachers a better view about the social, cognitive and behavioural aspects of the students (Mazza (a) 2003). For example, teachers are able to monitor the assiduity of their students by knowing their access times and the length of the course material. With such information, teachers can provide weak students with the resources and help they need to raise their level, after investigating the underlying reasons. Visualisation tools are needed here to help teachers to visualise these data and present them in an easy way so as to see their students’ performance at first glance. Also the use of these tools to visualise their participation in discussions can help the teachers to measure the level of understanding of their students of the topics taught.

Student’s progress can be monitored by viewing the grades of the quizzes and assignments posted by them. Teachers can use these records to compare them with the accessing of the course material to find out whether a student has been putting in enough effort to obtain the grade s/he gained or not. Also they can, for example, evaluate the course material by viewing the overall performance of the students on the topics provided. All these can be done much quicker and more accurate by if visualisation tools are used rather than by bringing such huge amounts of data to teachers and making them investigate them, because that would be a waste of lots of effort and time.

A number of visualisation techniques can be used in Distance Learning and web-based learning systems in order to visualise the data provided to teachers. For

Table 3.1: Summary of information about students the respondents found interesting, (Mazza, 2003)

<table>
<thead>
<tr>
<th>Access to the course</th>
<th>Quiz and assignment grade</th>
<th>Participation in discussions</th>
<th>Posting e-mail to colleagues</th>
<th>Frequency of re-visiting of the same page</th>
<th>Participation in chat</th>
<th>Participation in group exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely interesting + Very Interesting</td>
<td>54.35%</td>
<td>64.13%</td>
<td>66.30%</td>
<td>32.61%</td>
<td>25.00%</td>
<td>28.26%</td>
</tr>
<tr>
<td>Interesting + Somewhat interesting</td>
<td>34.78%</td>
<td>26.09%</td>
<td>22.83%</td>
<td>44.57%</td>
<td>36.96%</td>
<td>41.30%</td>
</tr>
<tr>
<td>Not at all interesting + I don’t know</td>
<td>7.61%</td>
<td>8.70%</td>
<td>6.52%</td>
<td>18.48%</td>
<td>26.09%</td>
<td>27.17%</td>
</tr>
</tbody>
</table>
example, teachers can use focus and context techniques in order to view the data on a graph that shows an area of interest quite clearer and detailed than other areas with less interest. "Focus and context concept is exemplified by the following Information Visualisation techniques:

- *Detailed views of particular parts of an information set are blended in some way with a view of the overall structure of the set.*
- *Any presentation technique that displays a large information space (the context) with some portion of it in more detail (the focus)* (Brautigam 1997).

This technique is a good idea to consider a trade-off between information density and clarity (Björk and Holmquist 1998), however, Björk and Holmquist (1998) argued that these "methods are useful when display space is scarce". For example, in the following figure, a teacher can view the whole list of his/her students with their names, numbers or even grades.

![Figure 3.1 Diagram with students numbers (Context)](image)

When the teacher wants to view a specific student, s/he can choose that particular student to view his/her records, such as, accessing data to the course materials, messages posting or quiz and assignments details. The following figure shows that very clearly.

![Figure 3.2 A selected student (Focus)](image)
Zooming and Filtering are other useful techniques that can provide teachers with a better handling of data. These techniques "work by reducing the amount of context in the display" (Brautigam 1997). In visualisation terms, filtering "usually refers to the de-emphasis or removal of elements from the view" (Herman, Melançon and Marshall 2000). "If this filtering takes the form of selecting a subset of the data along a range of numerical values of one or more dimensions, …[then] this kind of filtering [is called] zooming" (Brautigam 1997). This technique can be used to cut huge amounts of data into smaller amounts that teacher is interested in. Then the teacher can use a zooming technique in order to view specific data. For instance, the teacher can use a filtering technique to select weak students, and then s/he uses the zooming technique to concentrate on specific aspects like grades or interactivity level.

3.3 Introduce OpenDX and GraphViz as investigated tools:

Visualisation tools have been developed since information visualisation became an attractive field for researchers and large software companies. Because these tools have a wide usage in number of fields, we worked on mining data and trying to investigate them with more depth. There are many available visualisation tools that can be used in Distance Learning and web-based learning systems. But this project worked on investigating free available tools, such as, OpenDX and GraphViz. Therefore, this section will look at these tools and give the reader a brief summary about them.

3.3.1 OpenDX:

OpenDX is a powerful free visualisation tool. It is the open source software version of IBM's Visualisation Data Explorer Product (About OpenDX). It can be used to visualise anything from "examining simple data sets to analyzing complex, time-dependent data from disparate sources"(About OpenDX).

This tool works perfectly in a Unix environment. Therefore, if someone wants to implement it on another platform, such as, Microsoft Windows then s/he need to install a programme to build a Unix environment on the Windows platform. This tool can be downloaded for free from the following web site

The user can start the application by typing the "opendx" command line on the command prompt window. Then the programme starts by showing a window as shown in the following figure.

To show the samples provided by the programme, the user should click on the "Samples..." icon. There are number of examples to show the user how to build up
images in different forms, such as, two or three dimensions. Furthermore, it uses mainly ".net" extensions, for the coded files, which build up the images of visualised data. The following figure shows the options provided by that programme.

![Sample Program Selection](image)

**Figure 3.5 OpenDX Sample Program Selection Window**

There are two type of files which should be available in order to build up the images. One of these files has a ".net" extension –and this file should have the codes to build the image-. The other one has the ".cfg" extension –and this type of file should have some statements for the first file-. When "2D_DATA" has been selected from the left hand column, all two-dimensional coded data appears in the right column. When "AlternateVisualisations.net" file has been selected, a window like the following figure, appears to show the seven ways in which a user can visualise two variables. When one of the methods of visualising is selected, the programme executes and builds the image.
For example, when the "red, green, blue" method is selected the image in Figure 3.7 Red, Green, Blue Image came up. It also represents the colours with their variables as shown in Figure 3.7 Red, Green, Blue Image, whereas, when the "bands and contours" method is selected, then the image built is the same as in Figure 3.8 Bands and Contours Image.

This tool displays a better use for visualising complex data and for drawing different relations. For example, it can be used to show the accessing of students to course material with relation to their grades from submitted quizzes and assignments. Besides, it can be used to show the level of interactivity between students from their posting of e-mails and messages to each other.

As this tool appears to be very large it can be used to visualise any type of data requested by the teachers, such as, monitoring the accessibility of students to the
course materials. It can also be used to visualise the interactivity between the students by viewing their participation in group exercises or in chatting.

### 3.3.2 GraphViz:

GraphViz consists of a number of graph drawing tools. It is an open source program. Its main goals are to "find efficient algorithms for making very readable drawings of graphs up to several hundreds of nodes, [and] approaching the quality of manual layouts (made with CAD tools) … to create convenient graph drawing systems and web services" (GraphViz, 2000).

This tool can be used to visualise data from Distance Learning and web-based learning systems such that showing the interactivity between student and teacher. It can be compiled on a multitude of platforms. Therefore, there is no need to install any program first to set the environment to anything that should suites the GraphVis, as long as the right package is installed. All packages and versions can be downloaded for free from the following site [http://www.research.att.com/sw/tools/graphviz/download.html](http://www.research.att.com/sw/tools/graphviz/download.html). This tool uses a coding method. It also has three different layout engines, which are *dot*, *neato* and *twopi*. Each one of these forms different shapes. The following figure shows the main frame of the program.

![GraphViz main page](image)
This program uses a coding method, as mentioned earlier, in order to access the main output files. For example, the following coding is used to show the messages passing between teacher and students.

digraph G {
    subgraph cluster_c0 {a0 -> a1 -> a2 -> a3;}
    subgraph cluster_c1 {b0 -> b1 -> b2 -> b3;}
    Teacher -> a0;
    Teacher -> b0;
    a1 -> a3;
    a3 -> a0;
    a1 -> a1;
    label = "Messages Passing Diagram\na0-a3 a group of students\nb0-b3 a group of students";
    fontsize=10;
}

When using the *dot* layout engine the output was like that shown in the following figure:

![Diagram](image)

Figure 3.10 Using dot layout engine
When using the *neato* layout engine the output was like that shown in the following figure:

![Diagram using neato layout engine](image1)

Figure 3.11 Using neato layout engine

When using the *twopi* layout engine the output was like that shown in the following figure:

![Diagram using twopi layout engine](image2)

Figure 3.12 Using twopi layout engine
This tool can create a better way of drawing diagrams to show the interactivity between the students and their teachers. It can also show the participation between students within groups and show the performance in group exercises.

Finally this tool seems difficult to use by teachers involved in distance learning, because it needs a good understanding of coding such diagrams. Also such a tool needs to be easy to maintain and use. Therefore, I would recommend the use of UML tools to draw such diagrams, because they are easier to use and implement.
Chapter 4: Feasibility of using Information Visualisation in web-based learning

This chapter will consider a number of issues concerning the feasibility of using Information Visualisation in web-based learning. These problems split into two: technical problems and the difficulties of teachers’ understanding the figures and graphs. In the first section, this chapter will concentrate on technical issues, such as, installation difficulties. The second section will investigate the problems that teachers face in understanding the figures of visualised data and how this might be overcome.

4.1 Technical problems:

There are number of technical difficulties confronting the user of these investigated free tools. For example, OpenDX tool is a platform specific. It needs a Unix operating system to work with it and if the user wants to install it in another system, such as, the Microsoft Windows platform, then s/he will need to install a program that builds a Unix environment on Windows, such as, "Cygwin 1.1.2" (Siddiqi). Whereas, the case is not the same with GraphViz as long the right tool and version is installed.

One of the greatest difficulties that faced by this project -and which any user of OpenDX might face - is the installing of the program. As already explained, OpenDX needs a Unix platform in order to work. When the project reached the point where it was necessary to install it, it first needed the Unix operating system to be installed. Therefore, RedHat 8.0 was installed and then the OpenDX. But the problem was that there were a number of files which needed to be installed first to complete the full process. Therefore, more advanced help was needed. This help was provided by a PhD student (Riccardo Mazza), who studies in Leeds University, and he provided three files that have to be installed first. These files are "openmotif-2.1.30-4_MLI.i386", "openmotif-devel-2.1.30-4_MLI.i386" and "openmotif-2.2.2-12.i386". After installing them the process went smoothly and finally the program worked. So it appears that this tool needs some experience in handling such problems, however, the situation was different with GraphViz, which needed non of that process.
To use these tools needs programming skills. They are not straight forward like Microsoft Windows, where data is plugged into the program and the computer does the rest of the work, for instance, the Excel program where the user chooses the way of visualising the data in any form like scoter plot, bar or pie charts. This project assumed that distance teachers are not qualified as programmers. Therefore, it would be difficult -if not impossible- for them to use OpenDX. For example, the following figure –which was taken from the sample provided by the program itself- needs about 4 pages of coding, which can be found in Appendix D, where as Figure 3.7 needs 28 pages of coding. On the other hand, GraphViz does not require the high level of skills needed in OpenDX. Anyone with the skill of coding a web page should be able to use GraphViz. As shown in the previous chapter, a small number of lines of coding using GraphViz can fulfil the users’ requirements. But unfortunately, GraphViz does not have the wide range of usage as that of OpenDX.

![Generalimport Image taken from the sample provided by OpenDX](image)

This issue can be improved by offering some programming course for the teachers to enable them to build such images and create a better use for OpenDX and GraphViz. By contrast, this can provide teachers with an adequate use of these skills, but these courses will require greater costs and spending. Therefore, it might be more efficient to buy an affordable and straight forward visualisation tool to use.

As has been shown using these tools will require long pages of coding and which needs too much time, as a result, it would sometimes mean a waste of time. For
example, in a personal conversation with Riccardo Mazza, a number of images and figures were provided by him to be used in a set of interviews that were to be conducted—as this will be discussed later on in this project. These figures can be found in Appendix E. He said that it took about a month for him to code these figures. Then the question that might arise is, will teachers have the time to do such things? The answer is most likely to be no. That is because of the work-load on the teachers in setting the course material, assessing their students, improving their materials and communicating with their students, which might take a great deal of the time because of the distance barrier between students and their teachers, who try to make sure that their students understand what they are talking about. Because normally in face-to-face conversation all these meanings can be illustrated by body language.

These tools can be improved in standard research, where the interface can be build on the top of these tools. It can use the idea of Microsoft Excel. So the teacher can plug the data into the program and it will perform its computation and coding for the user. Moreover, the user, for example, can draw images and place nodes on the plane screen, where the program does the coding for him/her, such as Microsoft Frontpage or Dreamweaver which are used to build web pages.

4.2 Understanding figures and graphs:

Sometime figures look very complicated and difficult to understand for normal people. Therefore, it is better to make them simple and easy to understand. That is because the main purpose of Information Visualisation is to simplify complicated data and present them in an easy way to understand. Also this project presumes that distance teachers are not experts in reading complicated graphs and figures.

As a result of one of the interview—which will be discussed in the following chapter—although, the participant has a higher level skill in reading graphs and figures compared with the others, he preferred 2 dimensional technique in visualising data rather than 3 dimensional. Also he suggested that—from his experience- not all teachers were capable of reading complicated visualised data. Furthermore, he argued that, although, 3 dimensional figures look very professional, the main purpose is to
understand the data not to present them, and visualising techniques are a way of clarifying this understanding.

Teachers can be trained to read figures and diagrams by offering some courses which can show them how to visualise data and how the key elements can be understood from any given graph.
Chapter 5: Case Study: "Nathan Bodington" – How teachers could use Information Visualisation in their practice

5.1 Objectives of the study:

The main aim of this chapter is to examine an existing web-based learning system to look at its use of the available resources in comparison with what distance teachers are keen to know about their students, depending on the results of conducted research such as in Table 3.1, which is based on Riccardo’s study. In fact, the main aim of this study was to investigate the type of data that teachers who are involved in the Nathan Bodington Building are keen to know about their students who use the building and how teachers use this data in their assessment process. Using the findings of this study to provide teachers with the techniques of visualising this data in a way that makes it easy for them to improve their understanding of their students, which as a result will improve the quality of their judgement and assessment. But the real findings of the study from the interviews were not as expected, therefore, the aim changed slightly to use the outcome of this study to examine the possibility of using Information Visualisation to improve Nathan Bodington’s efficiency.

5.2 About the Nathan Bodington Building:

"The Bodington Common is an interactive website which supports learning and teaching at the University of Leeds" (School of Earth Sciences 2003) and the Nathan Bodington Building is one of many buildings located on the Bodington Common. The Nathan Bodington Building is a web-based learning system, made by the University of Leeds. It "hosts interactive on-line learning resources provided by various departments and schools of the University" (Gardner and Maber 1998). Its main purpose is "to provide a place where learners can easily communicate with teachers and with other learners … [it is placed on the Internet] … to ensure equality of provision for all students and staff, whether full or part-time, working on or off campus, and staff in associated colleges" (Gardner and Maber 1998).
5.3 Methodology:

In order to conduct this study interviews were carried out. There was an idea put forward to design a questionnaire to gather data for the study and actually the questionnaire was designed, but there was no point in repeating the work. That was because a PhD student (Riccardo Mazza) had devised a similar questionnaire, which has been sent to Distance Learning Systems’ teachers. It has been sent to about 188 participants and conducted for about 2 weeks (02/12/2002 – 15/12/2002) and about 98 responses were received (Mazza (a) 2003). This questionnaire can be retrieved electronically on http://telos.usilu.net/survey/questionnaire.html and a hard copy of it can be found in Appendix B.

The interviewing method was selected to clarify a number of things related to the usage of the Nathan Bodington Building. Also the main findings of the questionnaire conducted by Riccardo Mazza were used as the rational rules to investigate the ability of the teachers -of the Nathan Bodington- to use Information Visualisation in their practice. Therefore, semi-structured interview methods were used because of they combined the features of structured and unstructured interviews. When the goals of the study were clearly understood, the interviews needed to be more like a conversation that focused "on a particular topic and … often [went] into considerable depth" (Preece, Rogers and Sharp 2002). A copy of these interview questions can be found in Appendix C.

5.4 Participants:

An e-mail was sent to 7 teachers from different departments involved with the Nathan Bodington Building. This e-mail explained the main aim of the project as a whole and the purpose of the interview. Only 3 individuals replied and dates for the interviews were arranged. Two of them were from the Business School and the third was from the Chemistry Department. These interviews were recorded for analysis purposes after obtaining the participants’ permission.

5.5 Results:

There were a number of findings that changed the aim of the study as mentioned earlier. Some of these reasons were because of the fact that the interviewees made no
use of the Nathan Bodington Building in their assessments, in monitoring the attendance of students or even in trying to improve the weak students. Also some of them were not aware of the facilities they could be provided, such as, user access to the course material and the participation level in discussion forums –where they existed- for each student.

The main outcome of these interviews was that most of the teachers were expecting to find the aggregated data rather details about each individual. That was the reason for the large number of students on the courses taught by the interviewees. For example, one of the interviewees (who teaches at the Business School) said that, on his course there were around 400 students and he had no time to investigate the details of each one. He also added that, he liked the idea of Information Visualisation, but would prefer it to cover the whole course’s students rather than each individual. Moreover, he could find no use for the Nathan Bodington Building as a good system to be used for distance learning. He considered it a helping tool to deliver materials to students, as it appears that group size acts as a rule of thump in the effectiveness of such systems.

With the existence of discussion forums in some modules, students tended to show no interest in using them. This was attributed to the availability of other different sources. Therefore, teachers tended to see no use for them in their final assessments. One of the interviewees (Bin Whitaker, who teaches in the School of Chemistry) has argued that the main reason for the failure of the discussion forums was the teachers themselves. This was because the staff responses to discussion forums were very limited.

After considering at these results, it was very nearly concluded that the Nathan Bodington Building had no use for or involvement in distance learning, the reason being that the Nathan Bodington Building was used as a supportive tool for modules taught on campus. But after having a personal conversation with Dr Vania Dimitrova, who is a supervisor for this project, the idea was changed, since she explained that there were several courses running as distance learning with distance learners. She also confirmed that these courses were available for students from anywhere in the world. It therefore, appeared that the wrong set of teachers had been selected and that
if teachers, who were involved in these distance courses were interviewed, the results would be more reliable.

5.6 Uses of Information Visualisation in Nathan Bodington:

Information Visualisation can provide Nathan Bodington’s teachers with a better use for Distance Learning. There are a number of techniques and steps to be adopted in order to reach this target. For example, Information Visualisation can be used to visualise the students’ access to the course material and the time taken in browsing this material. By comparing these records with the results of the students on a two or three dimensional graph the teacher can obtain a better view of the weak points, whereby s/he would be able to tell if the weakness was because of the student, who might not put in show enough effort to achieve the standard results, or because of the materials themselves, which might be poorly presented and be difficult to understand. With such a use of Information Visualisation teachers will be encouraged to use distance learning more frequently in their courses.

Teachers can use Information Visualisation to view student access to discussion forums and discover who participates in a discussion or who has just read a posted topic. By applying these types of technique, teachers will be able to tell how effective the discussion forums are. After getting them involved in these uses of visualising methods it would be easier for them to use discussion forums as an assessment method by giving a students who was involved in these discussions - either by reading or posting messages- marks on the total grade.

If discussion forums were used as a way of assessing students, there would be a good chance for them to achieve a fair grade on their work, because exams and tests are not always an appropriate way for assessing students, for a number of reasons, such as, illness and stress, etc. For example, discussions can be represented in three dimensional graphs, such as the one below, which was produced by Riccardo Mazza using an OpenDX tool, as mentioned earlier in previous chapters. This diagram shows the topics discussed, students who participated in these discussions and the data of the discussion. Furthermore, the colour and size of the balls indicates the importance of the topic discussed. With such an Information Visualisation tool, the teacher can
rotate the image in any direction s/he likes to obtain the precise representation s/he can understand. For instance, the teacher can rotate it to get a 2D figure in which s/he can view the topic discussed and the student who initiated this message.

Figure 5.13 3D Visualisation of the Students' Participation in Discussions (Mazza (b) 2003)
Chapter 6: Evaluation

This chapter will evaluate the project's progress by identifying the objectives stated at the beginning and look at what has been applied to achieve their successful completion. It will also provide an evaluation of the schedule produced in the mid-term report, to investigate the flow of the work throughout the project's duration.

6.1 Objectives' evaluation:

Objective 1: Review of Information Visualisation techniques with regard to visualising data in distance learning.

Were the Distance Learning's terms defined?
In covering this objective the reader has been introduced to the use of Distance Learning, its requirements and users. Then this project specified the web-based learning systems under investigation.

Were the Information Visualisation's terms defined?
This objective attempted to give the reader a clear idea about useful techniques that can be used in visualising data. Although, there are plenty of techniques in use, only some of them are presented and investigated. But the time was not sufficient to carry out an in-depth investigation of the techniques to obtain a perfect result from them.

Were the two areas linked together?
This objective tried to present the most suitable techniques that can be used to visualise data from web-based learning systems to help teachers in the assessing of their students. But the lack of skills left a negative mark on the final work.

Objective 2: Review of possible free available tools that can be used for visualising data in distance learning, e.g. OpenDX and GraphViz.
Were the tools reviewed free?
The main objective was to review possible free tools, though there are many tools available that can be bought off the shelves. This project succeeded in identifying these free tools, namely, OpenDX and GraphViz.

Were there other tools that could be used?
There are many available tools that can be investigated in more depth. But -as has been said- the main purpose was to investigate free tools. Moreover, although there are many other free visualising tools available, these particular tools were selected.

Were these tools efficiently investigated?
The OpenDX needed high programming skills, which this project lacked. But the situation was not the same with GraphViz, which did not need the same high skills as OpenDX. Anyone with the skill of coding a simple web page should be able to use it. Moreover, OpenDX took a great deal of the time to be installed and it only started to work at the end of this project, which did not afford sufficient time to master it very well.

Objective 3: Identify possible visualisation techniques and tools that can be used for helping teachers understand group activities in web-based learning systems.

Were the visualisation techniques and tools useful for the distance teachers?
This objective aimed to investigate the main techniques that can be used to help the distance teachers visualise data about their students that might be of help in assessing them. Although the techniques presented were the most appropriate ones, the tools were not the right ones for distance teachers. This was because the teachers were assumed to have no programming skills, so they were unable to use OpenDX, for example.

Did the techniques presented provide adequate help for the teachers?
Some of the techniques presented are actually in use. Some teachers were happy to know that such techniques could be used. This was because they were able to give them a better view of their courses. In addition, this project could not identify the crucial elements that teachers might be looking for to assess their students, for the
simple reason that the wrong set of teachers to be interviewed was selected, as was explained earlier.

**Objective 4: Investigate what might be the problems of using Distance Learning in Nathan Bodington and how Information Visualisation can help to address these problems.**

**Was Nathan Bodington the right choice for this case study?**

The main purpose of this study was to identify the main problems teachers face in visualising the data they receive about their students from the distance learning systems. However, the wrong selection of teachers to be interviewed, changed this aim. Thus, if the correct group of teachers had been selected, this project would have come up with a different result.

**Were the problem identified?**

The main result obtained, indicates that the principal problem of using the Nathan Bodington as a Distance Learning system was caused by the teachers involved in it. They did not employ the data available from this system in their final assessment. Moreover, some of the teachers were unaware that they could obtain such information about their students.

**6.2 Evaluation of the Schedule:**

The schedule produced at the beginning of this project was not adhered to as expected. This was because the objectives were not clear enough and due to an overestimating of what was possible in the given time. The general sequence of the project progressed as expected, although, some things changed and others were removed. But the project was completed in the requisite time. Moreover, the second phase took longer than expected, due to the installation and implementation of OpenDX. Furthermore, the minimum requirements were changed due to the findings of the interviews that were conducted.
6.3 Overall verdict:
The main objective of this project was to examine the possibility of using visualising techniques on application in web-based learning systems. It was a good experience and if time had been a bit longer, the outcome of this project would have been much better. After 7 month of working on this project it was realised that most of the time had been spent on background reading and consolidating the bases. Thus, if this project had been assigned at the beginning of the summer vacation, then it would have given a better opportunity to produce a better outcome to this project, because the period would have been around 10 rather than 7 months.
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Appendix A: Reflection of project experience
This project was a very worthwhile experience in my life. Despite the difficulty faced to complete this project, there were many valuable things learned especially how a project can be designed to look coherent. That could not be achieved without the helpful advice provided by my supervisor Dr Vania Dimitrova.

Research methods were one of the great things to be learned, which gave me the skills to confront any similar problem. Such research methods are those of selecting the right group for interviewing in order to achieve the target of such a study.

Another important lesson learned was how to be realistic in making a schedule for such a project. With this experience it was clear that things might be expected to go wrong, just like what happened with this project when the installation of OpenDX took longer than expected, which put serious pressure on the time specified for the completion of the other phases of this project. However, it was recognised that the minimum requirements needed to be changed and they were emended as they appear in the first chapter.

One of the drawbacks, which was not considered at the beginning of this project, was the need for programming skills in order to produce visualised data on some samples from a web-based learning system. But lack of these skills left a negative mark on whole progress of the project.

Background readings and tool searching took up most of the valuable time of this project. This was because the project period was quite limited: 7 months to complete the project, about which I have no background so more time was needed to make the work more consistent than it looks now. So, if this project had been assigned to me at the beginning of July, then those 10 months would have given me more opportunity to produce more work.
Recommendations for further study:

- Give greater attention to visualisation tools, especially OpenDX.
- A standard study can be made to improve OpenDX in such a way as to make it user-friendly. But such a project needs a number of students to work together as a team with high programming skills.
- A further study can be conducted to examine the real problem that distance teachers might face in presenting the data about their students that helps the teachers in assessing their students, but the interviewee needed to be selected carefully.

Finally, this project was a great experience in my life. Even though there will inevitably be some mistakes –since it is normal to say "no work is perfect"- but good things were learnt that might help in producing better work in the future.
Appendix B: A Questionnaire of Riccardo
Online Learning Environment Survey

Thank you for taking part in this study. Object of this research is to provide assistance to tutors in distance learning environments. The aim of this survey is to find out which information distance tutors need in their teaching activity in order to inform the design of a visualization tool that will enable distance learning environments to be used more effectively.

There are 17 questions which may take approximately 20 minutes to answer. If you do not know an answer, give the best answer you can, or leave it blank.

The study respects the confidentiality and anonymity of participants. No personal or confidential data will be collected.

Click on Submit button at the end of the questionnaire when ready to send your answers.

Part A: User related

1. Please indicate how many on-line courses you are involved in.
   - 1
   - 2-5
   - 6-10
   - over 10

2. Please indicate your involvement in on-line courses (you can select more than one option)
   - Instructional designer
   - Course coordinator
   - Instructor/teacher/tutor/facilitator
   - Teacher assistant
   - Helpdesk
   - Technical assistant
   - Student
   - Other

3. What level of students have you worked with in on-line courses?
   - Secondary school
   - University/college undergraduate
   - University/college postgraduate
   - Continuous education/adult courses
4. How many students were in your largest class taught at a distance?
   - Less than 20
   - 20-50
   - 51-100
   - More than 100

5. How long have you been involved in distance learning courses?
   - 1 year or less
   - 2 years
   - 3 years
   - 4 years
   - 5 years or more

Part B: Platform related

6. Which of the following web-based course management tools have you used in distance learning courses? (you can select more than one option)
   - Ariadne
   - BlackBoard
   - Bodington
   - BSCW
   - Centra
   - First class
   - ILIAS
   - Lotus Learning Space
   - Toolbook
   - TopClass
   - Virtual-U
   - WebCT
   - Other tool (Please specify)

7. Which of the following facilities have you used in on-line courses? (you can select more than one option)
   - Content materials
   - Discussion forum
   - E-mail
   - Chat (synchronous communication)
   - Shared whiteboard
part C: Assessment related

8. Which of the following assessment techniques and tools have you uses in on-line courses? (you can select more than one option)
- Quiz test (e.g. multiple-choice, fill-in the blank, match, etc.)
- Assignments (evaluated by the teacher)
- Group work
- Analysis of discussions in forums
- Usage statistics (e.g. pages visited, track of student activities, etc.)
- Analysis of log files
- Other assessment methods (please specify) [ ]

9. Which of the following information regarding a student are you interested in for your teaching activity?

<table>
<thead>
<tr>
<th>Access to the course (e.g. access frequency, number of pages read)</th>
<th>Extremely interesting</th>
<th>Very interesting</th>
<th>interesting</th>
<th>Somewhat interesting</th>
<th>Not at all interesting</th>
<th>I don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiz and assignment grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation in discussions (number of articles posted/read)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posting e-mail to colleagues</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of re-visiting of the same page</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation in chat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation in group exercises</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Is there any other information that you are interested in the previous question? Please specify the information and its importance for managing on-line courses.

11. Some information changes during the course. Which of the following time-dependent information are you interested in? (you can select more than one option)
- Level of knowledge of students during the time
- Access to the course materials
- Participation in discussions
- Others (please specify)

12. For each concept of the domain of your course, what information about your students with respect to the concept are you interested in? (you can select more than one option)
- Students who have read the course materials for that concept
- Students who have performed the evaluation proofs (e.g. assignments, quiz, etc.) for that concept
- Students who have found difficulties with that concept
- Level of knowledge of each student for that concept
- Other information (please specify)

13. Assuming that your learning environment can give you information about your students, how would you use this information in your courses: (you can select more than one option)
- To adapt teaching to individual or group of students
- To identify and remedy common misconceptions
- To set up optimal peer learning or tutoring groups
- To respond to specific individuals in an appropriate way
- Other (please specify)

14. In your on-line teaching activities, which of the following types of students are you particularly interested in: (you can select more than one option)
- Students who are progressing too quickly with the course schedule
- Students who are progressing too slowly with the course schedule
- Students who do (or do not) accessing the course for certain period
- Students who do (or do not) participate actively in discussions by posting messages
- Students who do (or do not) participate passively in discussions by reading messages
- Students whose results in assessments are significantly different from the mean of the results of the class (performing very badly or very well)
- Other categories of students (please specify)

15. Previous research has identified five kinds of interaction that affect the learning process in distance education (L. A. Sutton, 2001). For each one of those, could you please tell how important they are with respect to monitoring your students' activities and progress?

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Extremely important</th>
<th>Very important</th>
<th>Important</th>
<th>Somewhat important</th>
<th>Not at all important</th>
<th>I don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner-content interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner-instructor interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner-learner interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner-interface interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicarious interaction (see below for explanation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vicarious interaction takes place when a student actively observes and processes the interaction between other students or between other students and the instructor, without taking an active part in interaction.

**Part D: feedback related**

16. If you are interested in receiving a summary of this survey, please put in your e-mail address. You will be notified as soon as this summary is ready. You can leave it blank if you do not want information about the results of this study.
17. Any additional comments

Thank you very much for your participation, please press **Submit Survey** button to send your answers.
Appendix C: Interview Questions
1. What type of information about your students you normally use (need) in your web-based teaching?

2. Do you use this information in the assessment?

3. How does this information affect the final judgment?

4. Do you know that, there are log files stored about each user of the system (Nathan Bodington Building), that can provide you with more information about your students? e.g. access time, how long did s/he took, what pages did s/he red, what links did s/he followed. etc.

5. Do you think such data can help your assessment or in the preparation of your materials?

6. Do you think these data might be helpful for improving the course material or the feedback you give to the students?

7. Do you think it might be helpful in giving you a better idea about the weaknesses in each individual to correct them easily?

8. What do you think is the best way of presenting such data?

9. There are visualisation tools such as:
   - OpenDX…
   - Graphviz…

10. Do you give your students group work, do you think that monitoring their work with such system to assess or improve group work? If yes, what kind of information will you need?
Appendix D: Codes for Generalimport.net (Figure 4.1)
MODULE main

CATEGORY Macros

comment: This visual program imports worldwide temperature and wind data using the general array importer. The original data file is named "temp_wind.lis", and the general array import header which is used to import the data is named "temp_wind.general".

comment: The temperature values (degrees kelvin) and wind data (m/sec) are for 10/1/1987 at the 1000 mb pressure level.

workspace: width = 446, height = 521

layout: snap = 0, width = 50, height = 50, align = UL

macro main(
) -> {
) {

node Import[1]: x = 0, y = 3, inputs = 6, label = Import

input[1]: defaulting = 0, visible = 1, type = 32, value = "temp_wind.general"

input[3]: defaulting = 1, visible = 1, type = 32, value = "general"

main_Init_1_out_1 =
    Import(
        main_Init_1_in_1,
        main_Init_1_in_2,
        main_Init_1_in_3,
        main_Init_1_in_4,
        main_Init_1_in_5,
        main_Init_1_in_6


) [instance: 1, cache: 1];

//

// node Transpose[1]: x = 109, y = 25, inputs = 2, label = Transpose

// input[2]: defaulting = 0, visible = 1, type = 16777248,
// value = {"y", "x"}

// main_Transpose_1_out_1 =
// Transpose(
// main_Import_1_out_1,
// main_Transpose_1_in_2
// ) [instance: 1, cache: 1];

//

// node Select[3]: x = 69, y = 113, inputs = 3, label = Select

// input[2]: defaulting = 0, visible = 1, type = 32, value =
"temperature"

// main_Select_3_out_1 =
// Select(
// main_Transpose_1_out_1,
// main_Select_3_in_2,
// main_Select_3_in_3
// ) [instance: 3, cache: 1];

//

// node AutoColor[1]: x = 56, y = 191, inputs = 10, label = AutoColor

// main_AutoColor_1_out_1,
// main_AutoColor_1_out_2 =

// AutoColor(
// main_Select_3_out_1,
// main_AutoColor_1_in_2,
// main_AutoColor_1_in_3,
// main_AutoColor_1_in_4,
// main_AutoColor_1_in_5,
// main_AutoColor_1_in_6,
// main_AutoColor_1_in_7,
// main_AutoColor_1_in_8,
// main_AutoColor_1_in_9,
// main_AutoColor_1_in_10
// ) [instance: 1, cache: 1];

//

// node Select[4]: x = 205, y = 109, inputs = 3, label = Select
// input[2]: defaulting = 0, visible = 1, type = 32, value = "wind_velocity"

// main_Select_4_out_1 =
//    Select(
//       main_Transpose_1_out_1,
//       main_Select_4_in_2,
//       main_Select_4_in_3
//    ) [instance: 4, cache: 1];

// node Reduce[1]: x = 278, y = 142, inputs = 2, label = Reduce
// input[2]: defaulting = 0, visible = 1, type = 16777221, value = {4.0}

// main_Reduce_1_out_1 =
//    Reduce(
//       main_Select_4_out_1,
//       main_Reduce_1_in_2
//    ) [instance: 1, cache: 1];

// node Compute[3]: x = 345, y = 187, inputs = 2, label = Compute
// input[1]: defaulting = 0, visible = 0, type = 32,
// value = "abs($0.x) > 100.0  ||  abs($0.y) > 100.0  ?  [0.0, 0.0]  :  [-$0.y, -$0.x]"
// expression: value = abs(wind.x) > 100.0  ||  abs(wind.y) > 100.0  ?  [0.0, 0.0]  :  [-wind.y, -wind.x]
// name[2]: value = wind

// main_Compute_3_out_1 =
//    Compute(
//       main_Compute_3_in_1,
//       main_Reduce_1_out_1
//    ) [instance: 3, cache: 1];

// node AutoGlyph[1]: x = 302, y = 263, inputs = 7, label = AutoGlyph
// input[2]: defaulting = 0, visible = 1, type = 5, value = 0.300000
// input[3]: defaulting = 0, visible = 1, type = 5, value = 1.500000
// input[4]: defaulting = 0, visible = 1, type = 5, value = 1.500000
// input[6]: defaulting = 0, visible = 1, type = 5, value = 0.100000
main_AutoGlyph_1_out_1 =
    AutoGlyph(
        main_Compute_3_out_1,
        main_AutoGlyph_1_in_2,
        main_AutoGlyph_1_in_3,
        main_AutoGlyph_1_in_4,
        main_AutoGlyph_1_in_5,
        main_AutoGlyph_1_in_6,
        main_AutoGlyph_1_in_7
    ) [instance: 1, cache: 1];

//

// node Color[3]: x = 346, y = 340, inputs = 5, label = Color
// input[2]: defaulting = 0, visible = 1, type = 32, value = "magenta"
// input[3]:
Appendix E: Images used for the Interviews
Visualisation of **STUDENT ACCESS TO THE COURSE** (Mazza (c) 2003)

**Y axis:** list of students

**X axis:** dates of the course
STUDENT ACCESS TO THE COURSE (Mazza (b) 2003)
GLOBAL INFORMATION ABOUT ONE STUDENT's ACCESS TO COURSE (Mazza (b) 2003)

Summary of student's behaviours
from 2002-01-15 to 2002-04-11
Student: "massimo"

Access to content pages by topics

Global access to the course

Progress with the course schedule

messages

Quiz(Q) and Assignments(A) submissions
3D VISUALISATION OF THE STUDENTS' PARTICIPATION IN DISCUSSIONS (Mazza (b) 2003)
Size and colour of the balls represent the length of the discussion threads.

Here we can see the discussion related to the course units and dates.
3D VISUALISATION OF THE STUDENTS' PARTICIPATION IN DISCUSSIONS (Mazza (b) 2003)
Size and colour of the balls represent the length of the discussion treads.

Here we can see the discussions related to the students who initiated the discussions and dates.
Messages Passing Diagram
a0-a3 a group of students
b0-b3 a group of students
Messages Passing Diagram
S* Secretary
T* Teacher